

**ASSESSMENT OF IRRIGATION REQUIREMENT OF NARMADA  
COMMAND USING SOIL-CROP-CLIMATE DATA**

A THESIS

SUBMITTED TO THE  
GUJARAT AGRICULTURAL UNIVERSITY  
IN PARTIAL FULFILMENT OF THE  
REQUIREMENT FOR THE AWARD OF  
THE DEGREE

OF

**DOCTOR OF PHILOSOPHY  
(AGRICULTURE)**

IN

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

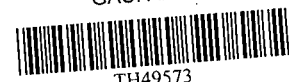
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ANAND CAMPUS, ANAND

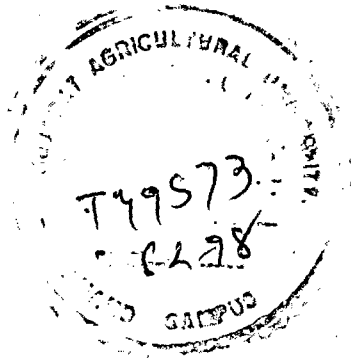
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# ABSTRACT

ASSESSMENT OF IRRIGATION REQUIREMENTS OF NARMADA COMMAND  
USING SOIL-CROP-CLIMATE DATA

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ABSTRACT

The assessment of irrigation requirement of Narmada Command covering an area of 18 lakh hectares (1.8m ha) has been carried out using data on soil available water capacity and evapotranspiration data on crops viz., pearl millet, groundnut, pigeonpea, cotton, castor, mustard and wheat. The crop evapotranspiration (ETc) is computed using crop coefficient values (Kc). While ETc has been found to be mainly dependent on the climatic component, the Net Irrigation Requirement (NIR) has been found to depend on climate mainly effective rainfall and the soil available water capacity (AWC). Differences between the Crop Water Requirement (CWR) and NIR were wide for the monsoon season, but narrowed down considerably in the winter and summer seasons. The AWC and the length of growing period of crop have also contributed to the NIR values. Soils with higher AWC had lower NIR while crops with longer growing season showed higher NIR. The AWC of soils has been found to be

mainly governed by the soil texture more so by the clay + silt or clay contents. In general, medium textured soils had higher AWC than either coarse or fine textured soils. The 50 per cent level of depletion of AWC has been used to initiate irrigation. The number of irrigations required and the quantity of water applied depends on the overall evaporative demand of climate, the length of growing season of the crop and the AWC of soils. Seasonal evaluation of the scheme water supply efficiency revealed that in general the values were below 1.0 and tended to be around 0.5. The values were around 0.5 during the months of high evaporative demand and considerably less during the monsoon and cooler months when the evaporative demand is lower. However, these values are expected to be higher once all the crops grown will be considered. Scheme efficiency (relation between supply required and actual supply) can be improved by growing perennial crops like sugarcane and banana and such other crops having a high requirement for water. Such crops are recommended to be grown on as soils with no root zone limitations or other limitations imposed by the physical and chemical properties of soils. During months of low water requirement use of exploitable ground water is also recommended. Such conjunctive use will help in saving water which otherwise will go as wasteful flow and also help to keep the ground water level well below problematic levels.

Use of data on soil-crop-climate to schedule irrigations for the various crops revealed it to have substantially less NIR values as compared to the IW/CPE ratio for monsoon season crops and compared well for the winter crops. In the summer, it predicted a less NIR than IW/CPE for groundnut but gave higher values than IW/CPE for pearl millet. The redeeming feature of the model is that it takes into consideration the effective rainfall (Total rainfall less that lost through run-off or deep percolation). The soil-crop-climate model compared well with the other methods of irrigation tried, for the yield of grain in all the crops studied. It gave less WUE than the critical stages approach for all the crops except wheat, where it gave higher WUE values. In case of pearl millet and mustard it gave less WUE than the IW/CPE ratio. This may be attributed to the fact that these crops have basically less requirement for water and hence, gave no significant response to any increase in water supplies beyond a certain level.

Studies on the behaviour of the model as compared to the other schedules for the nutrient depletion pattern indicate that no definite pattern with respect to nutrient uptake has emerged and the results had a fair measure of inconsistency. The inherent variability of the crops studied for their capacity of derive nutrition, the natural

relationships among the nutrients and the inherent difference in the soil's capacity to supply nutrients can be attributed to the observed inconsistency. Since the model gives moderate dry matter production, it causes moderate depletion of nutrient and hence with proper management and monitoring of the soil fertility, it is expected to give sustained agricultural production.

Study on evolving alternative irrigation management practices in areas suffering from problems of rising water table were carried out. Results revealed that for groundnut use of sprinkler system of irrigation with an application depth corresponding to 2.5 cm per irrigation at two stages of crop growth viz. pegging (55 DAS) and pod development (85 DAS) with two irrigation of 5 cm each as pre-sowing and pre-harvest proved to be the most beneficial (5.7 t/ha kernel yield). Growing groundnuts without irrigation (4.6 t/ha) except a pre-sowing irrigation was the next best alternative. Irrigating groundnut at pre-sowing, 55 DAS, 85 DAS and pre-harvest stages with 5 cm depth of application each time had serious negative effects on yield (2.6 t/ha). Under such situations use of sprinklers appears to be a promising alternative as besides giving higher yield it may also help in keeping the ground water level within manageable limits. Growing groundnut without irrigation

appear to be the next best alternative. From the study conducted it can be concluded that the soil-crop-climate model, can be used as an effective tool for predicting regional estimates of irrigation requirement inspite of the wide diversity of climate, soil and crops grown in any region, because it takes into consideration these very variables. It is also easy to compute the requirement and has the added advantage of using minimum data sets. The data collected once can be applied without the need for recurrent data collection for a reasonably long time. However, before final conclusions can be drawn, the model needs to be validated for larger number of crops, wider variety of soils and different climatic situations. Because of its requirement of minimum data sets, however it appears to be an attractive alternative tool for making regional estimates of water requirement and merits scientific attention.

Dr. G.R.Patel

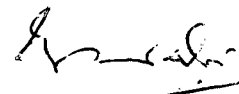
Major Professor (Retd.)

### CERTIFICATE

This is to certify that the thesis entitled " Assessment of Irrigation Requirement of Narmada Command using soil-crop-climate data" submitted by shri Jayant Dattatraya Giri in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Agriculture (Agricultural Chemistry and Soil Science) of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Anand

Date : 22 / 8 / 97



(G.R.Patel)

Major Advisor

## ACKNOWLEDGEMENTS

It is indeed with a sense of humility on one hand and that of pleasure on the other that I take this opportunity to express my immense gratitude to Dr. G.R. Patel, my major advisor (now retd.) for giving me full freedom in choosing the research work of my preference. I also deeply express my gratitude for the constant moral support and other working facilities made available to me during the entire period of research work, by him, as well as for keenly <sup>going</sup> through the manuscript.

I also wish to express my sincere thanks to the late Dr. H.N. Patel, Director of Campus, followed by Dr. R.S. Sharma the then Director of Campus in charge and Shri B.T. Rathod the present Director of Campus for the availability of facilities to conduct the research work.

I am indebted to Dr. N.M. Patel, Principal B.A. College of Agriculture, Gujarat Agricultural University, Anand for the interest and support accorded to me in my studies and research work.

I would be failing in my duty if I were to forget to express my utmost gratitude to Dr. J.L. Sehgal the Ex. Director, National Bureau of Soil Survey and Land Use Planning, ICAR, Nagpur who during his tenure gave me this

opportunity to improve my professional qualifications. I am also indeed grateful to Dr. S.T. Gaikwad who during his spell as Incharge Director and to Dr. M. Velayutham, the present Director for their continued support for the conclusion of my study.

I would also like to express my gratitude to Dr. R.L. Shyampura, Head, Regional Centre NBSS and LUP, Udaipur for relieving me immediately to take up my studies. I also wish to express my gratitude to the office, technical and supporting staff of the centre for their help in both official and personal needs.

I am also indeed very grateful to Dr. P.N. Upadhyay, Professor and Head, Department of Agronomy, B.A. College of Agriculture, Anand who as my minor advisor took keen interest in my research work and made available to me the facilities of the Agronomy Farm during the period of field experimentation. I would also like to express my gratitude to Shri Manharbhai Patel, Farm Manager, Agronomy Farm, BACA for looking to my daily needs during the course of field work. I also sincerely acknowledge the assistance received by me from the other farm staff. It is indeed my duty to express my special thanks to the Director, Water and Land Management Institute (WALMI), Anand for allowing me to use the facilities of the soil's laboratory. I am also

equally grateful to Dr. H.R. Patel, Farm Manager, WALMI, Agronomy Farm and his staff colleagues as well as Shri P.H. Kalathiya and Shri B.J. Raval Jr. Sci. Asstt. and Shri Gorkha, Lab. Attendant, Soils laboratory, for their help during the conduct of field experimentation and laboratory work.

I am equally grateful to Dr. N.K. Kalyansundaram the present Professor and Head, Dept. of Agricultural Chemistry and Soil Science for his keen interest in my work and his constant moral support and elderly affection.

I cannot and shall never forget the help, guidance and interest taken in my research work by Dr. C.L. Patel, presently Training Organizer and Unit Head, Tribal Research and Training Centre, Devgad Baria, Dist. Panchmahals. He has been a constant source of guidance throughout the period of research work and has also taken keen interest in giving shape to my manuscript. I am really very much indebted to him.

I take this opportunity to express my sincere gratitude to Shri L.V. Ashara, Chief Engineer, CAD, Narmada Sardar Sarovar Project, Narmada Bhavan, Chhani Road, Baroda, for extending his kind support for collecting the of soil samples from the command area. I sincerely acknowledge with

deep gratitude, the help rendered by Shri Y.M. Munshi, Soil Survey Officer, Narmada Sardar Sarovar Project, Bharuch for providing facilities of vehicle and support of staff and equipments and also for sparing his valuable time while accompanying me to various sampling sites of the command area.

I am also very much grateful to all my teachers and committee members for their constant help and guidance in my studies. The constraints of space prevent me from naming them individually.

My thanks are also due to other members of the Dept. of Agril. Chem. and Soil Science for their friendly support and guidance. I am equally grateful to Dr. K.P. Patel, Associate Res. Sci. and the staff members of the ICAR Micronutrient Project and the supporting staff for extending their help and whenever required

I take this opportunity to express my sincere gratitude to Dr. J. C. Patel, Professor and Head, Dept. of Biochemistry and Research Scientist (NARP), BACA, Anand for the continued support, guidance and extension of facilities of laboratory working space which has gone a long way in the successful completion of my research work.

I am also grateful to Dr. Ramesh Bhatnagar and Dr. J.G. Talati, Assoc. Professors and their technical as well as the supporting staff for being always ready to lend their helping hand during my period of work in the Biochemistry Department.

I am indeed very grateful to Shri Narendrabhai Patel, Agril. Asstt-cum-Store Keeper, Dept. of Agril. Chem. and Soil Sci. for always providing me all the facilities like, chemicals, glasswares, equipments etc. during the course of research work. The help rendered by the supporting staff is equally acknowledged.

Special mention and an expression of deep gratitude is required for the continuous help and co-operation rendered to me by Shri Sanjay L. Pawar, Ph.D. Student, Dept. of Agril. Chem. and Soil Science whose association has gone a long way in the successful culmination of my research work.

My stay has really been made pleasant and memorable by the love and affection shown to me by Shri J.C. Chavda, Asstt. Plant Physiologist, BTRS, GAU, Anand and Mrs. Chavda, Dr. D.N. Yadav, Research Scientist, Biological Control Project, GAU, Anand and Mrs. Yadav, Dr. M.M. Pathak, Assoc.Res. Scientist, RBRU, GAU, and Mrs. Pathak, Dr. K.P.

Patel, Asso. Res. Scientist, ICAR, Micronutrient Project, BACA, Anand and Mrs. Patel and Shri Devandra P. Dave, Sr. Clerk, Dairy Science College and Mrs. Dave all of whom always treated me as their family member.

I am also grateful to Shri T.M. Bharpoda, Asstt. Prof. Dept. of Entomology and Asstt. Rector, P.G. Hostels, BACA, Anand for his co-operation during my stay as a hostel inmate, because of which my stay in the hostel was comfortable and troublefree.

I consider it my sacred duty to express my utmost gratitude with all the humility at my command towards my dear father Shri Dattatraya Giri and my loving mother Smt. Bhavnabai Giri for their sacrifice, love and ofcourse assistance that has made me what I am. I dedicate this work to them.

I am also equally grateful to my parents-in-law, Shri Shamrao Kaluskar and Smt. Shantabai Kaluskar for always being ready to come to my assistance throughout the course of study. Their contribution is in no way less important.

Last but really not the least, I am indeed immensely grateful to my loving wife Dr. (Mrs.) Sandhya Giri who by the dint of her courage faced the long spells of

separation from me and beautifully managed the household responsibilities as well as the sharp attention paid towards the children's education and their needs in my absence. I am really proud my children, Chi. Bhругu (17 yrs.), Chi. Janhavi (16 yrs.) and Chi. Uma (13 yrs.) who inspite of my absence carried on sincerely with their studies and came out with flying colours.

Finally, I am indeed grateful to and appreciative of the fine work rendered by Shri Bharatbhai in typing this manuscript with patience and zeal and with care to keep the mistakes, if any, to the minimum.

Place : Anand

Date : 19/08/97.

  
(J. D. GIRI)

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# INTRODUCTION

## CHAPTER - I

### INTRODUCTION

Three basic natural resources and the nature of their proportion, viz. climate, soil and water, determine the extent and the nature of successful crop production, either for a particular region or the country as a whole. On this, depends the satisfaction of the needs of food, fibre and shelter for the population, be it human or animal. Contrary to the general understanding prevailing among the masses, all these resources are finite in nature and their misuse can only spell doom for the very survival of all life forms. The ever increasing population has intensified the finite nature of land. Erratic rainfall, its uneven distribution, and the ever increasing exploitation of all sources of water to meet the agricultural, domestic and industrial demands, has brought realization of the finite nature of water. Ever increasing incidences of atmospheric pollution induce a measure of finiteness for climate too. While land and climate are equally important, successful crop production heavily depends upon the sufficiency of available water. Lack of water, its paucity or even excess, causes poor crop production or even total failure. The main

source of water for surficial or underground storage, is ofcourse rainfall or snow. In India, the annual average rainfall is around 112 cm, amounting to 370 million hectare-meter of water. The rainfall is widely variable, ranging from less than 30 cm in western Rajasthan to around 1000 cm in Cherrapunji in Meghalaya (N.C.A. 1976). Most of this comes during the months of June to September, leaving most of the areas dry for the remaining part of the year. This necessitates the erection of irrigation facility, to make crops grow successfully. Provision of irrigation is possible by harnessing the surplus water of the high rainfall areas as also the water that seeps into the soil and forms the underground water source. An estimated 215 million hectare-meter of precipitation enters the soil, of which 165 million hectare-meter is held within the root zone depth and accumulates as ground water (Prihar and Sandhu, 1987). The total water resources of the country as documented by the National Commission on Agriculture (1976) is 185 million hectare-meter, comprising of 135 million hectare-meter as surface water and 50 million hectare-meter as underground water. However, due to limitations imposed by topography, climate, and soil, surface water cannot be fully exploited due to limitations of pumping depths and availability of power. The quality of ground water is also another limitation. Altogether, it is estimated that about 70 million hectare-meter of surface water and 35 million

hectare-meter of underground water can be utilized, causing a creation of an ultimate irrigation potential of 113.5 million hectares (Prihar and Sandhu, 1987).

Investment in irrigation, has for long been a major priority for the Government of India. In 1950-51, the net irrigated area in India was 21 million hectares which increased to 42 million hectares in 1985. Presently, the net irrigated area is 71 million hectare. It is on account of this, that India could achieve a phenomenal increase in food production and change from a food importing country to a food sufficient one. In spite of these achievements the irrigation sector suffers from a number of shortcomings, which have prevented the full achievement of its potential. This sector is characterized by low average yields by as little as half ~~of~~ those obtained elsewhere in Asia, a low average cropping intensity of 130 per cent, a 10 per cent gap between irrigation potential created and area actually irrigated, and declining standards of construction and maintenance (Pike, 1995).

The low productivity and sustainability problems of the sector have generally been ascribed to poor water management practices, a low level of maintenance and inadequate agronomic inputs. One of the most prevalent problems of irrigated agriculture in India is the huge loss of water during conveyance and distribution. These losses

have been estimated to be around 22 to 50 per cent, depending upon location and management (Pike, 1995). However, this problem is now being attended (to) through lining of water courses, the cost of which is recovered from the farmers in installments spread over long periods. Another problem, is the wastage of irrigation water in the field due to faulty irrigation methods, lack of proper land leveling and grading, over irrigation and untimely application of water. Though alternative methods like sprinkler and drip irrigation systems exist, yet the benefits derived through these, vis-a-vis their cost of installation, their operation efficiency under various situations of water availability, quality of crops that can be grown and other environmental factors need to be assessed. Yet another problem which is quite serious in nature and of common knowledge, is that of water logging and secondary salinization and to date, no single irrigation project has remained free from this malady (Prihar and Sandhu, 1987).

It is in this backdrop, that the most debated multidimensional project "The Sardar Sarovar Project", on the river Narmada, is to be viewed. According to the World Bank, "the benefits of this project are so large that they substantially outweigh the costs of immediate human and environmental disruption. If the waters of the Narmada river continue to flow to the sea unused, there appears to be no

alternative to escalating human deprivation, particularly in the dry areas of Gujarat". The Narmada command will bring an area of 18 lakh hectares (1.8 m Ha) under irrigation covering 12 districts, all agro-ecological, regions, soil types, and cropping systems, in its purview. Besides, it will augment the drinking water supplies of both the areas within and outside its purview. The project will generate power to the tune of 1450 Mw and create an employment potential of 0.6 million man years after it is completed. It will also help in stopping the progress of the desert and overcome flood hazards in nearly 30,000 ha (Anon., 1990).

In view of the variety of climate, soils and crops that this project is going to tender to, it stands to reason that a blanket irrigation schedule, based on agro-climate alone, a single soil type or a single cropping pattern, would be untenable. In fact, such restricted approaches and their recommendations in the presently active projects might be cited as causes for the resultant serious water logging and salinity/ problems.

Realising the dynamic nature of the climate, crops and soils, the present study is being undertaken with following objectives :

- (1) To assess the irrigation requirement of the command by integrating the components of climate (PET - the demand side), the soil (AWC - the supply side) and the crops (the user side).

- (2) To validate the irrigation schedule model in the middle Gujarat agroclimatic region for the 7 crops selected.
- (3) To compare the efficiency of this model vis-a-vis the presently used schedules, through crop performance studies.
- (4) To study the impact of various irrigation schedule on nutrient concentration in and their uptake by the crops selected.
- (5) To explore alternate irrigation management options in areas affected by rising water table along the canals.

It is believed that the results of this study, will form a base for similar experimentation in other agro-ecological regions, soil types and crops.

The study was conducted at the Agronomy farms of the B.A. College of Agriculture, Anand and the Water and Land Management Institute, Anand.

**REVIEW  
OF  
LITERATURE**

## CHAPTER - II

### REVIEW OF LITERATURE

Availability of water at correct time and in correct quantity is one of the important factors influencing crop yields. The seasonality of rainfall, particularly in arid and semi-arid areas does not render it capable of fulfilling all the water requirements of different crops and hence, there is a need for creating irrigation facilities in these areas. Development of irrigation facilities, be it major, medium or minor, involves huge investment of public funds and therefore it is imperative that this facility be used rationally. For any reason, if irrigation water is unable to reach all farmers in the command area in an equitable manner and at the proper time, the use of water becomes inefficient. In view of the above factors, it becomes all the more necessary to explore means and methods to find irrigation scheduling programmes that will, while reaching all the beneficiaries, be also based on the soil type, the crops grown and the overhead climate. Numerous studies have been carried out and are being carried out the world over and in India too, with the objective of coming up with a solution that will have a measure of universality. The present chapter attempts to review the existing

literature on the following aspects of water management in irrigated commands.

- (1) Methods adopted to assess the irrigation requirements of irrigation commands.
- (2) Methods adopted to arrive at a particular irrigation schedule.
- (3) Effect of different irrigation schedules on yield, consumptive use, water use efficiency and quality and nutrient uptake by crops so irrigated i.e., crop performance.
- (4) Methods adopted to manage irrigation water under shallow water table conditions and their effect on crop performance.

First of all the methods adopted to arrive at a particular irrigation schedule shall be dealt with :

Irrigation schedules should be developed with the objective to achieve :

- i) high yield of crops of good quality
- ii) higher water use efficiency
- iii) maintain and protect soil productivity and
- iv) low cost of irrigation

At present, such a irrigation scheduling program, satisfying all of the objectives mentioned above is absent, which results in the farmers practicing methods that lead

to either over irrigation or under irrigation. In either case, production per unit of water applied is low.

A scientifically sound irrigation schedule can be achieved through proper understanding of the soil-water-plant relationship.

Prihar *et al.* (1975) have made a critical appraisal of research on irrigation scheduling of crops. It is now universally understood that irrigation needs of crops depend upon evaporative demand of the surrounding atmosphere, soil water regime in the root-zone and the crop in question. Hence, soil, plant and the atmosphere have been used as parameters or criteria for scheduling irrigation to crops, either individually or in various combinations. A brief account of these indices follows :

## 2.1 SOIL WATER CONTENT

In the beginning, irrigation was applied when the soil water content in the root zone reached an assumed threshold value. Another technique adopted a fixed interval of time between each irrigation for different crops. However, it was soon realized that both these criteria varied widely for the same crop with varying soil texture (Prihar and Sandhu, 1987). Ritchie *et al.* (1972) put forward a new concept of lower limit of soil water content for potential evapotranspiration of crop ( $LLE_0$ ) as the basis for

irrigation. It was assumed by these workers that below this limit, crop growth is likely to suffer. They fixed a limit of 18 cm/180 cm in a clay loam soil for soybean. In a study on medium textured soils in crops like spring wheat, alfalfa and grass in south western Saskatchewan Canada, Cutforth *et al.* (1991) suggested a lower limit of - 4 MPa or possibly - 10 MPa.

Prihar *et al.* (1978) observed that, to be more meaningful, the threshold depletion can be defined with respect to potential yield of crop, because crops may give potential yield without evapotranspiring at potential rates.

## 2.2 DEPLETION OF AVAILABLE SOIL WATER

In this approach, a fixed level of depletion of the available soil moisture of the active root zone is allowed, after which irrigation is initiated. Singh *et al.* (1960) have presented the work of researches in India and abroad, based on this approach. Horner and Mojtehedi (1970) while working on grain legumes observed that irrigation based on level of depletion should consider the stage of crop growth because, if greater depletion is allowed during bloom and early maturity the effects may be devastating. Lembke and Jones (1972) opined that the extent of depletion that can be allowed depends on the water holding capacity of the soil. Fangmeier and Mohammed (1977) concluded that

scheduling irrigation based on level of depletion requires careful monitoring of the soil moisture and plant conditions. Prihar *et al.* (1978) while conducting irrigation scheduling based on soil moisture depletion, observed the retentive capacity of soil to be the determinant for fixing the extent of depletion that can be safely allowed. Prihar and Sandhu (1987) have after numerous studies and review of the existing literature observed this method to suffer from the following drawbacks. First, the assumption of a fixed root zone is against the dynamic nature of roots which continue to go deeper during most part of the growing period. Second, it is difficult for a common farmer to carry out periodical determination of soil moisture depletion and rooting depth. Third, even a part of the root system located in a wet layer at deeper depth may meet the entire ET needs of the crop, although the assumed root zone depths may be dry enough to warrant irrigation.

### 2.3 SOIL MOISTURE TENSION

This energy index of soil water has also been used as a criterion for scheduling irrigation to crops. Miller and Duley (1925) were probably the first to use soil moisture tension as a criterion for scheduling irrigation to maize. Richards (1942), and later on Richards and Marsh (1961) also employed tensiometers installed at specific soil depths to monitor soil moisture tension for irrigation

purpose. Taylor (1952) advocated the use of mean tension, averaged over the entire root zone, as a more reliable indicator for scheduling irrigation than the soil moisture tension of the shallow soil layer. Taylor (1965) prepared an irrigation guide that served the purpose of scheduling irrigation for different crops, under different evaporative demands in different soils. Gypsum blocks (Haise and Kelley, 1946; Taylor, 1952) were recommended for crops which could withstand greater depletion of water, than is measurable by tensiometers. In spite of their applicability, in scheduling irrigation to a wide variety of crops under different soil types and climatic conditions, yet the use of tensiometers and gypsum blocks remained largely unacceptable due to following shortcomings. Tensiometers have a very narrow range of workability (0-0.8 bar), while gypsum blocks are not useful at low tensions. While these instruments do indicate the need for irrigation, yet they do not provide information on the quantity of water to be applied. Because of the time lag, for equilibrium to be reached, between the porous cup and the surrounding soil, tensiometers usually indicate the energy status of soil water at some earlier time (Prihar and Sandhu, 1987).

#### 2.4 CLIMATOLOGICAL INDICATORS

The adequacy of soil water supply governs the direct relationship between evaporation and

evapotranspiration of a crop. Different meteorological concepts and approaches have been used by various workers for scheduling irrigation. Potential evapotranspiration ETP or PET, according to Penman (1948, 1956) is "that quantity of soil moisture thrown by a short green crop fully covering the soil, per unit time from a soil that is never short of water". This concept, thus, assumes that PET is equal to or is a fraction of the water evaporating from a free water surface. Thus, if the PET data over short periods, and the allowable soil moisture depletion from the root zone are known, it can be possible to schedule irrigation. The PET data can be known through the use of lysimeters; but, because lysimetric studies are very costly, empirical coefficients are established between experimentally determined crop ET and PET estimated from any one of the empirical evaporation formulae and other techniques involving meteorological data (Prihar and Sandhu, 1987).

Briggs and Shantz (1916) were the first to demonstrate a close relationship between transpiration and open pan evaporation. Later on several workers (Jensen, 1969, 1972; Jensen *et al.*, 1970; Jensen and Wright, 1978; Kundu *et al.*, 1982; Swaney *et al.*, 1983; Chesness *et al.*, 1994; Steele *et al.*, 1994; Lamm *et al.*, 1994; Lyle and Brodovsky, 1995), used ET data and soil moisture data to prepare water budgets for individual fields as well as a

whole region. This technique has also been adopted by Tripathi (1992) for scheduling irrigation to wheat crop on soils with different textures and depth of water table. However, according to many workers (Wilcox, 1960, van Bavel *et al.*, 1968, Miller and Aarstad, 1972) equating depletion of soil moisture to ET may lead to many errors as in many soils water lost to deep drainage also constitutes a significant portion of ET.

Gornat *et al.* (1971) in the U.S. and Narang and Dastane (1971) in India advocated the use of the ratio between actual evapotranspiration (ETA) and pan evaporation ETP as a suitable index for determining when and how much to irrigate. According to these workers the ratio was independent of the plant ground cover. A series of ET models have since been developed to predict daily ET rates (Kanemasu *et al.*, 1976, Rosenthal *et al.*, 1977; Shouse *et al.*, 1980; Cull *et al.*, 1981; Brun *et al.*, 1985; Fuchs *et al.*, 1987; Camp *et al.*, 1988; Ragab *et al.*, 1990).

Prihar *et al.* (1974) developed a relatively more practical meteorological approach involving pan evaporation and the irrigation water depth. These workers advocated the use of a definite irrigation water depth (IW) to cumulative pan evaporation (CPE) ratio for scheduling irrigation. Since then the IW/CPE ratio has and is being extensively adopted throughout the country under various climate, soil

and crop conditions. The application of this technique has resulted in significant saving of irrigation water. In spite of the relative ease of this method in scheduling irrigation, the main drawback of this method is the problem of advective energy which may give higher values of pan evaporation resulting in some over irrigation. Such possibility is greater in the arid and semi-arid environments which are prevalent in the Indian peninsula. That advection is a source of energy for evaporation has been experimentally established by Hanks *et al.* (1971). These workers found three sources of advection viz., within canopy, border and larger scale advection.

## 2.5 PLANT INDICES

Physiological measurements have been used to form a basis for fixing irrigation schedules (Hagan and Laborde, 1964, Kramer, 1963). Any plant character which is related to plant water deficit, directly or indirectly and responds to the integrated influence of soil water, plant factors and evaporative demand of the atmosphere, can serve as a criterion for timing irrigation to crops. Since the type of plant species, the stage of development and the prevailing environmental condition in large measure control the extent of harmful effect of water stress, it is really very difficult to evolve a universally applicable irrigation schedule based on plant indices (Prihar and Sandhu, 1987).

Some of the important plant criteria employed for scheduling irrigation are described below :

#### 2.5.1 Visual plant symptoms

Visual symptoms of wilting, viz., drooping, curling, rolling of leaves etc. have been used by many as indicators of irrigation need (Prashar and Hagan, 1970). Downey (1971) and Downey and Miller (1971) estimated the critical stress level of 90% relative leaf water content from a set of photographic standards and plotted these values against vapour pressure deficit of the ambient environment and used this for scheduling irrigation. Though a distinct change in foliage colour has been used by many (Burman and Painter, 1964; Robins and Domingo, 1956) yet several factors like nutritional disorders, insect and disease incidence, varietal character and growth stage can also alter the colour and hence be misleading indicators (Prihar and Sandhu, 1987). Profile modification like mixing of sand (Dastane, 1970), compacting the root zone soil layer or introducing mechanical barriers to enhance moisture shortages in mini plots so that these can serve as indicators of irrigation needs earlier than the main fields can prove to be counter productive according to Sandhu *et al.* (1976) as such manipulations may encourage deeper rooting and thus delay the onset of wilting in the indicator plots.

### 2.5.2 Growth indicators

Since water deficit first affects the process of cell elongation leading to growth retardation of the most sensitive plant organ, these effects can be used as indicators of irrigation need. Oppenheimer and Elze (1941) used the change in fruit circumference, while Namken *et al.* (1971) used radial changes in stem, for scheduling irrigation in cotton. Wright and Berliner (1986) used the terminal leaf-let angle data of soybean and advocated the use of angle of the terminal leaflet of 45 °C or greater to the horizontal to decide the need for irrigating soybean, as this correlated significantly with the water content of the top 0.45m layer and the ET/E pan ratio. However, practical difficulties like inadequate standardization of techniques, non availability and high cost of instruments, selection of suitable growth parameters, lack of precision in growth measurements, variation of growth water relationships with stage and dependence of growth on other environmental factors do not permit their adoption on commercial basis.

### 2.5.3 Plant water content and water potential

The relative leaf water content and the leaf water potential are generally used as indices of plant water status. These values are expression of the lag between the evaporative demand and crop water uptake and when a certain threshold is reached, irrigation can be practiced. Namken

(1965) recommended irrigation to cotton when its afternoon RLWC over a large period dropped to below 72%. Similarly, Ritchie and Jordan (1971) used RLWC and relative ET relationship to define permissible limits of soil-water availability to sorghum. Since Et of a crop and the leaf water potential both are energy based, Shardakov (1957) and Petinov (1959) advocated the use of plant water potential as a basis for scheduling irrigation to cotton and wheat. Hiler et al., (1972) suggested leaf water potential based stress day index as a useful criterion for scheduling irrigation to peas. In case of narrow row cotton, Brodovsky et al. (1974) used soil water potential, leaf water potential and stress day index methods for timing irrigation and found the LWP and SDI to cause WUE increases by 17 and 38 per cent and pointed to the significant benefits of stretching irrigation intervals when plant based indicators are used. Stanley et al. (1981) combined various meteorological parameters to develop a model to estimate LWP and also evaluated the contribution of each of the meteorological parameters to this model. Greatest response by soybean cultivars was achieved when LWP was modeled using solar radiation and air temperature as the only input variables. While scheduling irrigation to wheat, McDonald et al. (1984) observed that when the leaf water potential reached - 4MPa, irrigation caused maximum dry matter production. However, high costs, intricate operation of the instruments, errors in

measurement due to external factors, lack of standardization of the techniques are some of the hindrances which come in the way of large scale adoption by the farmers.

#### 2.5.4 Leaf diffusion resistance

Several scientists have reported a close relationship between leaf diffusion resistance (LDR) and plant water stress. Sandhu and Horton (1977) observed that on cloudless days, LDR is a sensitive index of internal water balance in mild to moderate stress and holds a promise for scheduling irrigation. Sij *et al.* (1972) reported that LDR of sorghum leaves followed the plant water status and suggested that diffusion porometer, a device to measure LDR may prove a useful tool in scheduling irrigation.

#### 2.5.5 Plant temperature

During the recent past, extensive efforts have been made to study the effect of water stress on leaf canopy temperature. It is now well established that leaf canopy temperature is a sensitive index of plant water status in several crops like soybean (Carlson *et al.*, 1972); Oats (Sandhu and Horton 1978), barely (Horton *et al.*, 1970); alfalfa (Miller *et al.*, 1971); wheat (Idso *et al.*, 1981; Ehrler *et al.*, 1978; Gupta and Sastry, 1986 and Stegman and Soderland, 1972); Sorghum (Weigard and Namken, 1966) and corn (Sumayo *et al.*, 1980). Sandhu and Horton (1978)

observed that oat leaves subjected to mild to moderate stress, were 1° - 4° C warmer than the not stressed leaves. Wanjura et al. (1990) while comparing irrigation applied through water balance method, canopy temperature and pre sowing irrigation alone on water use, found that it reduced as the threshold temperature was raised. These workers included that the use of threshold canopy temperature permits automated decision making for irrigation scheduling but yield was positively related to water applied and water used. Many scientists have shown that difference between canopy and air temperature ( $\Delta T$ ) is a better criterion of water stress than the plant temperature alone (Carlson, 1972; Palmer, 1967; Ehrler, 1978 a,b; Sumayo et al., 1980) Ehrler (1973) reported that saturation vapour pressure deficit of air (SD) influences the sensitivity of  $\Delta T$  as a reliable indicator of irrigation. Jackson et al. (1977) suggested the use of stress degree days (SDD) computed as the summation of  $\Delta T$  for determining the timings and amounts of irrigations to crops. However, Stockle and Dugas (1992) have identified certain shortcomings in using canopy temperature to schedule irrigation, chief among them being the sensitivity of canopy temperature measurements to weather fluctuations. According to these workers irrigation to crops was predicted after some stress had already developed, which may limit its application for crops sensitive to water stress.

## 2.6 GROWTH STAGE APPROACH

Crop growth and yield generally exhibit differential sensitivity to water stress imposed at its various growth stages. Several field investigations have been made to identify critical stages of crops that are relatively more sensitive to water stress by missing irrigations at the growth stages (Misra *et al.*, 1969; Chauhan *et al.*, 1970; Musick and Dusek, 1971; Cheema *et al.*, 1973; Bhan, 1993). In spite of the simplicity of the approach, it is not based on sound and valid field results, because missing irrigations does not necessarily result into identical stress at the stages due to variable atmospheric evaporativity, initial water content and rain at these periods (Sandhu, 1994).

## 2.7 REMOTE SENSING TECHNIQUES

Jackson *et al.* (1987) evaluated evaporation from field crops using airborne radiometry and ground based meteorological data. Comparison of the airborne and ground techniques showed good agreement with the greatest difference being about 12 per cent for the instantaneous values. Estimates of daily evaporation were made from the instantaneous data of three and five days, the difference between the two techniques was less than 8% with the greatest difference being 25%. The results demonstrated that airborne remote sensing techniques can be used to obtain

spatially distributed values of evaporation over agricultural fields.

## **2.8 STRESS DAY INDEX APPROACH**

The stress day index (SDI) concept, developed by Hiler and Clark (1971) provides a quantitative means of determining the stress imposed on a crop during its growing season. Using this concept Hiler *et al.* (1974) accomplished irrigation timing, when the SDI reaches some predetermined critical value and achieved increased WUE over the other tried methods. Similar results were reported for sunflower (Hegde, 1988) and wheat (Garrot *et al.*, 1974).

## **2.9 EFFECT OF DIFFERENT IRRIGATION SCHEDULES ON CROP PERFORMANCE**

The present review attempts to study the work carried out by various researchers both in India and the world over on different crops with special reference to Groundnut, Pearlmillet, Pigeonpea, Cotton, Castor, Wheat and Mustard. The different methods of irrigation scheduling on which attention is paid are : (1) Various depletion levels, (2) IW/CPE Ratio, (3) Critical stage approach and (4) combination of soil-crop-climate data.

### **2.9.1 Depletion of available water capacity**

The moisture held between field capacity and the permanent wilting point is generally considered as the

available water for plant. At what point a soil is considered to be at field capacity and has reached permanent wilting point is strongly dependent on the soil texture, salt content, calcium carbonate content, organic matter content etc. As a general acceptable rule water held at a tension of 33 kPa is said to be at field capacity while water held at 1500 kPa tension is said to have reached the permanent wilting point. To what extent the water held between 33 kPa - the so called available water, should be allowed to be depleted has been widely studied and is presented hereafter.

#### 2.9.1.1 Wheat

In a study on the effect of various levels of depletion on the yield of wheat spread over 2 years (1969-1971) it was observed that in soils with coarse to medium texture, maximum wheat grain yield was obtained at 50% depletion while in fine textured soils, irrigating at 25% depletion gave the maximum yield (Anon. 1969-71). Beneficial effect of irrigating wheat at 50% depletion ASM have also been reported by Tripathi and Lal (1982), Singh and Singh (1983 also N & P uptake), Sinha *et al.* (1989, also WUE) and Singh *et al.* (1990 also N content & uptake). Different workers have reported different levels of depletion of ASM, at which wheat yielded significantly higher, these are : at 40% (Singh and Srivastava, 1971), at 20% (Shortriya and

Mishra 1975), at 25% (Reddy and Dakshinamurti, 1976), and at 35% (Sud et al., 1990 also N uptake). Prihar et al. (1978) in a three year study to establish a permissible limit of profile water depletion in soils with loamy sand and sandy loam textures, observed that for sandy loam soil the limit was 17 cm per 180 cm while for loamy sand it was 11 cm per 180 cm soil depth. From the above it is clear that the soil texture in large measure and varietal differences to some extent have a effect on the level of depletion of ASM which can be allowed, to maintain economic yield.

#### 2.9.1.2 Groundnut

In case of groundnut, irrigation applied at 75 per cent ASM (i.e. 25% depletion) has been found to give the highest kernel yield (Lenka and Misra, 1973), oil yield, shelling per cent, oil content and P uptake (Zalawadia and Patel, 1983). Saini et al., (1973) observed irrigation at 50 per cent depletion of ASM to give significantly higher kernel yield, shelling percent and oil content in case of groundnut (cv. M 145, spreading type). Studies by AICRP (Water management) observed 25% depletion (Summer crop), 50% (clayey soil, rabi crop) and 75% depletion (Kharif crop) to give higher yields (Anon., 1971-79).

#### 2.9.1.3 Cotton

Studies on irrigation effects on performance of cotton have also been carried out. Fangmeier and Mohammed

(1977) found irrigation at 50% depletion of ASM to give higher lint yield and good quality fibre. Similar results have been reported (Anon., 1971-79) at Madurai and Rahuri, India. Cull *et al.* (1981) while studying the effect of irrigation scheduling on cotton grown in a climate with uncertain rainfall observed that during an evenly spread rainfall, irrigation scheduling did not cause any significant variation in lint yield, but in case of uneven rainfall, cotton can tolerate depletion upto 70 per cent of ASM without adverse effect on yield. Similar effects have been reported (Anon., 1971-83) in Tamilnadu and Karnataka, India. Investigating the effect of over irrigation when 100, 60 and 20 mm water was depleted from 0-90 cm soil layer, de Bruyn (1982) concluded that maximum lint yield could be attained from normal irrigation throughout and that similar yields could be attained from plants experiencing moderate over irrigation after on set of flowering. However, at Hissar, India maximum yield was attained at 25% depletion of ASM (Anon., 1971-83).

#### 2.9.1.4 Pearlmillet

Studies on the effect of irrigating pearlmillet (Bajra) at different levels of depletion of ASM have also been carried out at different centres of the AICRP (Water Management). The results have been compiled and reported by Prihar and Sandhu (1987). The influence of soil texture is

apparent from the results reported. In clayey soils, maximum yield was obtained at 75% depletion while for sandy loam and loam it was 50% and 25%, respectively.

#### 2.9.1.5 Mustard

Studies on the effect of level of depletion of ASM on mustard have been also carried out and the results have been compiled and reported by Prihar and Sandhu (1987). In sandy loam soil at Karnal, Haryana *Raya* crop gave good yield at 75% depletion but in clayey soils of Navsari, Gujarat mustard crop gave good yields when irrigated at 40% depletion level.

#### 2.9.2 Irrigation based on IW/CPE ratio

The ratio between the fixed amount of irrigation water (IW) and cumulative open pan evaporation (CPE) minus rain since previous irrigation, is a practical and innovative approach evolved by Prihar *et al.* (1974) at Ludhiana, Punjab. Since its evolution most of the irrigation scheduling research on virtually all crops throughout the country has been carried out using this approach. There is therefore no dearth of literature on this approach and hence only some of the important findings are included.

### 2.9.2.1 Wheat

Prihar *et al.* (1974) on the basis of 2 years study on sandy loam soils in wheat concluded that irrigating the crop with IW/CPE ratio of 1.0 constant throughout the growth period gave highest grain yield. In a further study on comparison of irrigation based on IW/CPE ratio with irrigation at important growth stages, Prihar *et al.* (1976) concluded that irrigating wheat at IW/CPE ratio of 0.75 irrespective of growth stages yielded as much as five irrigations at five growth stages and needed 12 cm less irrigation water in addition to greater WUE. Jalota *et al.* (1979, 1980) compared the efficiency of irrigating wheat at IW/CPE ratio of 0.75 on sandy loam calcareous soils to which light and heavy presowing irrigations were given and concluded that for IW/CPE ratio of 0.75 to be effective, a heavy presowing irrigation is essential. Prihar and Sandhu (1987) have compiled the experimental results of studies conducted at various centres of the AICRP (Water Management) based on IW/CPE concept and have concluded that the optimum ratio for most of the centres was 0.9; while, for heavy black clay soils at Indore and Rahuri it was 1.05. In medium black clayey soils of Saurashtra, Gujarat, Bhaliya *et al.* (1983) obtained significantly higher yield of wheat grain at IW/CPE ratio of 1.2 than that obtained at 0.6 or 0.8. Singh *et al.* (1986) compared different IW/CPE ratios under normal and low rainfall years and found IW/CPE ratio of 0.75 and

0.9 to give maximum wheat grain yield and WUE under normal and low rainfall years, respectively. In a study on the effect of irrigating wheat with different IW/CPE ratio from 0.8 to 1.2 on sodic clayey soils, Gupta *et al.* (1990) found highest grain yield while irrigating with ratio of 1.2 with 30-to-50 mm water per application. In sandy loam soils at Morena (M.P.), Khan *et al.* (1990) found no statistically different yields of wheat when irrigated with IW/CPE ratios of 0.75, 0.95 and 1.15. This, they attributed to good winter rains and good capillary conductivity of the soils. Rathore *et al.* (1991) utilized different IW/CPE ratios to irrigate wheat on sandy loam soils at Srignaganagar, Rajasthan and found IW/CPE ratio of 1.0 to give highest grain yield and uptake of N, P and K. In deep clayey soils of Chambal command, Yadava (1991) found that irrigating wheat at IW/CPE ratio of 0.6 as compared to 0.4 and 0.8 resulted in greatest uptake of N,P and K. Patel and Upadhyay (1993) used higher IW/CPE ratios of 0.8, 1.2 and 1.6 for irrigating wheat grown on sandy loam soils at Anand and found that the ratio of 1.6 gave significantly higher grain yield than 0.8. Irrigating wheat with IW/CPE ratio of 0.6, 0.8 and 1.0 grown on sodic soils (pH 9.2, ESP 38), Sharma (1994) found that in both the years of study (1986-88) the ratio of 1.0 gave the maximum WUE of 6.49 and 6.55 kg mm<sup>-1</sup> for 1986-87 and 1987-88 respectively. Ashok Kumar *et al.* (1995) further increased the IW/CPE ratio to 1.2 to irrigate wheat on the above

mentioned sodic soil and obtained better yield and N uptake in grain and straw than the other ratios tried.

#### 2.9.2.2 Pearlmillet

Experiments conducted at various centres of AICRP (Water Management) on irrigating pearlmillet based on IW/CPE ratio, revealed that for *kharif* (monsoon) crop a ratio of 0.6 was the best at Rahuri, while for *rabi* (winter) crop the ratio of 0.8 was the best at Hyderabad (Anon., 1971-83).

In pearlmillet, Iruthayaraj and Sennaiyan (1984) in Tamil Nadu, found a IW/CPE ratio of 0.5 to give maximum grain yield in *kharif* (monsoon) which accounted for 280 mm of water use applied through 7 irrigations. Patel *et al.* (1994) at Anand, Gujarat, used several IW/CPE ratios (0.5, 0.7 and 0.9) in summer pearl millet and found a ratio of 0.9 to give maximum grain and straw yields. Using several IW/CPE ratios (0.6, 0.8 and 1.0) in summer season pearl millet grown on clayey soils in south Saurashtra region of Gujarat, Vyas *et al.* (1994) found a ratio 1.0 to give maximum of grain and straw yields, WUE and N and P uptake.

#### 2.9.2.3 Cotton

The experiments conducted at different centres of AICRP (Water Management) for irrigating cotton based on IW/CPE ratio, revealed that at Dharwad a ratio of 0.6, at Hyderabad a ratio of 0.9; and a ratio of 0.8 at Rahuri,

Bhavanisagar and Srirangaganagar centres was the best (Anon., (1971-83).

Pandyan and Iruthayaraj (1991) used IW/CPE ratios under abundant and limited supply of irrigation water to cotton (cv. MCU-9) in Tamil Nadu. They found a ratio of 0.4 to be the best under adequate water availability while under limited water supply a ratio of 0.3 was the best, albiet it did cause a slight decrease in yield. Investigating the effects of applying irrigation water to cotton at rates corresponding to 0.7, 0.9, 1.1 and 1.3 times the ETC, Ayars *et al.* (1991) observed that applying irrigation far in excess of the ETC often resulted in poor yields due to excessive vegetative growth. Singh and Suraj Bhan (1993) at Kanpur, India based irrigation to cotton on CPE and observed that maximum lint yield was achieved when irrigation was initiated at 80 mm CPE.

#### 2.9.2.4 Groundnut

The results of experiments conducted at various centres of AICRP (Water Management) on groundnut revealed that for *kharif* (monsoon) season, a ratio of 0.6 was the best in Kharagpur while at Rahuri the best ratio was 0.4. In case of *rabi* (winter) season, the ratio of 0.6, 0.9 - 1.0 and 1.2 were the best for Bhavanisagar, Kharagpur and Hyderabad and Cheplima, respectively. For summer crop the

ratio at Navsari was 0.9 while at Parbhani it was 1.2 (Anon. 1971-83). In their studies on the effect of irrigating groundnut during summer, based on cumulative pan evaporation (CPE), Birajdar and Ingle (1979) observed irrigation at 100 mm CPE to be optimum for groundnut grown on medium black clay soils. Gajera and Patel (1984) using different IW/CPE ratios to schedule irrigation to summer season groundnut found a ratio of 0.8 to give yield (25.39 q/ha) which was on par with that achieved using a ratio of 1.0 (27.69 q/ha). However, Kachot *et al.* (1984) found ratios of 1.0 and 1.2 (22.5 and 23.1 q/ha, respectively) to yield significantly higher groundnut kernel as compared to the IW/CPE ratio of 0.8 (20.8 q/ha). While scheduling irrigation to groundnut based on cumulative pan evaporation (CPE), Reddy (1984) observed that application of 2 cm water at CPE of 9 cm resulted in maximum kernel yield than the other depths of application (4, 6 and 8 cm). Irrigating groundnut grown during the summer on deep black clay soils at Navsari, Gujarat, Desai *et al.* (1985) found the IW/CPE ratio of 0.7 to result in the highest WUE (4.58 kg/ha/mm). Rao and Singh (1985) combined the IW/CPE ratio with critical stage in *kharif* (monsoon) grown groundnut. Irrigation at pegging stage gave increased pod yield by 145, 122.6 and 87.5 % over control, only one irrigation at 70 % pegging and irrigation at 0.8 or 0.6 IW/CPE ratio. Also the oil yield was the highest under this irrigation schedule. Ravikumar *et al.*

(1985) irrigated *rabi* (winter) season groundnut at Hyderabad, under various IW/CPE ratios and achieved highest pod yield (28.1 q/ha) when a IW/CPE ratio of 0.9 was maintained throughout the growth period. Using irrigation schedule to summer season groundnut based on different IW/CPE ratios of 0.6, 0.8 and 1.0, Jaggi and Bisen (1986) observed appreciably higher pod yield (20 q/ha) under the ratios of 0.8 and 1.0, and so also the irrigation interval under 0.8 ratio were suitable. Similar results have been found by Patel *et al.* (1988) at Junagadh, Gujarat and Thorat *et al.* (1988) at Dapoli, Maharashtra. Irrigated peanuts grown at South Suwalesi, Indonesia, receiving water based on 35 and 70 mm pan evaporation and were found by Prabowo *et al.* (1990) to yield significantly higher (3 fold), as compared to rainfed peanuts. The yields among the pan evaporation treatments however were on par.

#### 2.9.2.5 Mustard

Studies on irrigation scheduling to mustard based on IW/CPE ratio have been carried out at various centres of AICRP (Water Management). The results revealed that mustard yielded the maximum when irrigated at a ratio of 0.3 at Hisar, Haryana; 0.8 at Pusa, Bihar and Roorkee in U.P.; 0.6 at Kharagpur, West Bengal; 1.05 at Madhupura, and 0.4 at Jobner in Rajasthan (Anon., 1971-1983). Uptake of P by grain and both N and P by the plant were reported to be the

highest by Khan and Agarwal (1983) when mustard was irrigated at IW/CPE ratio of 0.4 or 0.6 than that by rainfed, at Hisar, Haryana. Results of 3 years study on irrigating mustard using IW/CPE ratio, at Junagadh, Gujarat, revealed that a ratio of 0.8 gave the highest seed and straw yield (Malaviya et al., 1988). Similar effect of 0.8 IW/CPE ratio on yield and oil content have been reported by Prasad and Eshanullah (1988, 1990) at Pusa, Bihar, Singh and Dixit (1989) at Faizabad, U.P. and Patel et al. (1989) at Navsari, Gujarat. At Pantnagar, Sharma and Arvindkumar (1988) found greatest seed yield and N uptake by mustard when irrigated at IW/CPE ratio of 0.6 than that at a ratio of 0.4. Sharma and Arvindkumar (1991) while irrigating mustard at different phenological stages and IW/CPE ratio of 0.4 and 0.6 found that as the frequency of irrigation increased seed yield also increased. Similar results were reported by Jadhav and Singh (1993), Sharma et al. (1994), Dobariya and Mehta (1995) and Pramanik et al. (1995). Jadhav et al. (1995) irrigated mustard at different phenological stages and at 60, 80, 100 mm CPE and found irrigation at phenological stages to yield significantly higher than irrigating at 100 mm CPE, while it was at par with irrigation at 60 and 80 mm CPE.

Comparing different genotypes of Toria (*Brassica* spp.) for effect of irrigation at different cumulative pan evaporation values, at Hisar, Haryana, Raja and Bishnoi

(1988) observed no effect on oil content, but oil yield was higher at 150 mm CPE value than 200 CPE value. In south eastern Australia, Wright *et al.* (1988) found that irrigating rapeseed (*Brassica napus*) at 50 mm CPE gave higher seed yield, oil content and oil yield but lower N concentration in all plant parts, as compared to no irrigation.

#### **2.9.2.6 Pigeonpea**

Response of summer pigeonpea to different irrigation schedules was studied by Rana and Malhotra (1989) at Ludhiana, Punjab. They found that irrigating pigeonpea 2 and 3 weeks after sowing (WAS) with subsequent irrigation at CPE of 100 and 150 mm gave significantly higher yields than when irrigation was given at a CPE of 200 mm. At Navsari, Gujarat, Patel and Patel (1994) observed that at 0.25, 0.5 or 0.75 IW/CPE ratio yields of pigeonpea were at par but were significantly higher than rainfed crop and the ratio of 0.25 was the most beneficial schedule.

#### **2.9.3 Irrigation Based on Critical Stage Approach**

When water is adequate and the soil does not offer any limitations to crop growth, frequent irrigation can give good yields of crops and utilize the precious inputs, like good seed and fertilizers, most efficiently. However, when water is inadequate or the soil suffers from limitations of

depth, accumulation of salts or any other unfavourable soil condition, application of water should be restricted. It is under these conditions that the concept of irrigating crops during its critical stages comes into play. Every crop has certain phases during its growth period which are critical, during which any imbalance in inputs may cause serious loss of yield. This concept is also useful when growing rain dependent crops, and in case of failure of rain during any of the critical growth stages, supplemental water can be applied to prevent serious decline in yield. This section deals with the findings of various workers who have used the concept of irrigation during critical stages of crop growth.

#### 2.9.3.1 Wheat

The important growth stages in case of wheat are the crown-root initiation (CRI), the tillering (T), the jointing (J), the milk formation (M) and dough (D) stages. Results of a 3 year study carried out at centres of AICRP (Water Management) at Hisar revealed that maximum grain yield in wheat can be achieved when irrigated at CRI, F, M and D stages (Anon., 1971-1983). Chauhan *et al.* (1970) have indicated the important stages i.e. days after sowing (DAS) in wheat when one to five irrigations are to be given. Singh *et al.* (1971) studied the effect of irrigating tall wheat at critical stages on yield and uptake of N and P and found irrigation at the 4 stages (T, J, F and M) to give higher

yields but uptake of N and P was not significantly affected. Tomar and Singh (1971) concluded that in absence of pre-flowering irrigation, post flowering irrigation was meaningless and for achieving higher yields over control one pre-flowering irrigation is essential. Studying the effect of the time of first irrigation, Singh and Singh (1973) found that irrigation at 21 DAS was necessary to achieve higher yields when combined with irrigation at other critical stages. Similar beneficial effect of timing of first irrigation (21 DAS) have also been reported by Singh et al. (1975) in heavy soils of Tarai in U.P.; Pal et al. (1979) in Bundelkhand region; as well as by Singh (1979); Krishna Murari and Pandey (1982) and Reddy and Bhardwaj (1982). Comparing the effect of irrigating wheat at a constant tension of 0.6 atm with that at different critical stages on yield, content and uptake of N, P and K, Reddy and Bhardwaj (1983) observed yield and uptake of N, P and K in grain and straw to be highest when irrigated at 0.6 atm; while the content of N and P in grain and that of K in grain as well as straw was higher when one irrigation was given at CRI (21 DAS) stage. Sharma and Bhardwaj (1983) concluded that the concept of irrigating at critical stages in wheat is effective only in absence of rain during any of these stages. Similar observations were also made by Raghu et al. (1984). Patel and Patel (1985) while investigating the causes of mottling in wheat grain, observed irrigation at

21 DAS to significantly reduce the mottling percentage as well as cause 40 per cent increase in grain yield. Sharma (1984) found that the concept of irrigating at critical stages was more effective in wheat than in pea and mustard. The effect of irrigation scheduling to wheat grown on sodic soils was studied by sharma *et al.* (1990). These workers found irrigation at 3 critical stages to be most beneficial for higher yield and WUE. Under shallow water table conditions Jhorar *et al.* (1991) found yields to increase significantly only upto 2 irrigations. Under limited water supplies where conflicting demands among urban and rural users becomes acute, MacMaster *et al.* (1994) found irrigation at late jointing to be most beneficial. In rice-wheat sequence on soils of high water storage capacity, Dhyani *et al.* (1994) found that irrigation at CRI (21 DAS) is dependable. Pal *et al.* (1996) found that irrigating wheat at CRI, mid tillering (MT), boot (B) and milk stages (M) gave the highest yield (3187 kg/ha) and WUE (9.2 kg/ha/mm).

#### 2.9.3.2 Cotton

Ahlawat (1973) found that irrigating cotton with 6 irrigations (one at flowering, 4 between flowering and boll development and 1 at boll ripening) gave the highest lint yield. Similarly, Marani and Levi (1973) found regular irrigations in cotton to give higher yield over no irrigation or heavy irrigations.

### 2.9.3.3 Groundnut

Investigating the effect of irrigating *kharif* groundnut, Bhan and Khan (1979) observed that in years of good rainfall one irrigation at pod filling stage gave the highest yield while in years of poor or uncertain rainfall, irrigation at the designated critical stages gave higher yields. Singh *et al.* (1994) found that irrigating *kharif* groundnut at vegetative, flowering, pegging and pod development stages gave the highest pod and haulm yield, WUE, oil content and P uptake.

### 2.9.3.4 Mustard

Response of mustard to irrigation at flowering and flowering and seed setting stage over no irrigation was studied by Bhati and Rathore (1982). They observed that 2 irrigations gave higher yield, oil content and oil yield, and N content and uptake, in stover. Similar effect of higher frequency of irrigation on yield, oil content and oil yield of mustard have been reported by Suraj Bhan and Khan (1982), Samui *et al.* (1986); Saran and Giri (1986). However, Ramani *et al.* (1995) found irrigation to mustard at branching, flowering, anthesis and siliqua formation to give maximum seed yield and consumptive use, though WUE decreased. Praveenkumar *et al.* (1996) found irrigation to mustard at 35 DAS to give highest seed yield. However, oil content and protein content were higher under no irrigation.

Similar effect of irrigation on yield, oil content, protein content and seed yield have been reported by Yadav *et al.* (1996) when irrigated during flowering and siliqua formation.

## 2.10 Irrigation Schedule for Shallow Water Table Conditions and Effect on Crop Performance

One of the earliest resultant problems in areas receiving irrigation water through the canal network is probably that of rising water table. This is all the more encountered in areas in proximity of the canal and those downstream. Management options that are available under such situations could be any of the these (i) delaying irrigation or restricting irrigation altogether, (ii) changing the crop sequences to include crops that can tolerate excess water or requiring less water, (iii) changing the method of irrigation from flooding to some other technique i.e. sprinkler or drip etc. Since the problem of a rising water table is becoming increasingly prevalent, various workers have addressed to this problem in a scientific manner to find a relatively lasting and economic solution. The work of such researchers is presented in the following section :

Follett *et al.* (1974) studied the effect of irrigation applied to corn, sugarbeets and alfalfa grown on shallow (92 and 69 cm), medium (166 and 145 cm) and deep (186 and 193 cm) water table. Irrigation was applied at 0,

0.5, 1.0 and 1.5 times the ET. At the end of each season (1971 and 1972) water table declined by 94 and 69 cm. No response was observed to irrigation on shallow water table, but all the crops responded to irrigation in medium and deep water table conditions.

Kruse et al. (1993) studied the effect of shallow saline water table on the irrigation requirements of corn, alfalfa and winter wheat. The water table was at depth ranging from 0.6 and 1.05 m. The amount of seasonal ET contributed by underground water increased as the level of water table rose and that irrigation requirements also reduced as the depth of water table decreased.

Comparing the effect of irrigation applied through sprinklers at the rate of 0 (precipitation only), 0.5, 1.0 and 1.5 times the ET, to corn, sugarbeet and alfalfa grown on shallow, medium and deep water table, Benz et al. (1978) observed maximum WUE for all crops grown on shallow water table without irrigation. Response to irrigation grown over deep water table increased with increase in irrigation amounts, but never equalled those of the crops grown on shallow water table without irrigation. In a lysimeter experiment with alfalfa grown with four different water table depths (46, 101, 155 and 210 cm), and surface irrigations applied which in combination with received rainfall equalled 0.3, 0.8 and 1.3 times the ET, Benz et al.

(1984) observed that at the shallowest water table depth yields of alfalfa were depressed and ET was excessive. At other depths water from underground water table contributed 38.4 % of the total ET at the lowest level of irrigation (1.3 times ET) Alvino and Zerbi (1986) conducted field studies to obtain data on the effect of water table on grain maize grown in rainfed and irrigated conditions. The data showed that grain yield decreased as water table depth increased with the change being more rapid in rainfed than irrigated conditions.

Shih (1986) studied the ET and WUE of sorghum grown under shallow, medium and deep water table conditions and observed ET and WUE to be inversely related to water table depth and yields increased as the water table depth increased.

On a sandy clay loam soil with water table fluctuating between 43 and 67 cm, Chaudhary and Pandey (1975) observed no response by wheat to one irrigation at CRI as against no irrigation.

Wheat root growth and seasonal water use as affected by irrigation under shallow water table conditions have been studied by Tripathi and Mishra (1986) on clay loam, silty clay loam and loam soils. These workers observed root length density and depth of root penetration to be greatest in the loam. Avoiding irrigation at late jointing stage caused shifting of the zone of peak density downwards

and concentration of roots near water table both in the clay loam and the silty clay loam. Contrary to this, irrigation at late jointing, and late jointing and milk stages produced deepest root system in the loam. Roots followed the receding water table. ET was affected by number of irrigations and water table depths. Water table contribution ranged from 61.6 - 64.5 % of total ET in clay loam, and 39 - 46.8 % of total ET in loam. Yield was significantly higher in the treatments with scheduled irrigation at CRI and late jointing stages in the clay loam and silty clay loam and at CRI, late jointing and milk stages in the loam. Tripathi *et al.* (1989) studied the irrigation requirements of wheat grown on clay loam, silty clay loam and loam soils with shallow water table depths. These workers found that irrigating wheat at CRI in clay loam soils (WT 0.4 to 0.8 m) and at CRI and flowering stages on silty clay loam and loam soils (0.66 to 1.4m and 1.8 to 2.4 in resp) were similar to those obtained by 5 irrigations. WUE and yield were higher in silty clay loam and loam soils as compared to clay loam soils.

Irrigation requirements of wheat grown over shallow water table depth between 0.36 to 0.55 m was studied by Yadav *et al.* (1995). The yield of wheat with one irrigation at CRI was on par with two irrigations at CRI and milk stage, while increasing the irrigation frequency caused yields to decrease.

In a study conducted on growing cotton under water table conditions, Bradford and Latey (1992) found that under freely drained soils, irrigation should be applied to the extent to prevent deep percolation losses, while under water table conditions a heavy pre irrigation water application can cause salt leaching while low water application during crop growth will reduce the extent of rise. These workers also concluded that high cotton yields can be achieved for several years as long as irrigation is applied enough to equal ET losses.

## **2.11 Planning Regional Needs For Irrigation**

With more and more area coming under irrigation as a result of implementation of various levels of irrigation projects viz., major, medium and minor, it is becoming increasingly realized, that for greater equity in the distribution of water leading to greater efficiency, there is a need for estimating accurately the amount of water requirement. Such an estimate will give information needed to those involved in distribution of available water in a manner that will reduce incidences of over irrigation or under irrigation. It is also quite essential, that estimates of water requirement be based both on long term and short term needs. Also it is necessary to acknowledge that both these needs, though different cannot however, be dealt with in isolation. Short term needs are generally taken to be the

water requirements during the crop life in any given season. Such estimates when available will help in day to day work on the farm and enable the soil moisture deficit to be kept within acceptable limits. The earliest such concept was developed by Penman (1948), followed by models developed by several other workers viz., Thornthwaite (1948), Blaney and Criddle (1950); Jensen (1966); Pruitt (1966); Doorenbos and Pruitt (1977); Hargreaves (1974) and Hargreaves and Samani (1982). Each method has different data requirement and claims advantage under a set of climate conditions. The choice of method is purely a matter of selection depending upon the availability of data. The following is a brief account of the work done by several researchers in the field of estimating the regional needs of irrigation, carried out the world over and in our country.

Hogg (1969) while estimating the long term irrigation needs of England and Wales concluded that long term irrigation needs computed through water balance sheets when combined with plant and soil data, gave reasonably accurate estimates of long term irrigation needs. David and Hiler (1970) developed a continuous soil moisture accounting model based on soil moisture depletion equations and concluded that where root zone seepage errors are negligible ET estimates can be used to predict soil moisture depletion. Combining the ET data, soil moisture depletion and data on rainfall probabilities, long range irrigation planning was

found to be feasible by these workers. Assessment of long term irrigation need by integrating the data on soil and crop characteristics and climate, was carried out by Dent and Scammell (1981). These workers concluded that it is possible to calculate the frequency of irrigation need of a region, inspite of differences in soils and crops grown. Evaluating the use of crop growth simulation models for irrigation practices, Kandu et al. (1982) concluded that a properly structured plant growth simulation model which takes crop variety, soil and climate into account, can be successfully used to quantify the effects of irrigation practices on crop yields. Such models can also be an aid in making important water management decisions like optimum moisture depletion and replenishment levels and timing and amount of irrigation during different crop growth stages. Tsakiris and Kiountouzis (1982) described a procedure to derive the optimal irrigation policy (timing and depth) which will minimize the total cost per unit time during each stage in the growing season of a single crop. While modeling water demands of irrigation projects, Maidment and Hutchinson (1983) first estimated the per unit area irrigation demands for each identified unique combination of soil, crop type and irrigation strategy using daily soil moisture balance simulation over a number of seasons of recorded climate data. These were then combined with crop areas and estimated application efficiency and then applied

to demand estimates for a large project. Swaney *et al.* (1983) while studying the impact of weather characteristics on irrigation decisions in case of soybean concluded that estimates can be improved by using historical data of more than 20 years and that estimates for one region cannot be extrapolated to other regions differing in climate, crops or soils. A water balance model was developed by Chesness *et al.* (1986) to predict the seasonal irrigation requirements of coarse textured soils. These workers found the mean absolute difference between predicted and seasonal irrigation water requirements to be 16 per cent. These workers expressed the irrigation requirements in terms of probabilities. Chhabda *et al.* (1986) made a comparison between the modified Penman and the Hargreaves and Samani (1982) methods for computing reference crop evapotranspiration which is used as a basis of estimating crop water requirements. These workers concluded that the Hargreaves and Samani (1982) method which requires only data on temperature is as accurate as the modified Penman method and can be used for estimating crop water requirements of irrigation projects. Hargreaves and Samani (1987) used only temperature data to estimate potential evapotranspiration of crops as a measure of water requirements in El Salvador and emphasized the need for developing simplified procedures for scheduling irrigation in irrigation projects of tropical countries so that such simple technique can be easily

adopted by farmers of low reference levels of these regions and thereby minimize the risk of failure of irrigation projects in these areas. For simulating the drainage and irrigation response of the Everglades Agricultural Area in South Florida, Melaika and Bottcher (1988) developed a model which incorporated data on potential evapotranspiration, crop water use coefficients and rainfall records. According to these workers their model could prove to be an effective tool for designing, managing and evaluating water management and conveyance system for similar high water table soils and irrigation and drainage systems. A simulation model for irrigation scheduling under variable rainfall was developed by Villalobos and Fereres (1989). The components in the model were rainfall probability, crop ET, evaporation, transpiration and allowable soil water depletion. It was concluded by these workers that the model can be used to develop stochastic irrigation schedules that give dates and amounts for a chosen level of probability of exceedence of soil allowable depletion of moisture. Madsen and Holst (1990) have carried out a nation-wide mapping of irrigation need based on computerized soil and climatic data. These workers used an empirical model with daily values of PET and precipitation as driving variables and developed a relationship between root zone capacity and irrigation need for different climate zones of Denmark and have constructed an irrigation map. In a feasibility study on using Pan

evaporation data for estimation of crop water requirement for designing and operating irrigation systems, Palaskar *et al.* (1990) found good agreement between estimates generated by Pan evaporation and modified Penman technique for ETo, consumptive use, net irrigation requirement (NIR) of crops and peak NIR. These workers therefore recommended the use of the Pan evaporation data in view of its simplicity. Rajput and Michael (1990) developed a water balance model to estimate different parameters of the soil moisture balance and to schedule canal deliveries. They found the model to fix the delivery schedule of the surface irrigation water and in addition also helps in determining the ground water budget of the area as well. A study on regional irrigation water demand using field level estimates was conducted by Gutwein and Lang (1993) in western United States. These workers utilized the crop and water use data of the last 30 years and tried to correlate it with crop acreage and climatic variables using the Blaney-Criddle ET method, but found limited success. These workers suggested to find out whether use of larger data set than employed by them could yield better results. Verheye (1995) has opined that if crop stage, the length of growing season, crop coefficients, the ET of crop and available water capacity of soil are used in tandem, proper irrigation water requirements of any irrigation command can be estimated.

Thus, from the above review of the work carried out elsewhere and in India, it is now clearly established that if accurate estimates of crop water requirements as represented by crop evapotranspiration, and the soil water availability data are available, it is possible to have a regional estimate of the water requirement. Such estimate may prove to be beneficial in proper distribution of water and may prevent the problems of over irrigation leading to greater efficiency of the irrigation scheme.

In the present study available data on climate i.e., rainfall and PET, determined soil available water capacity and likely crop coefficients have been integrated to arrive at an irrigation schedule. Based on the crop water requirement so generated and the available data on crop acerages (crops studied) and the data on net cultivable command area a scheme water requirement is generated. The exact methodology is described in the subsequent chapter.

**MATERIALS  
AND  
METHODS**

## CHAPTER III

### MATERIALS AND METHODS

The present study was conducted with a view to integrate the data on climate (PET-the demand side), soil (Available water capacity - the supply side) and crop (reference crop evapotranspiration, ETC the user side) and arrive at a value of water requirement for the entire growing period of some major crops of all the three growing seasons viz., *kharif* (monsoon), *Rabi* (winter) and summer.

The crops selected were :

1. Groundnut (*Arachis hypogea*)
2. Pearlmillet (*Pennisetum typhoides*)
3. Castor (*Ricinus communis*)
4. Pigeonpea (*Cajanus cajan*)
5. Cotton (*Gossypium hirsutum*)
6. Mustard (*Brassica juncea*)
7. Wheat (*Triticum aestivum*)

The first two were grown during summer (Feb.-May), the next three during the *kharif* (June till March) and the last two during the *Rabi* (Oct. - April) seasons of 1995-1996. The field work was carried out at (1) B.A. College of Agriculture, Agronomy Farm, Anand for groundnut, pearlmillet, cotton and pigeonpea and (2) At Water and Land

Management Institute's Farm, Anand for castor, mustard and wheat crops. The details of each crop viz., variety, date of sowing, date of harvest, seed rate, spacing, fertilizers applied, FYM added etc. are given in Table 3.1. The physical and chemical properties of the soils of both the farms are presented in Table 3.2. As far as fertility is concerned, both the farm soils are of medium fertility, sandy loam in texture (surface), have an alkaline reaction and low in salt content. They have a low organic carbon content and have a good physical condition and good productive potential and can yield good results to all levels of management.

Standard analytical techniques (Jackson, 1979; Klute, 1986; Page, 1982 and Piper, 1966) have been employed for determining the physical and chemical properties of the soils of the farm as well as those collected from different profiles (21) representative of soil family classes within the command (Table 3.3). Similarly, plant samples were digested and their nutrient contents estimated (Table 3.4) as per the standard techniques (Page, 1982). The amount of water retained at tensions from 0 to 1500 KPa have been determined by the pressure plate apparatus available in the WALMI laboratory as per the standard technique (Klute, 1986). The statistical design selected was Randomized Complete Block Design having six treatments of irrigation schedules replicated four times. The statistical analysis procedure followed was as per Chandel (1978), Steele and

Table 3.1 : Details of the crops selected for the study

Crop/Variety	Date of sowing	Date of harvesting	Seed rate (kg/ha)	Spacing (cm)	Fertilizer applied (kg/ha)			FYM t/ha
					N	P	K	
Groundnut GG 2	14.2.95	26.5.95	125	30 x 30	25	50	0	10
Pearlmillet GHB 235	21.2.95	2.6.95	4.0	45 x 45	80	40	0	10
Pigeonpea BDN 2	14.7.95	5.2.96	1.5	90 x 30	25	50	0	10
Cotton GCH 8	26.6.95	21.1.96	4.0	90 x 60	240 (4)	0	0	10
Castor GCH 4	2.8.95	2.4.96	6.0	120 x 60	110 (2)	50	0	Green manured
Wheat GW 496	13.11.95	12.3.96	120.0	30	120 (3)	60	0	"-
Mustard GM-1	19.10.95	16.2.96	4.0	45 x 15	75 (2)	50	0	"-

Figures in parenthesis indicate split application of nitrogen through urea as per recommendation. Yield from each plot was based on yield of net plot after removing the ring line plants. From the net plot yield, per hectare yield was calculated. Plant protection measures, when needed were taken as per recommendations.

Table 3.2 : The physical and chemical properties of the soils of the experimental site.

Parameter	Experimental site at		
	B.A.C.A.	WALMI	
	Agronomy Farm	Agronomy Farm	
	(G.nut, Pearl millet, cotton, Pigeonpea)	Site 1 (Wheat)	Site-2 (Mustard, Castor)
<b>Mechanical Analysis</b>			
% Sand	72.00	72.50	74.08
% Silt	14.54	15.50	7.28
% Clay	13.48	10.00	18.64
Bulk Density $Mg/m^3$	1.40	1.38	1.44
<b>Available Water</b>			
Capacity mm/m	15.50	116.0	155.50
% Pore space	47.17	47.92	45.66
Textural class	SANDY LOAM	SANDY LOAM	SANDY LOAM
<b>Chemical</b>			
pH (1:2)	7.90	7.82	7.99
EC $dSm^{-1}$ (1:2)	0.28	0.22	0.54
Organic Carbon %	0.12	0.20	0.23
CaCO <sub>3</sub> , %	4.75	5.20	-
<b>Cation Ex.Capacity</b>			
C.mol <sup>(p+)</sup> <sub>kg<sup>-1</sup></sub>	14.38	14.50	17.90
Total Nitrogen %	0.03	0.03	0.03
Available P <sub>2</sub> O <sub>5</sub> , kg/ha	22.0	18.00	21.00
Available K <sub>2</sub> O, kg/ha	450.0	460.0	465.00

Table 3.3 : Methods employed for estimating the important soil attributes

Sr. No.	Characteristics	Method employed
<b>A. Physical Properties</b>		
1.	Particle size Distribution (Mechanical Analysis)	International Pipette Method (Piper, 1966)
2.	Bulk density	*Based on weight/volume Method
3.	Moisture Retention	Pressure Plate Apparatus (Klute, 1986)
<b>B. Chemical Properties</b>		
1.	Total Nitrogen	Kjeldahl Digestion and Distillation Method (Jackson, 1979)
2.	Available P <sub>2</sub> O <sub>5</sub>	Olsen et al. (1954) (Jackson, 1979)
3.	Available K <sub>2</sub> O	N N NH <sub>4</sub> O Ac Extn. (Jackson, 1979)
4.	Organic carbon	Datta et al. (1962)
5.	CaCO <sub>3</sub> (%)	Rapid Titration Method (Piper, 1966)
6.	CEC	Bower et al. (1952) (USDA Handbook, 1968)
7.	pH (1:2 Soil:Water extract)	Chopra and Kanwar, 1980
8.	EC (1:2 Soil:Water extract) dSm <sup>-1</sup>	Chopra and Kanwar, 1980

\*Bulk density was determined at 33 kPa tension by calculating the volume the ring and the weight of soil occupying the whole volume of ring.

Table 3.4 : Methods employed for estimation of nutrient concentration in plant samples

Sr.No.	Nutrient	Method
1.	Nitrogen	Kjeldahl Method (Jackson, 1979)
2.	Phosphorus	Vanadomolydate Yellow Colour Method (Jackson, 1979)
3.	Potassium and Sodium	Flame Photometer (Jackson, 1979)
4.	Calcium and Magnesium	EDTA-Versanate Titration Method Cheng and Bray, 1951 (Jackson, 1979)
5.	Zinc, Iron, Copper and Manganese	Atomic Absorption Spectrophotometer method (Page, 1982)
6.	Wet Digestion for P, Ca, Mg, K, Na, Zn, Fe, Cu, and Mn	Diacid mixture of 4:1 HNO <sub>3</sub> -HClO <sub>4</sub> acids (Page, 1982)

Torrie (1960) and Panse and Sukhatme (1967). Stepwise regression analysis was carried out as per Gomez and Gomez (1984). The treatment details are :

Treatment No.	Detail	Depth of water applied (Net)
T1	Irrigation at 30 % depletion of AWC	60 mm
T2	Irrigation at 50 % depletion of AWC	78 mm
T3	Irrigation at 70 % depletion of AWC	108 mm
T4	Irrigation at IW/CPE ratios	
	Groundnut 1.0	60 mm
	Pearlmillet 1.0	60 mm
	Castor 1.0	60 mm
	Cotton 1.0	60 mm
	Pigeonpea 1.0	60 mm
	Wheat 1.0	60 mm
	Mustard 1.0	60 mm
T5	Irrigation at critical stages	60 mm
	Groundnut 25, 40, 55, 65, 80, 91 and 102 DAS	
	Pearlmillet 25, 45, 55, 65 and 80 DAS	
	Castor 30, 60, 90, 120, 150, 180 and 210 DAS	
	Cotton 30, 60, 90, 120 and 150 DAS	
	Pigeonpea 75 and 100 DAS	
	Mustard 45, 60 and 70 DAS	
	Wheat 21, 45, 56, 67, 78, 91 and 101 DAS	
T6	Irrigation as per soil-crop-climate model in case of groundnut, pearlmillet, cotton, pigeonpea, castor, mustard and in case of wheat (50%depletion of AWC)	78 mm (All rest) 58 mm (only wheat)

For the depletion treatments, gravimetric determination of soil moisture at 4 depths i.e. 0-30, 30-60, 60-90 and 90-120 cm, was carried out periodically and when the required depletion was attained, irrigation was initiated. From the other treatments also, gravimetric determination of soil moisture status prior to irrigation was carried out. For the IW/CPE treatment, when the cumulative pan reading (U.S. class A open pan evaporimeter with wire mesh lid) reached to meet the recommended ratio, irrigation was initiated. For the critical stages approach, irrigation was applied on the day the designated critical stage was reached.

These five irrigation schedule methods were compared with the proposed soil-crop-climate model. The approach and the basic equation adopted is explained in the following manner.

### 3.1 APPROACH AND BASIC EQUATION

Numerous studies have shown that under nearly adequate water supply conditions the total water evaporated from planting to harvest for a given crop is almost same on all soils under similar climatic conditions (Tripathi, 1985). The quantity of water, usually expressed as volume per unit area is called seasonal ET. Direct measurement of daily Et is not only difficult but costly. However, ET can easily be determined through appropriate models such as

Hargreaves and Samani (1982) and the crop growth stage coefficient (Kc). Hargreaves and Samani (1982) after numerous studies on comparison between ETo data and several equations concluded that the results predicted from climatological data, limited only to radiation and temperature closely approach the ETo (reference evapotranspiration) given by lysimeters. The original relationship suggested by Hargreaves (1974) related ETo to Rs and temperature as :

$$ETo = 0.0075 \times Rs \times T^{\circ}F \dots \dots \dots (1)$$

Where, T<sup>°</sup>F is the mean air temperature in degree Farenheit and Rs is the solar radiation reaching the earth expressed in mm day<sup>-1</sup>. <sup>The</sup> ETo is also expressed as mm day<sup>-1</sup>. However, measured data for Rs are normally not available. Relationship between Ra (which is almost independent of the variations in climate) and Rs was developed as :

$$Rs = Kt \times Ra \times TD^{0.5} \dots \dots \dots (2)$$

Where, Kt = a calculated coefficient

Ra = extra terrestrial radiation mm day<sup>-1</sup> and Td is the difference in mean maximum and mean minimum temperature in °C

The values of Kt are higher near ocean, due to the moderating effect on the temperature range and are approximately the same for plains, plateaus and large valleys and tend to be low in high mountain valleys.

Combining the above two equations, the equation developed by Hargreaves for universal application is :

$$ET_o = 0.0023 \times R_a (T^{\circ}C + 17.8) \times TD^{0.5} \dots \dots \dots (3)$$

Where,

$ET_o$  = Reference crop evapotranspiration, mm day<sup>-1</sup>

$R_a$  = Extra-terrestrial radiation, mm day<sup>-1</sup>

$T^{\circ}C$  = Mean temperature in degree centigrade

$TD$  = Difference in maximum and minimum temperature in  $^{\circ}C$ .

The equation is comparatively very simple and requires only temperature data apart from the latitude. The temperature data are normally available. The equation claims to be superior to many other equations at least for interior locations in the plain topography where the growing season of the crops are frost free.

It is because of the relative simplicity of the equation, that it is proposed to be adopted in the State (Sheikh, 1989) and is being adopted in the present study. The PET values for the meteorological stations in the command area as computed and documented in the report (Sheikh, 1989) have been used as component of the demand side of the proposed model. A comparative study of  $ET_o$  calculated by the modified Penman method (Doorenbos and Pruitt, 1977) and the Hargreaves and Samani (1982) for data

collected over 24 years in Maharashtra State (Anon., 1988) have showed a very close similarity with a mean ratio between these two equations being 1.11.

Jensen (1973) has opined that in areas where cloud cover is not strongly influenced by local orographic features, measurements of  $R_s$  at a single observatory may be used for irrigation scheduling purposes over large areas (100-200 km in diameter) without significant error. Similar observations have been made subsequently by Trimmer (1980) and Hashmi *et al.* (1995).

Thus, these observations go in favour of calculating PET by Hargreaves and Samani (1982) method which was used in the present study.

### 3.2 SOIL WATER BALANCE

The availability of soil water during the course of crop growth determines largely its yield. Soil water availability depends on rainfall, potential evapotranspiration, the type of soil and crop water use. Differences in soils, especially with regard to moisture storage and release characteristics (Available water capacity) strongly influence the crop growth and the need for supplemental water during periods beyond the rainy season. The frequency and the quantity of water that needs to be applied is also strongly governed by the available

water capacity characteristics of the soils. Thus, a study of soil water balance is prerequisite in planning irrigated farming for optimum irrigation water use.

In the present study water balance is computed on the assumptions that - (1) the soil has complete crop cover during the period of computation and (2) the run-off or deep drainage can occur only after the maximum soil water storage capacity is satisfied. The second assumption in most cases is applicable only during the monsoon season computations.

The soil water storage at the point of time when irrigation need arises is the cumulative depletion of soil moisture (Wd) from the previous date of field capacity or date of sowing (first irrigation after sowing) to the date and can be calculated as :

$$Wd = \Sigma Et - \Sigma Re \text{ or } \dots \dots \dots (4)$$

$$Wd = \Sigma Et = Wo \dots \dots \dots (5)$$

Where,

$\Sigma Et$  is the cumulative evapotranspiration, in mm

$\Sigma Re$  is the effective rainfall representing portion of the rainfall retained in the root zone replenishing soil moisture deficit, in mm

$Wo$  = allowable available soil moisture depletion, mm

Number of days till next irrigation (N) was estimated using average Et for the preceding three days as :

$$N = Wo - Wd/Et \dots \dots \dots (6)$$

$W_o - W_d$  is the difference between the allowable soil moisture depletion ( $W_o$ ) and cumulative soil moisture depletion ( $W_d$ ).  $W_d$  is 0 after irrigation or adequate rainfall :  $N = W_o/E_t$ .

### 3.3 CROP COEFFICIENTS ( $K_c$ )

The Hargreaves and Samani method (1982) like all other climatological methods predicts the value of  $E_{To}$  i.e. the reference evapotranspiration per day. The evapotranspiration of any crop ( $E_{Tc}$ ) is related to the  $E_{To}$  by :

$$E_{Tc} = E_{To} \times K_c \dots \dots \dots (7)$$

Where,  $E_{Tc}$  is the reference evapotranspiration of crop in  $mm \text{ day}^{-1}$  and  $K_c$  is the crop coefficient. In the present study in absence of actual measurement or availability of measured  $K_c$  values, the  $K_c$  values for the crops studied have been selected taking into consideration the local climatic conditions. The values of  $K_c$  so assumed for the different stages of crop growth are given in table 3.5. Thus, it is apparent from table 3.5 that the gap between two irrigations is wider for the initial and last stage of growth while it narrows down considerably during the middle growth stages, corresponding to the grand growth stage. The cumulative  $E_{Tc}$  value when equals the allowable depletion, which in the present study was 50 per cent the available water capacity

Table 3.5 : Crop coefficients (Kc) for the selected crops for different stages of crop growth (number of days) at RH > 20 % but < 70 % and wind speed 3-6 m sec<sup>-1</sup>. (Values of Kc are adjusted according to local climatic conditions)

Crop	Stage of growth				Duration (Days)
	I	II	III	IV	
Pearl millet	(0-15) 0.8	(16-40) 0.8	(41-80) 1.05	(81-105) 0.9	105
Groundnut	(0-20) 0.8	(21-40) 0.8	(41-70) 1.05	(71-120) 0.6	120
Pigeonpea	(0-30) 0.50	(31-80) 0.76	(81-140) 1.2	(141-210) 0.7	206
Cotton	(0-30) 0.45	(31-80) 0.56	(81-150) 1.2	(150-210) 0.65	210
Castor	(0-30) 0.70	(31-90) 0.80	(91-180) 1.15	(181-240) 0.7	240
Mustard	(0-20) 0.60	(21-50) 0.80	(51-95) 1.05	(96-120) 0.90	120
Wheat	(0-15) 0.60	(16-40) 0.80	(41-90) 1.10	(91-120) 0.6	115

Source : Doorenbos and Pruitt (1977)

I = Initial developmental stage;

II = Vegetative stage

III = Reproductive stage

IV = Harvest stage-Maturity stage

Figures in parentheses are days after sowing.

(i.e.,  $\frac{1}{2}$  AWC), irrigation was initiated. In the following sections the actual steps in computation are described :

### 3.4 STEPS IN COMPUTATION

1. At the time of sowing, the soil moisture content was determined at 0-30, 30-60, 60-90 and 90-120 cm depths using a soil auger. From this moisture content, the amount of moisture at wilting point (i.e., 1500 kPa) was deducted for each depths and on multiplication of this value with the bulk density and the depth increment (i.e., 30 cms) and their summing up, gave the available water till 120 cm depth. From the total AWC, 50 per cent of the AWC was deducted to obtain the allowable soil moisture depletion until first irrigation or adequate rainfall. The sum of AWC of each 30 cm soil layer to a depth of 1 meter was the total AWC, expressed as mm/m (AWC = Difference between moisture content at 15 kPa and 1500 kPa for all crops and 10 kPa and 500 kPa in case of wheat, as the soil was comparatively coarser in texture).
2. The  $ET_o$  in  $mm\ day^{-1}$  was determined using the Hargreaves and Samani (1982) equation by noting down the daily maximum and minimum temperatures in °C. The value of  $R_a$  was adopted from the tables already available (Anon., 1988, see appendix 3.1). For  $ET_c$ , the values of  $ET_o$  so calculated were multiplied by the  $K_c$  values for the

growth stage. Daily ETC values were summed up till these equalled the value corresponding to the  $\frac{1}{2}$  AWC. For planning irrigation in advance, the moisture content of the soil was determined a week before the probable date. The value was deducted from the value at  $\frac{1}{2}$  AWC. The result was divided by the average ETC value of the preceding three days. The quotient gave the next date of irrigation. Just three days prior to this date, the current allowable moisture depletion value was determined and divided by the ETC value of the past three days to get the exact date of irrigation. Irrigation was initiated on this date. Table 3.6 gives the details of the quantity of water applied through the Parshall flume at an assumed field application efficiency of 90 per cent at 7.0 cm head with a delivery of 2.7 litres  $\text{sec}^{-1}$  through 7.5 cm wide throat.

3. After irrigation or adequate rainfall, moisture content of the soil after it attains field capacity (usually 48-72 hours) was determined and also the ETC was calculated. This ETC value is the starting value of depletion. The steps mentioned above were again repeated to arrive at the next date of irrigation. In the event of rainfall, if the sum total of rainfall and the current allowable depletion value exceeds the total AWC, the excess was considered as the lost to drainage.

Table 3.6 : The quantity of water applied through the Parshall flume of throat width of 7.5 cm and 7.0 cm head delivering 2.7 litres per second.

Treatment	Quantity litres	Time taken	
		Min.	Sec.
Groundnut, Area : 16.29 Sq.mts. AWC 155 mm/m			
T1 = 30 % depletion	1085.4	6	42 i.e. 7 min.
T2 = 50 % depletion	1409.4	8	42 i.e. 9 min.
T3 = 70 % depletion	4723.9	10	48 i.e. 11 min.
T4 = IW/CPE 1.0	1085.4	6	42 i.e. 7 min.
T5 = Critical stage	1085.4	6	42 i.e. 7 min.
T6 = Soil-crop-climate	1409.4	8	42 i.e. 9 min.
Cotton and Pigeonpea, Area : 27 sq.mts AWC 155 mm/m			
T1 = 30 % depletion	1809.0	11	10 i.e. 11 min.
T2 = 50 % depletion	2349.0	14	30 i.e. 8 min.
T3 = 70 % depletion	7873.2	18	0
T4 = IW/CPE 1.0	1809.0	11	10 i.e. 11 min.
T5 = Critical stage	1809.0	11	10 i.e. 11 min.
T6 = Soil-crop-climate	2349.0	14	30
Pearl millet/16.2 sq.mts. AWC 155 mm/m			
T1 = 30 % depletion	1085.4	6	42 i.e. 7 min.
T2 = 50 % depletion	1409.4	8	42 i.e. 9 min.
T3 = 70 % depletion	4723.9	10	48 i.e. 11 min.
T4 = IW/CPE 1.0	1332.0	8	13 i.e. 8 min.
T5 = Critical stage	1085.4	6	42 i.e. 7 min.
T6 = Soil-crop-climate	1409.4	8	42 i.e. 9 min.
Castor, Area : 36 sq.mts. AWC 155 mm/m			
T1 = 30 % depletion	2412.0	14	53 i.e. 15 min.
T2 = 50 % depletion	3132.0	19	20 i.e. 19 min.
T3 = 70 % depletion	3888.0	24	0
T4 = IW/CPE 1.0	2412.0	14	53 i.e. 15 min.
T5 = Critical stage	2412.0	14	53 i.e. 15 min.
T6 = Soil-crop-climate	3132.0	19	20 i.e. 19 min.

Table 3.6 contd..

Treatment	Quantity litres	Time taken	
		Min.	Sec.
Mustard, Area 13.5 sq.mts AWC 155 mm/m			
T <sub>1</sub> = 30 % depletion	904.5	5	35 i.e. 6 min.
T <sub>2</sub> = 50 % depletion	1174.5	7	15 i.e. 7 min.
T <sub>3</sub> = 70 % depletion	1458.0	9	0
T <sub>4</sub> = IW/CPE 1.0	1400.6	8	38 i.e. 9 min.
T <sub>5</sub> = Critical stage	904.5	5	35 i.e. 6 min.
T <sub>6</sub> = Soil-crop-climate	1174.5	7	15 i.e. 7 min.
Wheat, Area : 13.5 sq.mts. AWC 116 mm/m			
T <sub>1</sub> = 30 % depletion	472.5	2	55 i.e. 3 min.
T <sub>2</sub> = 50 % depletion	877.5	5	25 i.e. 5 min.
T <sub>3</sub> = 70 % depletion	1215.0	7	30 i.e. 8 min.
T <sub>4</sub> = IW/CPE 1.0	904.5	5	35 i.e. 6 min.
T <sub>5</sub> = Critical stage	904.5	5	35 i.e. 6 min.
T <sub>6</sub> = Soil-crop-climate	877.5	5	25 i.e. 5 min.

Calculation : Source : Misra and Ahmad (1993)

Equation :  $qt = ad$

where, q = Size of stream, lit/sec.  
t = Time of application (mm/sec.)  
a = Area to be irrigated (sq.mts/ha)  
d = Depth of water to be applied (mm/cm)

The exact procedure to get to the date of irrigation is shown in appendix 3.2.

The moisture content of the soil prior to irrigation, from the plots receiving the IW/CPE, critical stages and soil-crop-climate model based irrigation treatments, was estimated. This value was deducted from the moisture content at field capacity. The difference in moisture content was converted to per cent moisture extracted. This per cent extracted moisture was determined prior to each irrigation application for the treatments mentioned above, summed up and the average value is presented as the moisture extraction pattern from each of the 30 cm layer.

Thus, it is seen from the appendix 3.2, that it is possible to arrive at a fairly accurate date well in advance by using the data of ETC and AWC of the soil.

### 3.5 ASSESSMENT OF IRRIGATION REQUIREMENT BASED ON SOIL-CROP-CLIMATE DATA FOR THE COMMAND (FAO, 1992)

The first step in this direction was the collection of soil samples of widely occurring soil families in the command area. This was carried out by digging pits of size 3' x 6' to a depth of 120 cm or weathered material or rock or root limiting layer whichever is shallower. The morphological characters were identified in the field and

samples from 0-30, 30-60, 60-90 and 90-120 cm were collected in soil sample bags to weigh approximately 1.5 to 2.0 kgs. The samples so collected were air dried and crushed to pass 2 mm sieve and stored for estimation of their physical and chemical properties including AWC using standard laboratory techniques as specified earlier.

Meteorological information of some of the stations in the command area is already available and documented (Sheikh, 1989, see appendix 3.3). The information on crops presently grown in the command area and projected area as per cent occurrence of CCA has been collected and presented (See appendix 3.4, Anon., 1985).

The method of irrigation practiced by the farmers is mostly flood irrigation.

### 3.5.1 Estimation of Crop Water Requirements

The crop water requirements (ETc) for the selected crops which are widely grown in the command area was calculated by the equation described earlier. The Net Irrigation Requirement of the crop is calculated according to the equation :

$$\text{NIR} = \text{ETc} - (\text{Eff Rain} + \text{Run off}) \dots \dots \dots (8)$$

These values have been calculated on standard week basis. For assessing the irrigation requirement of crops

being grown during the *kharif* season, long term data on rainfall, need to be analysed for detecting the likely periods of dryspell and their per cent probability of occurrence (Sheikh, 1989). The data of some of the stations ~~are~~ presented in appendix 3.5. In the present study, actual rainfall data ~~were~~ used to calculate NIR. Appendix 3.6 gives the standard weekwise data on PET and rainfall of the climatic stations of the command. For the *rabi* and summer season crops the NIR is the total crop water requirements less the effective rainfall wherever applicable. Once the crop water requirement values for each of the seven crops selected is arrived at, values for each district of the command, the next step is to calculate the requirement on monthly basis. The exact procedure is described as under :

### 3.5.2 Scheme Water Supply

The purpose of computing the water supply in a command is to determine the periodic irrigation requirement (weekly, monthly) of the command where, on varying areas and for different planting dates, several irrigated crops are grown. The information required for this besides, the crop irrigation requirement for the widely grown crops, is the area covered by each crop which can be expressed either in actual hectareage or per cent cover of the total command area. The actual calculation to compute the irrigation requirement of the command is given below :

### 3.5.2.1 Calculation

From the standard weekwise values of crop evapotranspiration, values of effective rainfall are deducted. The value arrived after such deduction is the net irrigation requirement which is also standard weekwise. Such calculations are carried out for each of the seven crops for each of the 12 districts falling under the command. Then the standard weekwise values of the net irrigation requirement is converted to monthly values for each crop. These values are then tabulated as monthly crop water requirements, for all crops of the district. Once this information is ready, the next step is the calculation of the monthly relative irrigation requirements for each crop in the district. For this the previously computed monthly values are converted to daily values by merely dividing the monthly value by the number of days in a particular month. The daily value so arrived at is then multiplied by the per cent area covered by each of the crop (Anon., 1985). First the per cent area is converted to its relation with 1.0. Thus, for example pearl millet covers 3.5 per cent (as summer crop) of the whole command. Its relative value (in comparison to 1.0) becomes 0.035. The relative irrigation requirement values are calculated by multiplying the daily crop water requirement values with the relative per cent area covered by a particular crop. This gives the monthwise relative irrigation requirements for each of the crop which is

tabulated thus. The monthly relative irrigation requirement values totalled over the crops gives the total ha-mm day<sup>-1</sup> value for that particular month. In this way the total mm day<sup>-1</sup> value for each month of the year (Jan.-Dec.) are computed. This value multiplied by the number of days of the month gives the total ha mm month<sup>-1</sup> value for each month of the year. The total daily ha-mm/day value for each month is then converted to litres/second/hectare by first converting the ha/mm values to litres/day and dividing this value by 86400 seconds, the litres/second/hectare value is arrived at. During each month, a definite percentage of area (corresponding to the area covered by the crops in that month) of the command will be occupied by the crops growing during that month. The coverage will be a part of 100 per cent coverage. So the litres/second/ha value are then converted to the 100 per cent value. Multiplying this value by 86400 seconds gives the litres/ha/day. This value when multiplied by the area in hectares (See appendix 3.7) (CCA) under the command in that particular district (Anon., 1991) will give the value in million cubic meters/day for that particular month. Multiplying this value by the number of days in the month in question gives the million cubic meters per month value. This is the net irrigation requirement value for that particular month in a particular district. In this way, values for the whole year are computed. After this, the next step is the seasonal evaluation of the scheme

water requirement. The exact procedure is explained as follows :

### 3.5.2.2 Seasonal evaluation of scheme water requirements

This evaluation is carried for each season separately viz., summer season (Jan./Feb.-May/June), winter season (*rabi* Oct./Nov.-March/April) and monsoon season (*kharif*-June-July - Oct. extendable to Feb./March depending as the length of growing period of a particular crop). For the purpose of seasonal evaluation, data on the actual water supply that is going to be available (Million cubic meters) during the different months is required. According to Anon. (1985), the water of the Narmada command canal system will flow at a minor distributory at the rate of 0.9 litres/second. From this value, the litres/day are computed and this value multiplied by the number of days in the month in question gives the actual monthly value in M-cu-m/m. The next requirement is the scheme water requirement value for each month of the season which is already computed as monthly crop water requirement in mm. This value is the net value. It is projected and also documented that the scheme efficiency will be at the most 50 per cent. Accordingly the net scheme water requirement values are converted to gross scheme water requirement values also in mm. These values are also computed monthwise. From the gross scheme water requirement the required supply in million cubic meters for

each month of the season is computed by multiplying the gross scheme water requirement values in mm by the area in hectares irrigated. The relation between the required supply expressed as million-cubic meters/month and the actual supply also expressed as million cubic meters/month converted to percentages is the final evaluation of the scheme water supply for each month of the season.

Once this is done, the next step is the actual working out of the irrigation schedule for each crop of each of the 12 district of the command. For this the data on available water capacity and the reference crop evapotranspiration values (ETc) in millimeters per standard week and the net irrigation water requirement in millimeters per standard week are required. The exact procedure is explained as follows :

### 3.5.3 Fixing the Irrigation Schedule

The calculation of the irrigation schedule is facilitated by working out the water balance in which, on a daily basis, the incoming and outgoing water flow (evaporation, rain, irrigation) in the root zone of the soil profile is being monitored. For fixing the irrigation schedule data on crop evapotranspiration, effective rainfall and available water capacity are required.

The information on crop water requirement is as per the method described in the earlier section. This represents the daily water need arising out of the evapotranspiration by the crop. The data on rainfall are included as input of the climate component. For the present study the values of monthly rainfall are converted to standard week basis and depending on the intensity and quantity of rainfall, effective rainfall values were computed (80 and 70 per cent of actual rainfall) and are thus used for the various climatic stations of the command. The validation study of the model is however, done on the actual data collected daily. The data used for irrigation scheduling in the present study is mainly the allowable depletion which allows the calculation of the readily available soil moisture content in the root zone (RAM). The soil data required and used in the present study are the total available moisture which is the difference in soil moisture content between field capacity and wilting point. This is the ultimate amount that is available, and is expressed as mm/m. The option to irrigate in the present study was exercised and is proposed to be exercised when  $\frac{1}{2}$  AWC is utilized by the respective crops. Procedure to arrive at a exact date is already explained earlier. The application depth is fixed taking into consideration the field irrigation application efficiency which in the present study is fixed at 90 per cent of the computed value.

### 3.6.4 Assessment of Water Requirement of Areas with Shallow Underground Water Table

Large areas in the proximity of the presently active Mahi command in middle Gujarat and the Ukai-Kakrapar command of the south Gujarat region have developed problem of rising water table which in many areas has reached a level of 1 to 1.5 m. This is within the root zone depth of many crops. Except the problem of a rising water table, these soils are otherwise productive. It is therefore pertinent to find out ways of managing these areas, so that agricultural productivity can be maintained while keeping the water table depth at manageable limits. With this objective in mind a field experiment was laid out in farmer's field at village Lingda (about 20 kms from Anand) in the summer season of 1996. The crop was groundnut var. GG-2. The crop was sown on 7<sup>th</sup> Feb.1996 and harvested on 27<sup>th</sup> May 1996. The total length of growing period was 110 days. The treatment details are :

Treatment	Details
T1	No irrigation except a pre-sowing irrigation of 50 mm depth.
T2	Sprinkler irrigation at 55 DAS (pegging) and 85 DAS (pod development) corresponding to 25 mm irrigation depth, with 1.0 m water table.
T3	Sprinkler irrigation at 55 DAS (pegging) and 85 DAS (pod development) corresponding to 25 mm irrigation depth, with 1.5 m water table.
T4	Irrigation with 50 mm depth, at 0, 55 and 85 DAS and as pre-harvest (4 irrigations).

In treatments T<sub>3</sub> and T<sub>2</sub>, also a pre-sowing and pre-harvest irrigation of 50 mm depth was given. All other practices like fertilizers, FYM, plant protection measures etc. were as practiced by the farmers.

Plot size : 5 x 20 m strips  
Replications : 5  
Design : R.B.D.  
Sampling for yield : 1 x 1 m area, 2 representative sites/  
(Kernel and haulm) replication

Periodically, soil samples from 0-30, 30-60, 60-90 and 90-120 cm depth were drawn with the help of screw auger for gravimetric estimation of moisture. These weight by weight values (%) were converted to volumetric values (cm<sup>3</sup> cm<sup>-3</sup>) for each soil depth (cm 30 layer). The product of moisture per cent of each layer at a particular tension and bulk density divided by the total storage depth (i.e. 100 cm) gives the volumetric content. Thus

$$\text{Moist } \frac{\%}{100} \times \text{B.D.} = \text{cm}^3 \text{ cm}^{-3} \dots \dots \dots (9)$$

With the help of already estimated hydraulic conductivity values (Patel et al., 1992) the upward flux from the shallow water table was calculated as follows (Cook and Dent, 1990).

$$q = K_u \frac{\phi_{rz} - \phi_{wt}}{Z_{wt} - Z_{rz}} \dots \dots \dots (10)$$

Where,

$q$  = The upward flux, mm/day

$K_u$  = Unsaturated hydraulic conductivity at the mean matric potential between  $Z_{rz}$  and  $Z_{wt}$ , mm/day

$\phi_{rz}$  = Total potential in the root zone, KPa

$\phi_{wt}$  = Total potential at the water table, KPa

$Z_{rz}$  = Depth of root zone, cm

$Z_{wt}$  = Depth of water table, cm

This gives the contribution from the ground water table in  $\text{mm day}^{-1}$ . This multiplied by the length of growing period will give the contribution from ground water table for the season. The periodic gravimetric estimation of the moisture content from each of the four layers will give an idea of the pattern of extraction by the roots of groundnut plants. The results, and the discussion of the findings of the present study are presented in the following chapter.

**RESULTS  
AND  
DISCUSSION**

## CHAPTER IV

### RESULTS AND DISCUSSION

The success of irrigated agriculture, depends on the correct time of application of water and in correct quantities. The literature is replete with the work of innumerable authors the world over, who have tried to arrive at the correct time and correct quantity of irrigation water. In spite of all this work, these two management decisions have continued to catch the imagination of irrigation scientists, and work on these two aspects of irrigated agriculture and is continuing to receive scientific attention. The basic problem in irrigated agriculture, (more so through the canal system), is the development of secondary salinization and alkalization and that of rising water table (Kay, 1990). It is probably difficult to find a canal system which is not associated with this malaise. It is with these points under consideration that the present work is being undertaken with the following objectives in mind :

- (1) To develop an irrigation schedule considering the three vital aspects, viz., climate (PET-the demand side), soil (available soil water capacity - the supply side) and the crop (the user side), so that the schedule will have a broad regional applicability.

(2) To compare the soil-crop-climate based irrigation schedule with the presently recommended irrigation schedules for the measure of correspondence or compatibility, through crop performance studies.

(3) To find alternative irrigation practices in areas which are likely to develop problems of rising water table and or salinity/alkalinity problems, and

(4) To study the impact of the various irrigation schedules on nutrient concentration and uptake by the crops being studied. *grown*

The need for water for a crop standing in the field is met through the soil. The extent, to which this need is being satisfied, depends on the soil's capacity to retain water in available form (Boedt and Verheye, 1986). Soils differ greatly in their capacity to hold water. The one single most soil property that is widely believed to affect the water retention capacity is the distribution of the various particle size fractions i.e. soil texture (Petersen et al., 1968). Soils have been found to retain water from 6 cm/m, in case of sandy soils to as high as 20 cm/m of soil profile in clayey soils. Similarly, crops which grow on these soils, have a wide range of tolerance for the extent to which this retained water is allowed to deplete, before they start showing signs of moisture stress. These limits may vary from 30 per cent in <sup>the</sup> case of alfalfa to nearly 80 per

cent in <sup>the</sup> case of beans near maturity (Hagan and Stewart, 1972). In one case Robins *et al.* (1967), have reported wheat crop to tolerate depletion of 90 per cent when near to maturity. From this information, it is quite clear that not only the irrigation requirements vary widely depending on the soil type, the crop type, but the stage of crop growth, also is a strong determining factor (Hagan *et al.*, 1959; Mishra *et al.*, 1969 and Singh, 1981). The climatic condition at a particular moment is also another important factor controlling the extent and frequency of irrigation need (Van Bavel, 1960; Jensen *et al.*, 1970; Wright and Jensen, 1978; Dent and Scammel, 1981). Thus, when the climatic demand for water is low, a plant can continue to extract water at rates which balance the transpiration demands over a relatively greater extent of soil moisture depletion but, when the evaporative demand of the climate is intensified, this same level of soil moisture depletion may lead to yield reduction, unless replenished. Therefore, the time and quantity of irrigation water application must be based on consideration of local climate, crop and soil data. The technique which has been followed in this work is based on daily crop ET (ETc) converted to standard-week basis, weekly rainfall i.e. effective rainfall and allowable soil moisture depletion in the root zone (50 per cent of available water capacity) at the end of which, irrigation is initiated. The irrigation schedule so developed has been compared with

other irrigation scheduling methods which are currently practiced or are recommended for being practiced. These are, different levels of depletion of soil available water viz., 30, 50 and 70 per cent, the IW/CPE ratio method and the method of irrigating at critical stages.

#### 4.1 DEVELOPMENT OF IRRIGATION SCHEDULE AND ASSESSMENT OF IRRIGATION REQUIREMENT BASED ON SOIL-CROP-CLIMATIC DATA

##### 4.1.1 The Soil Factor

As a first step in this direction, soil samples from widely occurring representative soil families within the Narmada command were collected and were characterised for their physical and chemical properties. The available water capacity of each of these soil samples was determined following the standard techniques involving the use of the pressure plate apparatus. The data on the physical and chemical soil properties and the available soil water capacity of the representative soil profile samples are reported in table 4.1.1. The total amount of water held expressed as mm/m of soil profile at various soil moisture tensions ranging from 0 to 1500 kPa (Kilo Pascal) has been plotted and presented as figures 4.1.1 to 4.1.21. The total amount of water held at various tensions for soils with contrasting particle size fractions i.e. soil texture is also presented in figure 4.1.22. It is seen from the

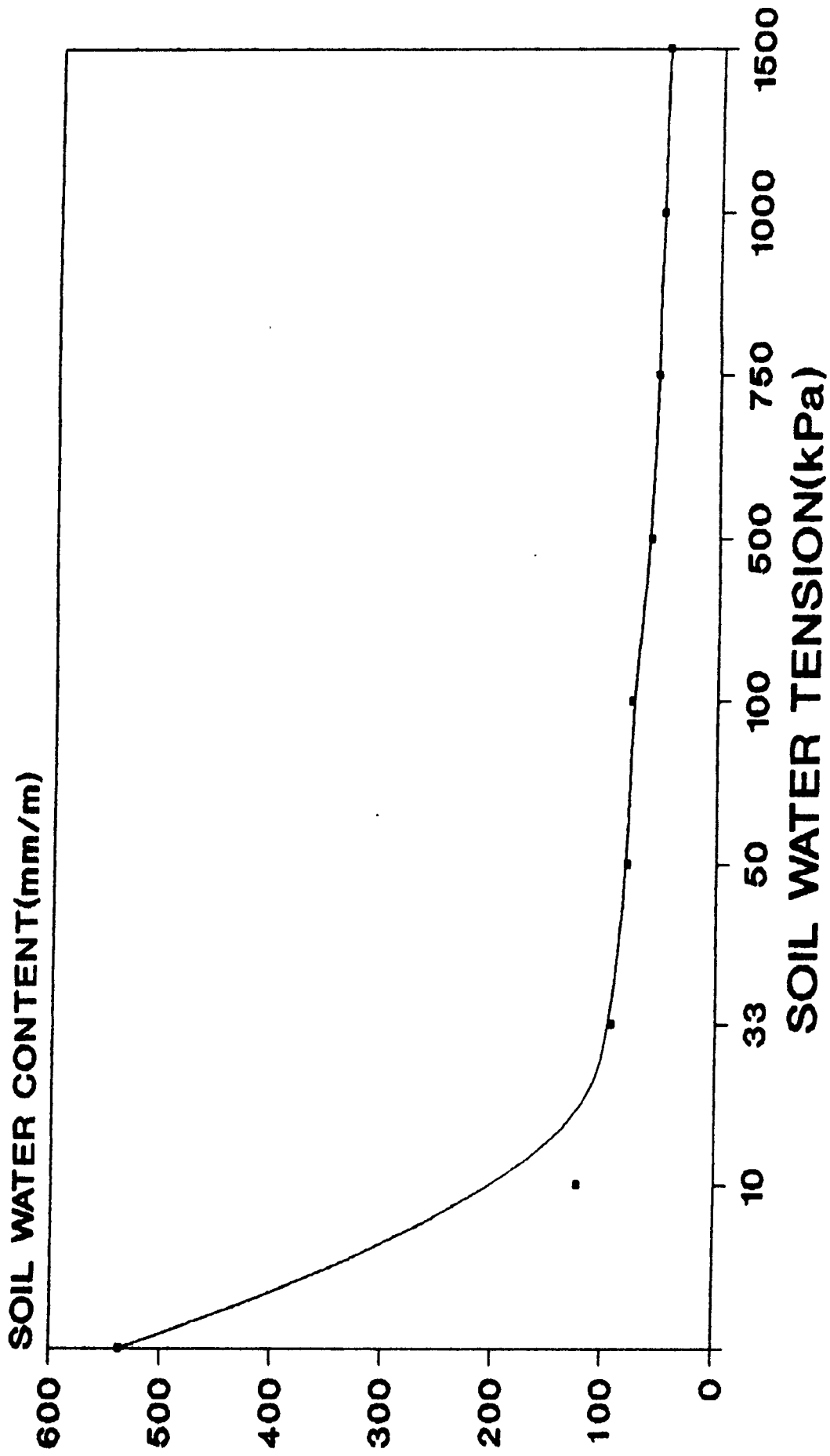
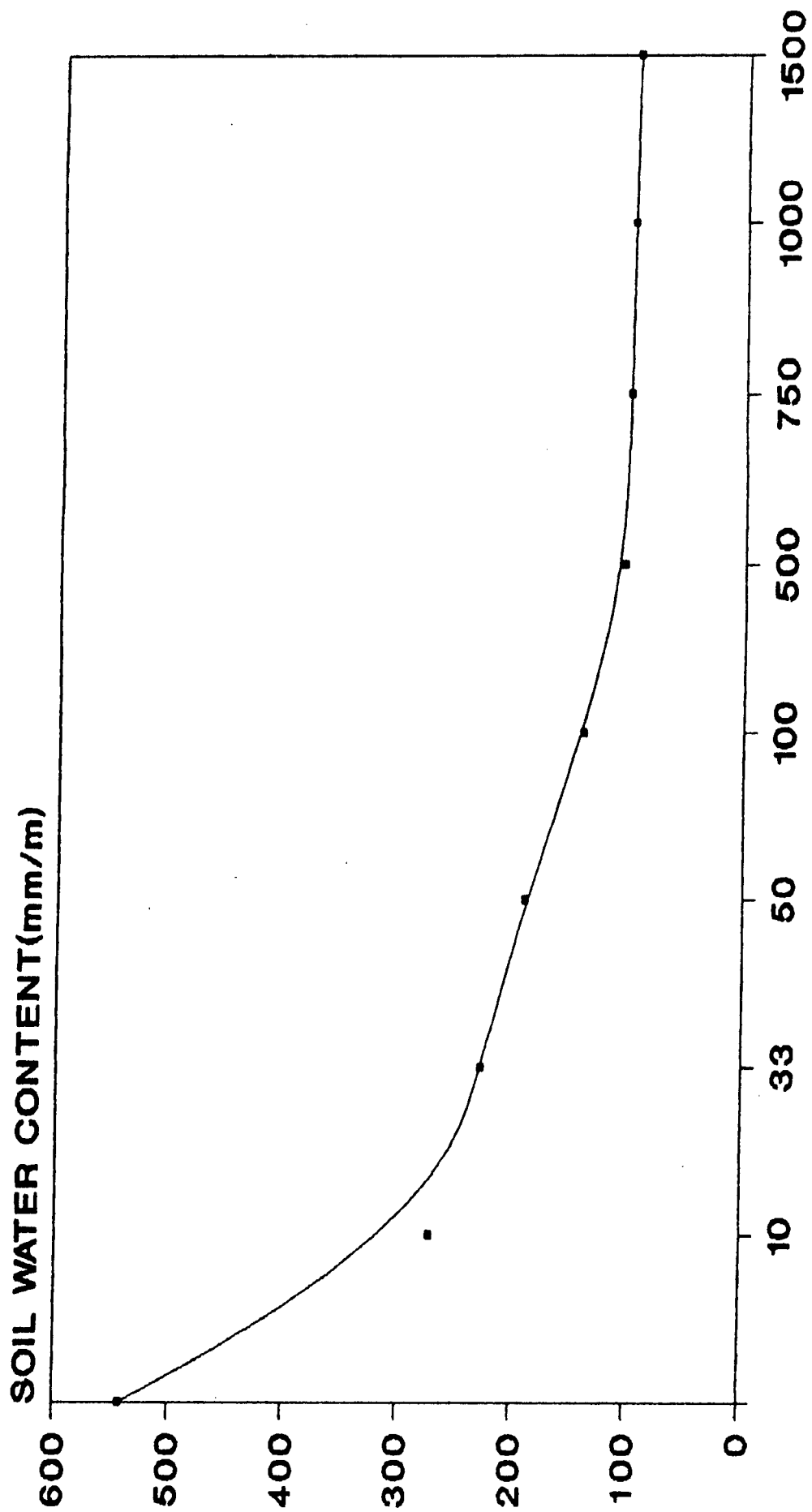


Fig. 4.1.1 : Moisture Retention Characteristics of Navapur Soil (Loamy Sand)



**SOIL WATER TENSION(kPa)**

**Fig. 4.1.2 : Moisture Retention Characteristics of Kasindra Minor Soil (Sandy Loam/Sandy Clay Loam)**

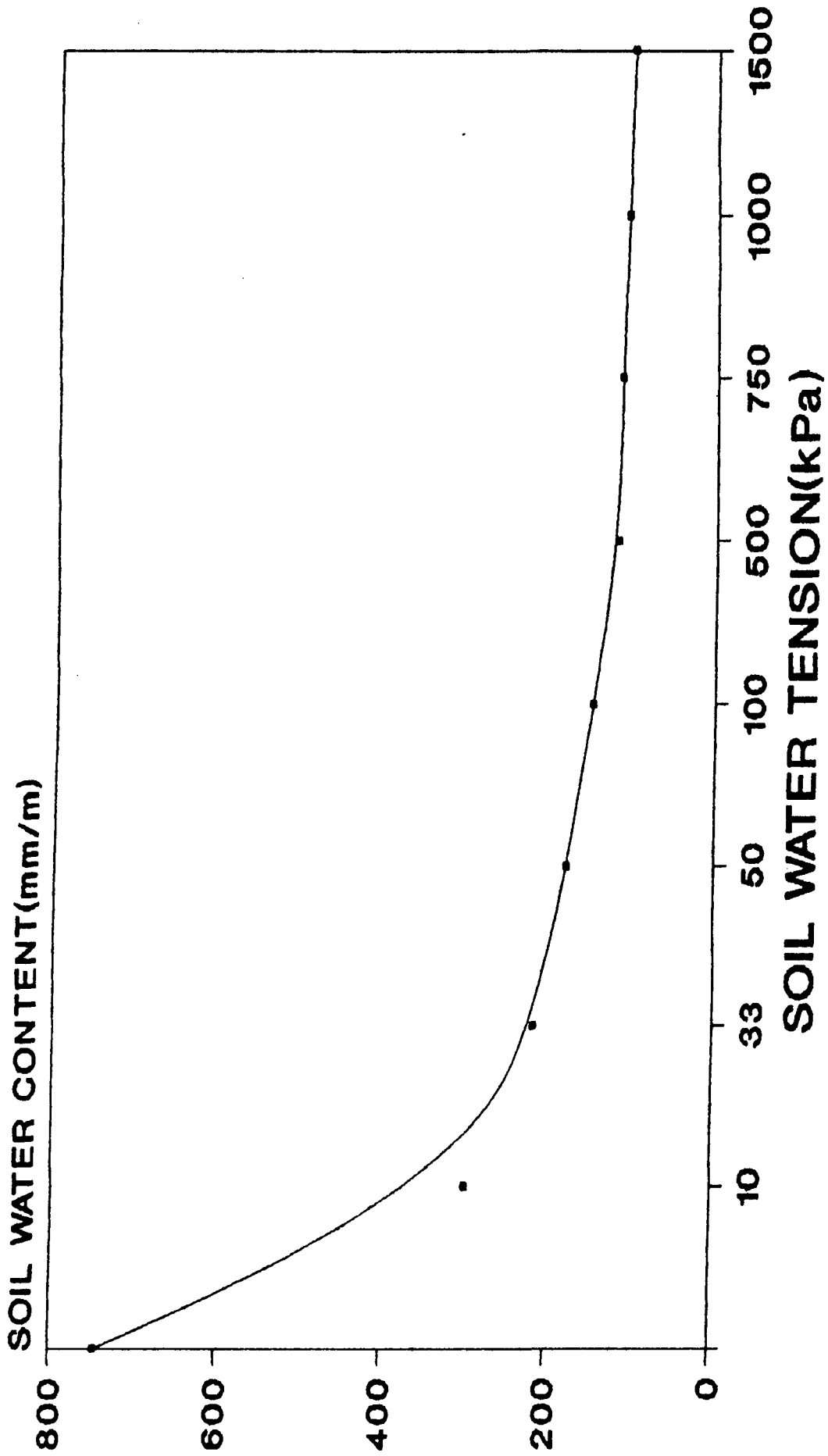
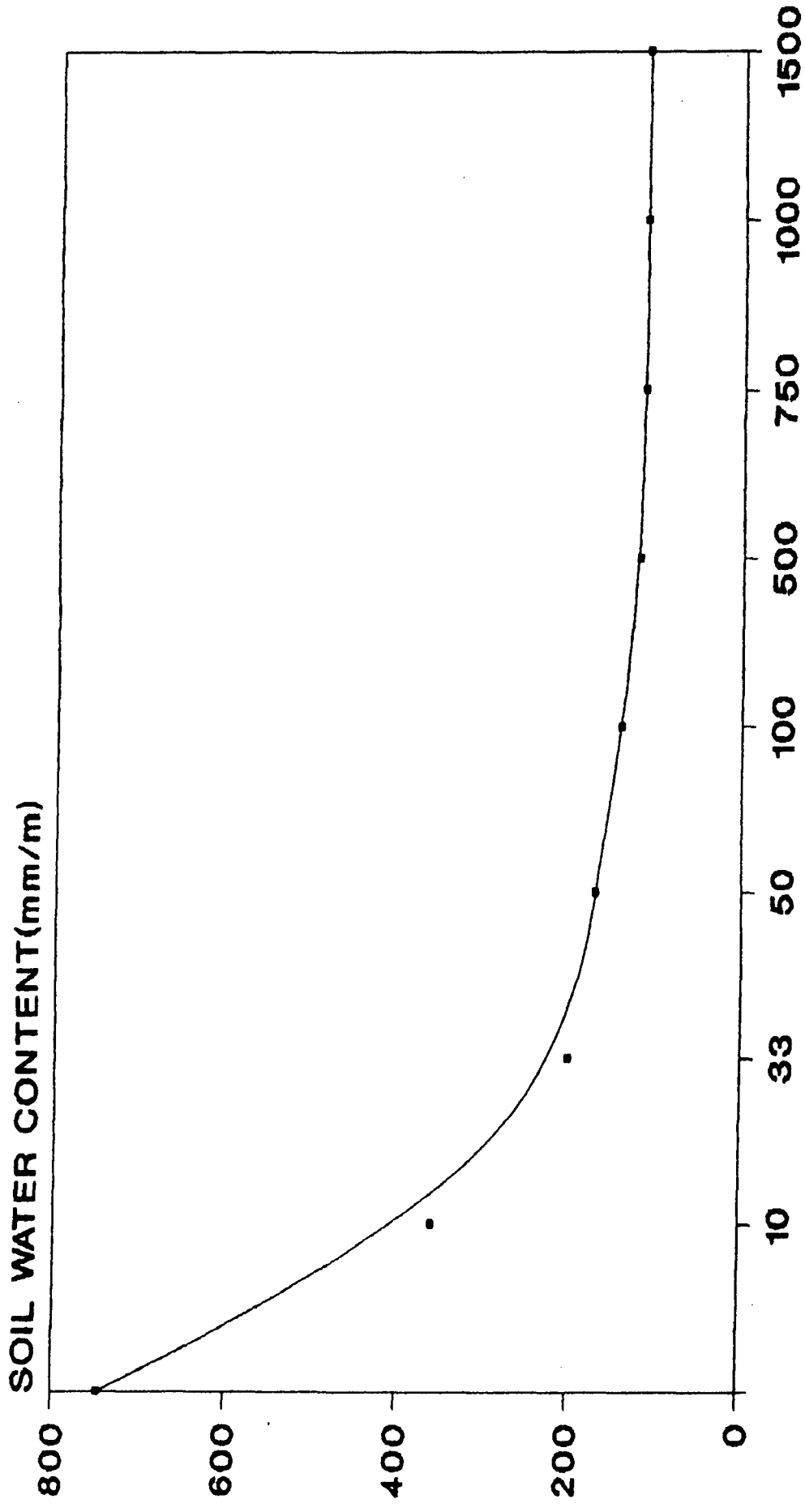


Fig. 4.1.3 : Moisture retention characteristics of Anand Soil (Sandy Loam)



**SOIL WATER TENSION(kPa)**

**Fig. 4.1.4 : Moisture Retention Characteristics of Debhassa Soil  
(Sandy Loam/ Sandy Clay Loam)**

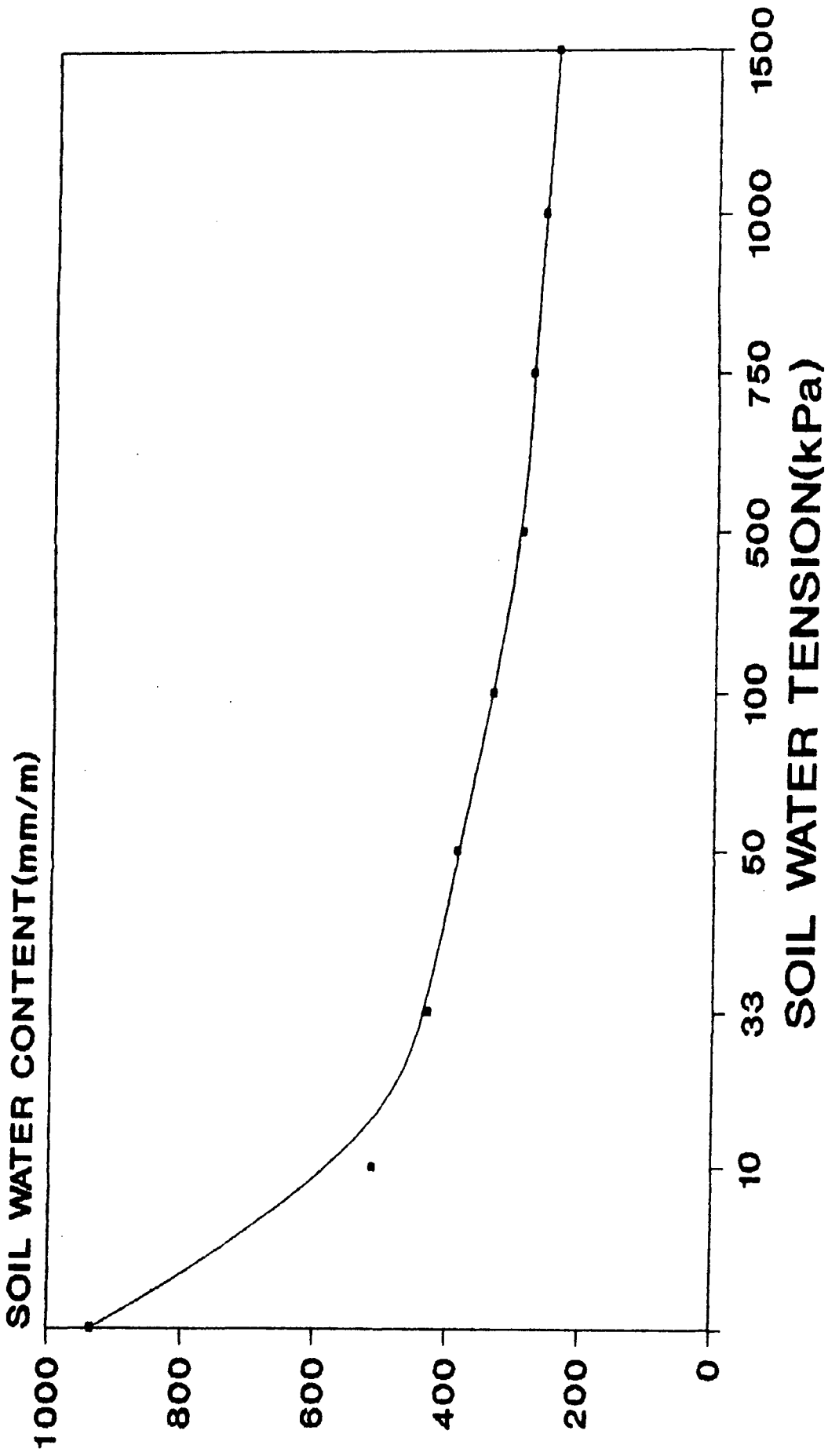


Fig. 4.1.5 : Moisture Retention Characteristics of Chandrad Soil (Clay Loam/Clay)

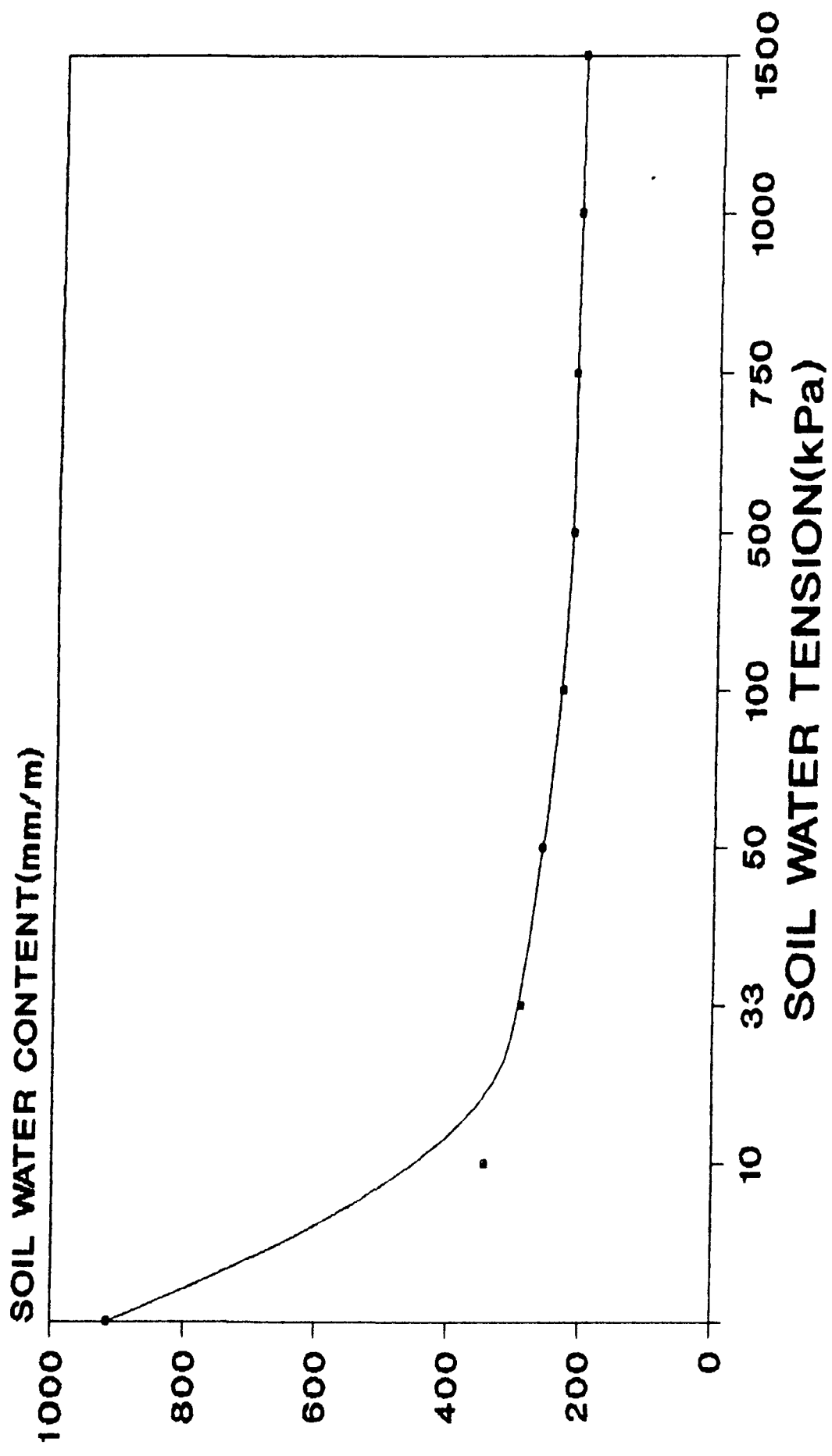


Fig. 4.1.6 : Moisture Retention Characteristics of Halol Soil (Sandy Clay Loam/Clay Loam)

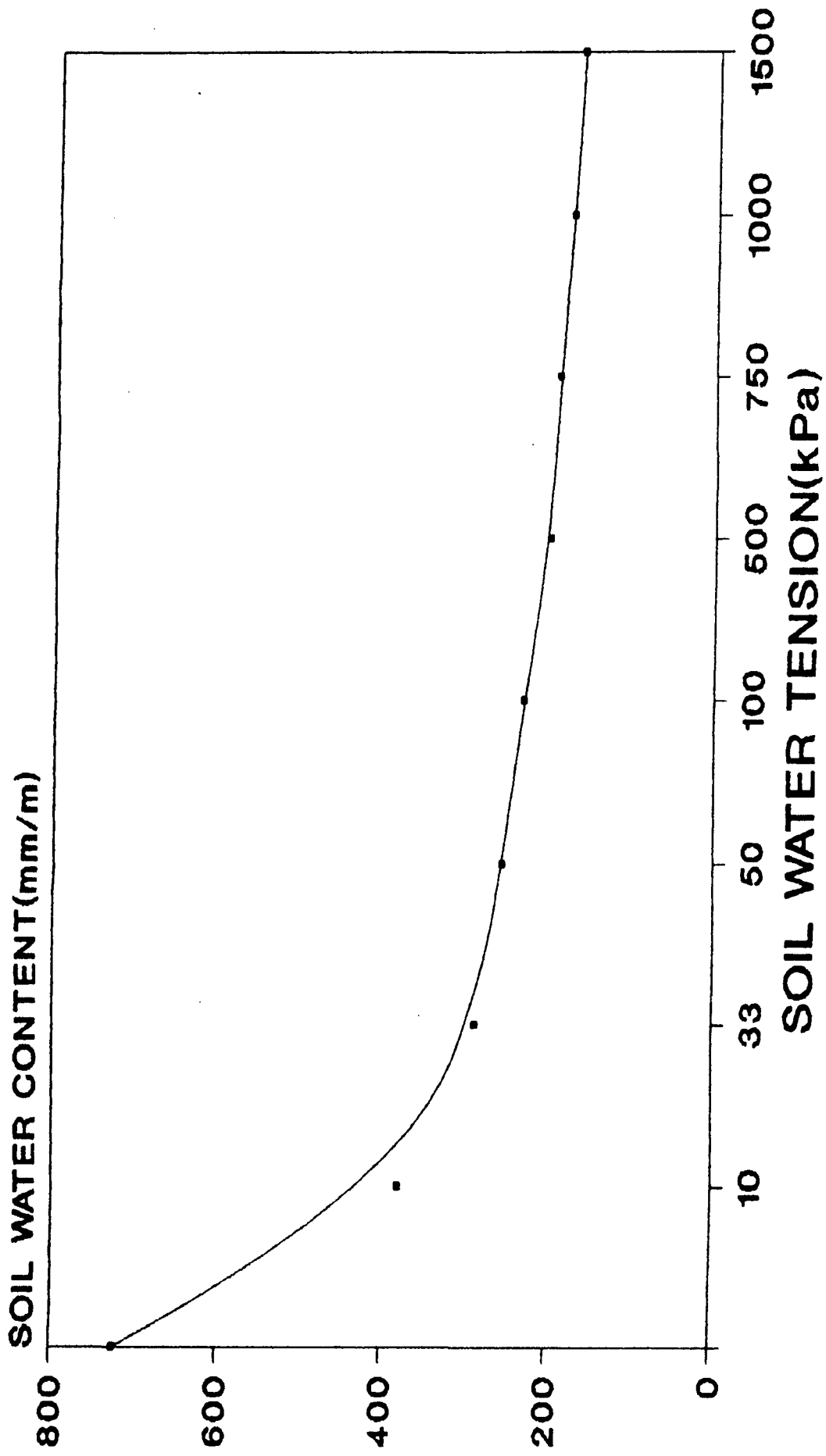


Fig. 4.1.7 : Moisture Retention Characteristics of Asod Soil (Sandy Clay Loam/Sandy Loam)

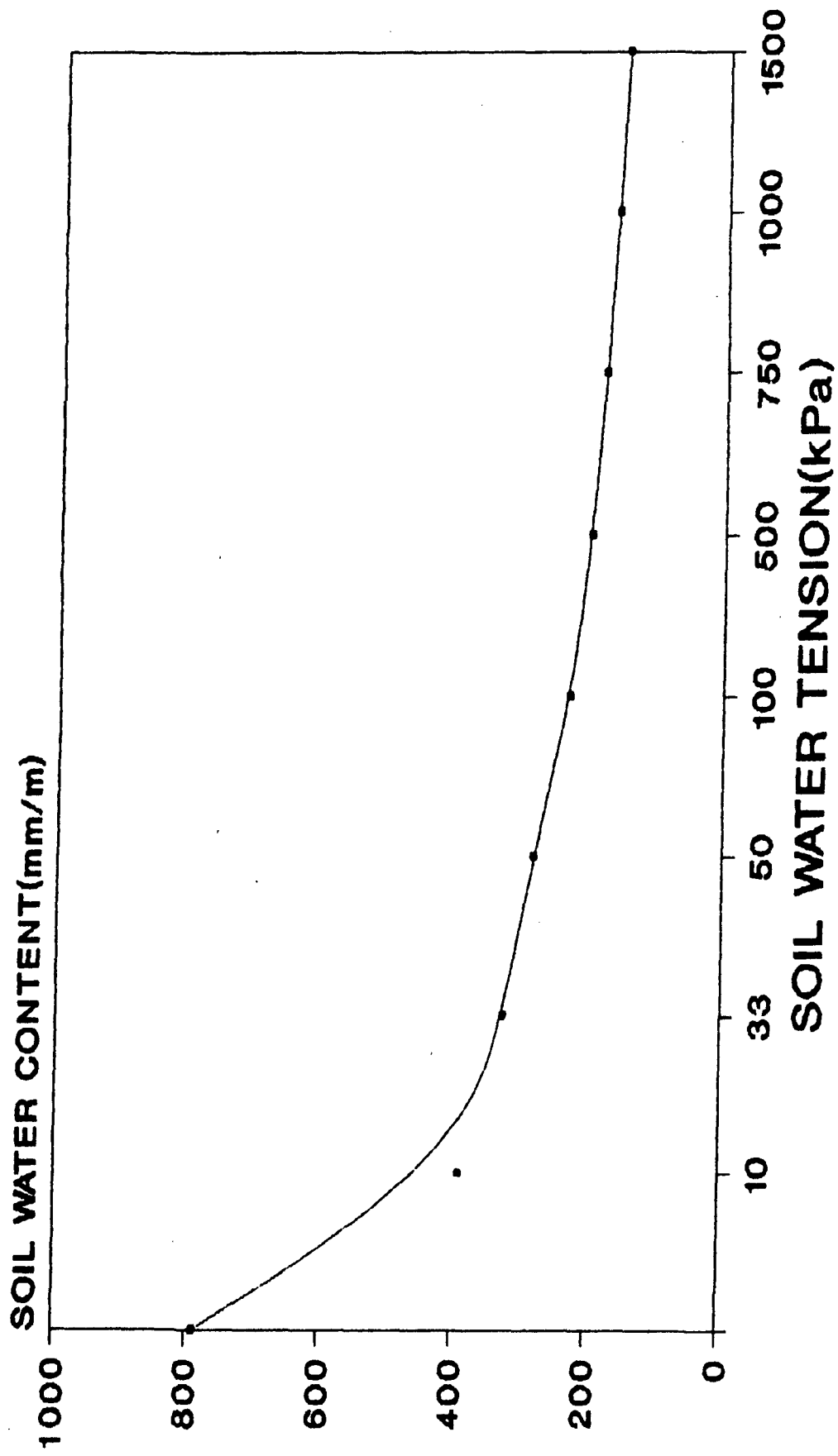


Fig. 4-1.8 : Moisture Retention Characteristics of Sunay Soil (Sandy Clay Loam)

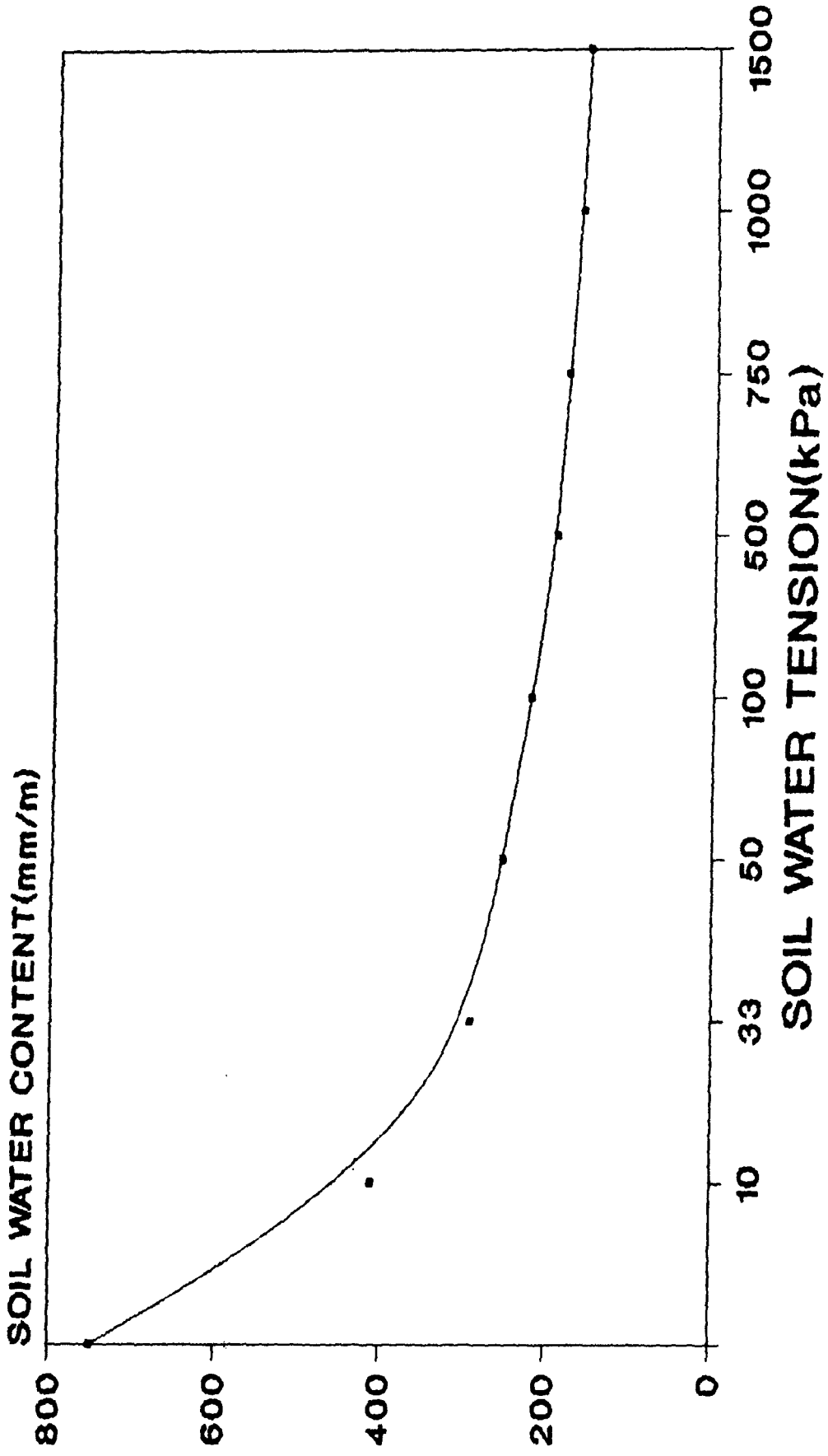


Fig. 4.1.9 : Moisture Retention Characteristics of Tarapur Soil (Sandy Loam/Sandy Clay Loam)

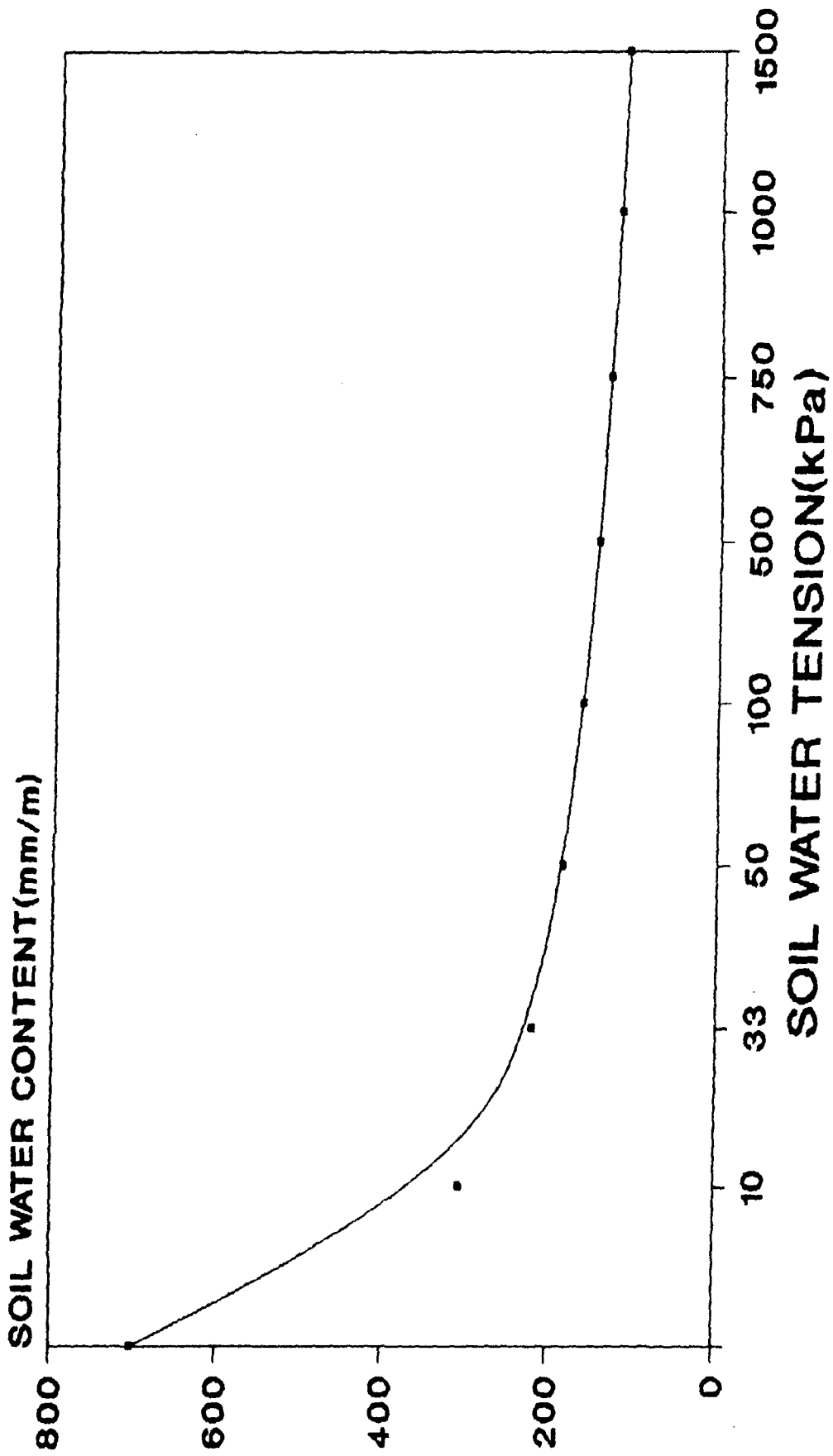


Fig. 4.1.10: Moisture Retention Characteristics of Dharmaj Soil (Sandy Clay Loam/Sandy Loam)

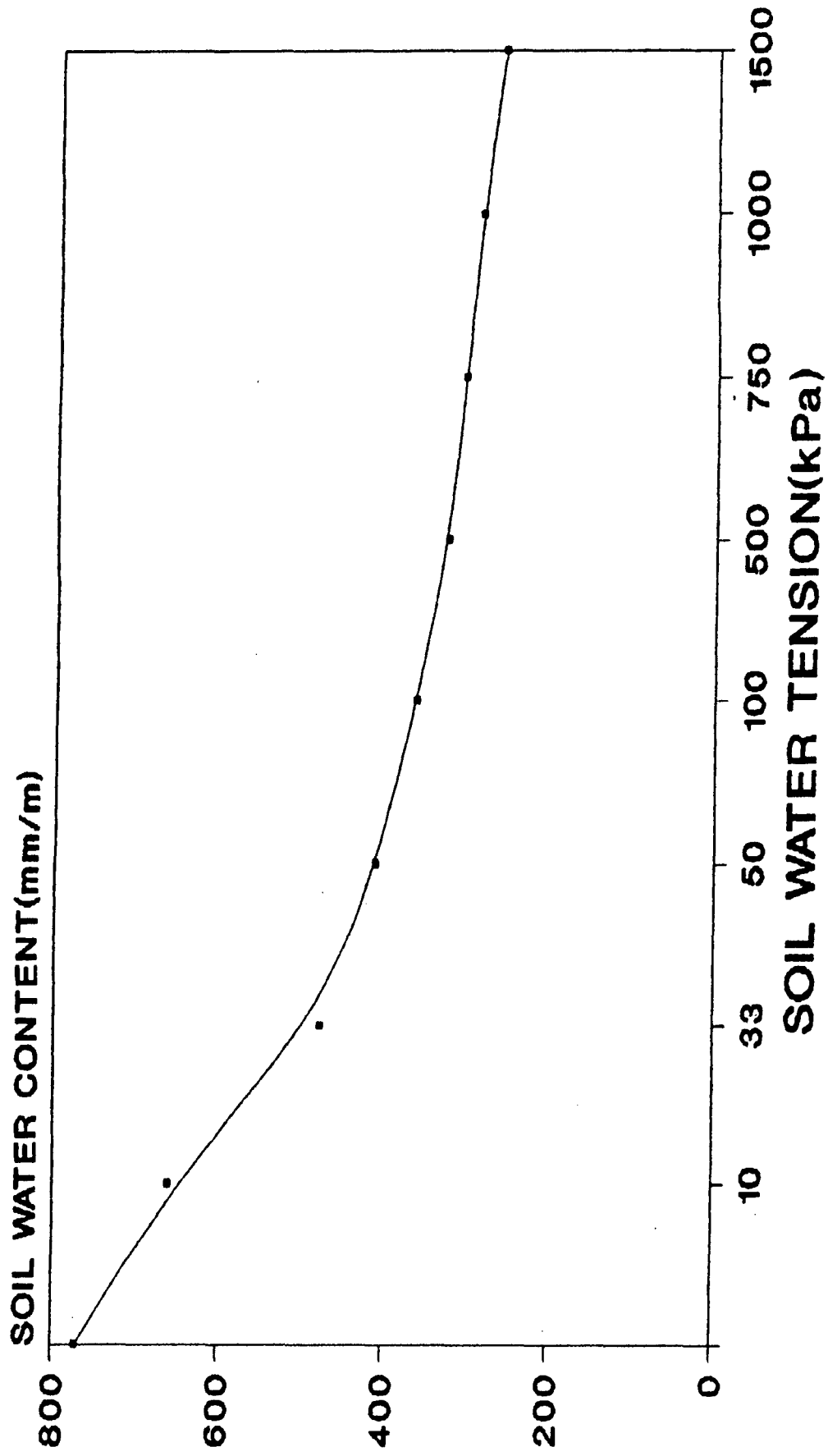


Fig : 4.1.11: Moisture Retention Characteristics of Dahej Soil (Clay Loam/Clay)

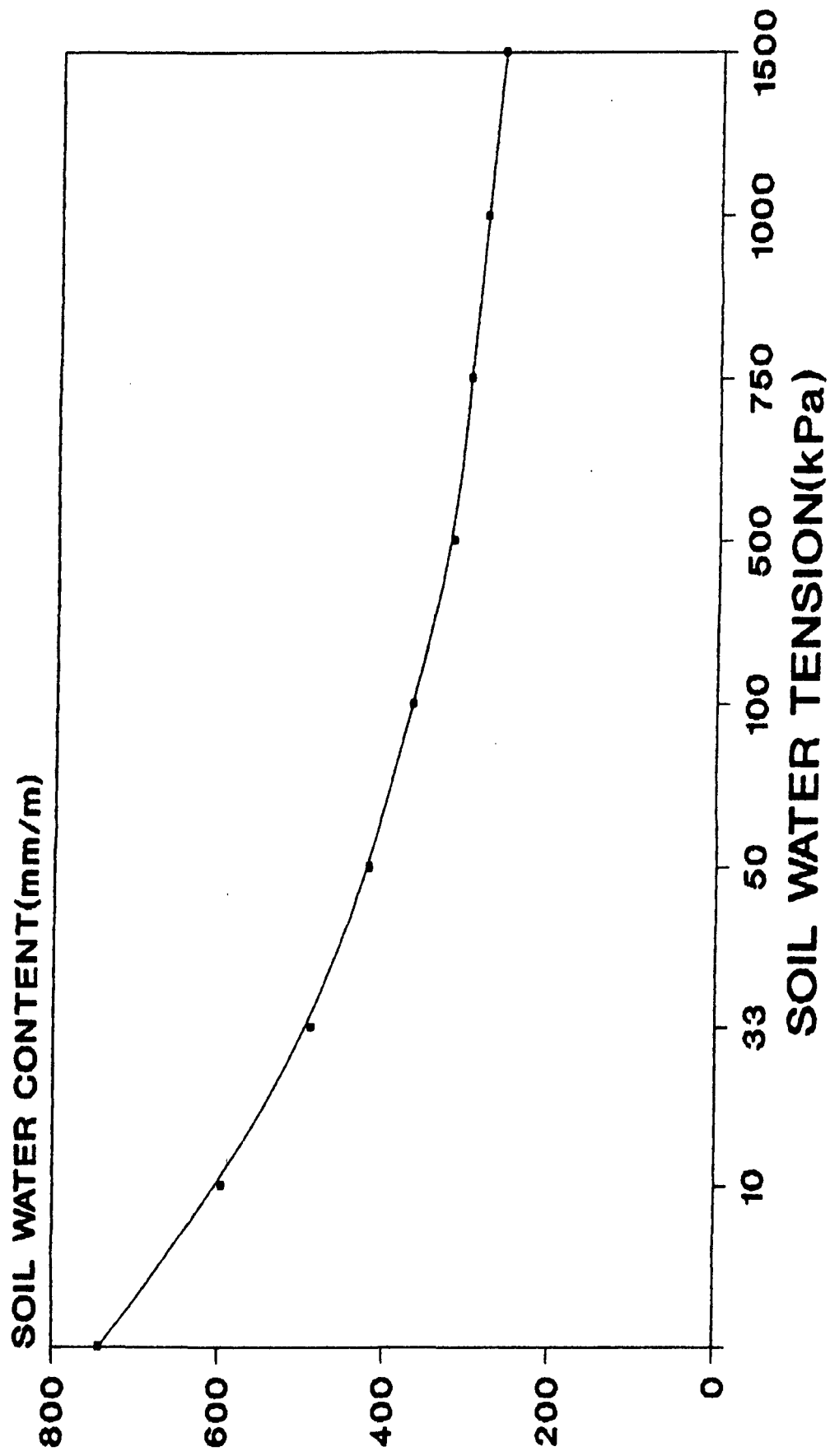


Fig. 4.1.12 : Moisture Retention Characteristics of Rahlad Soil (Clay Loam/Clay)

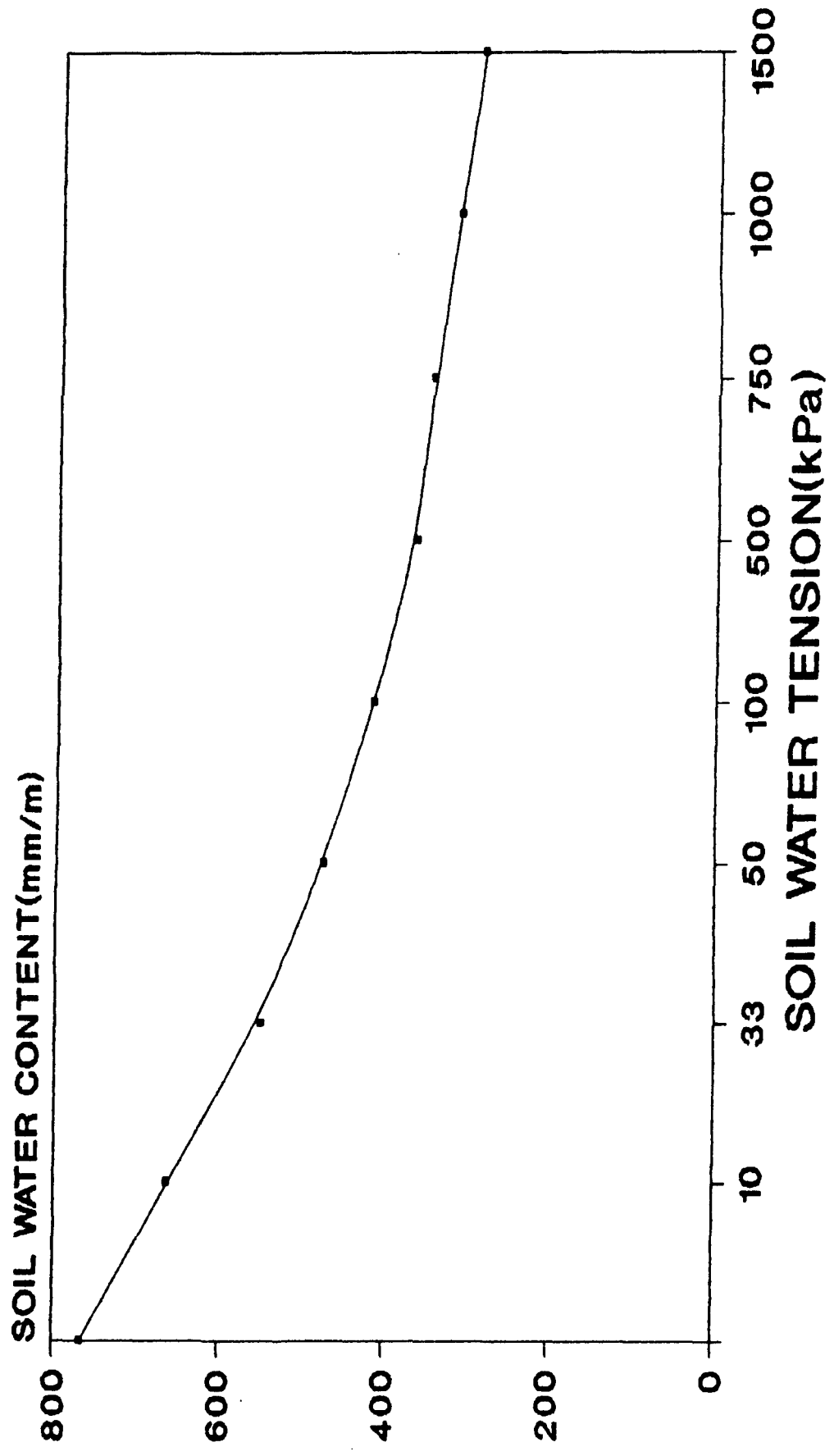


Fig. 4.1.13 : Moisture Retention Characteristics of Limri Soil (Clay/Clay Loam)

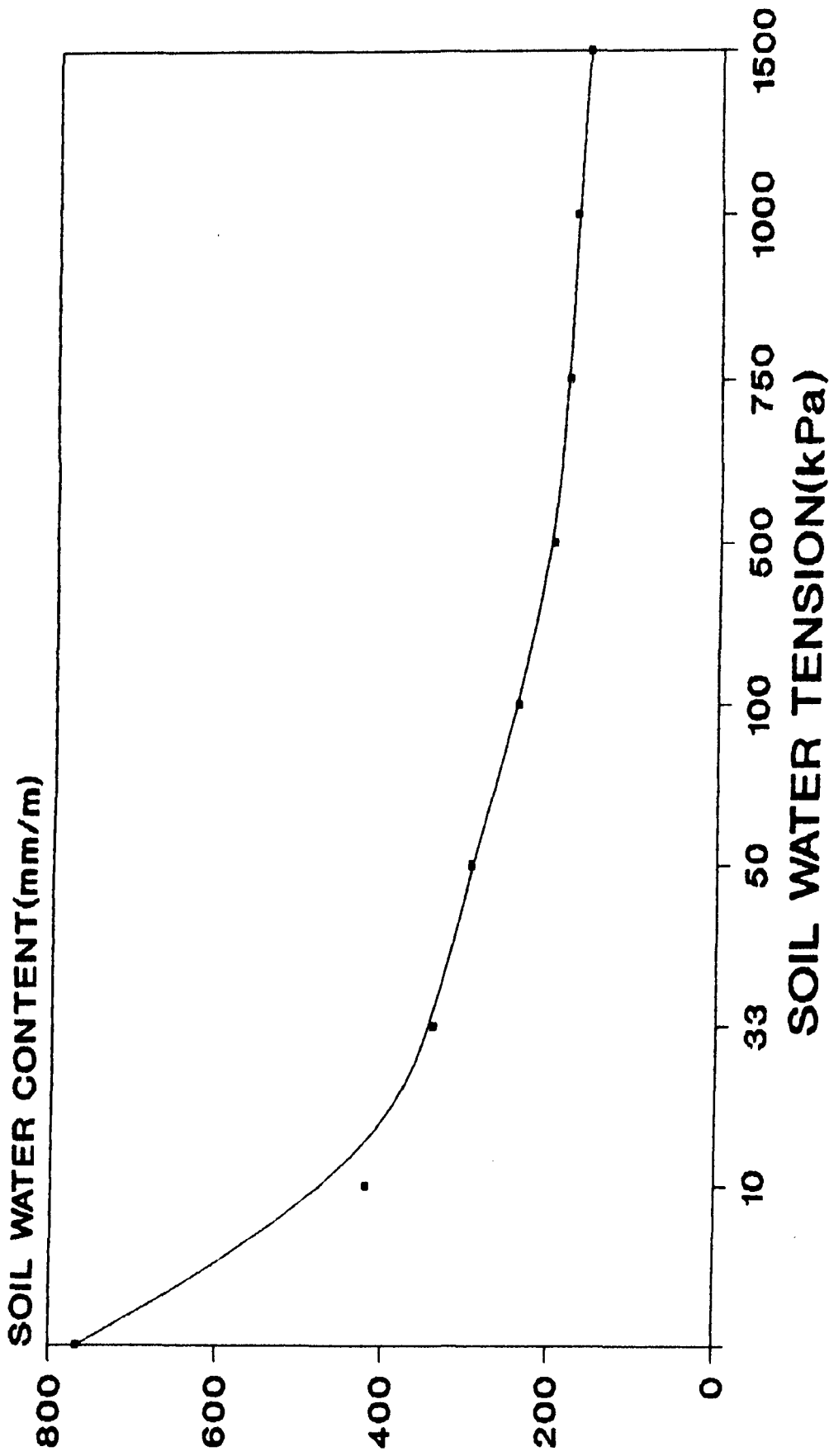


Fig. 4.1.14 : Moisture Retention Characteristics of Lingda Soil (Sandy Clay Loam)

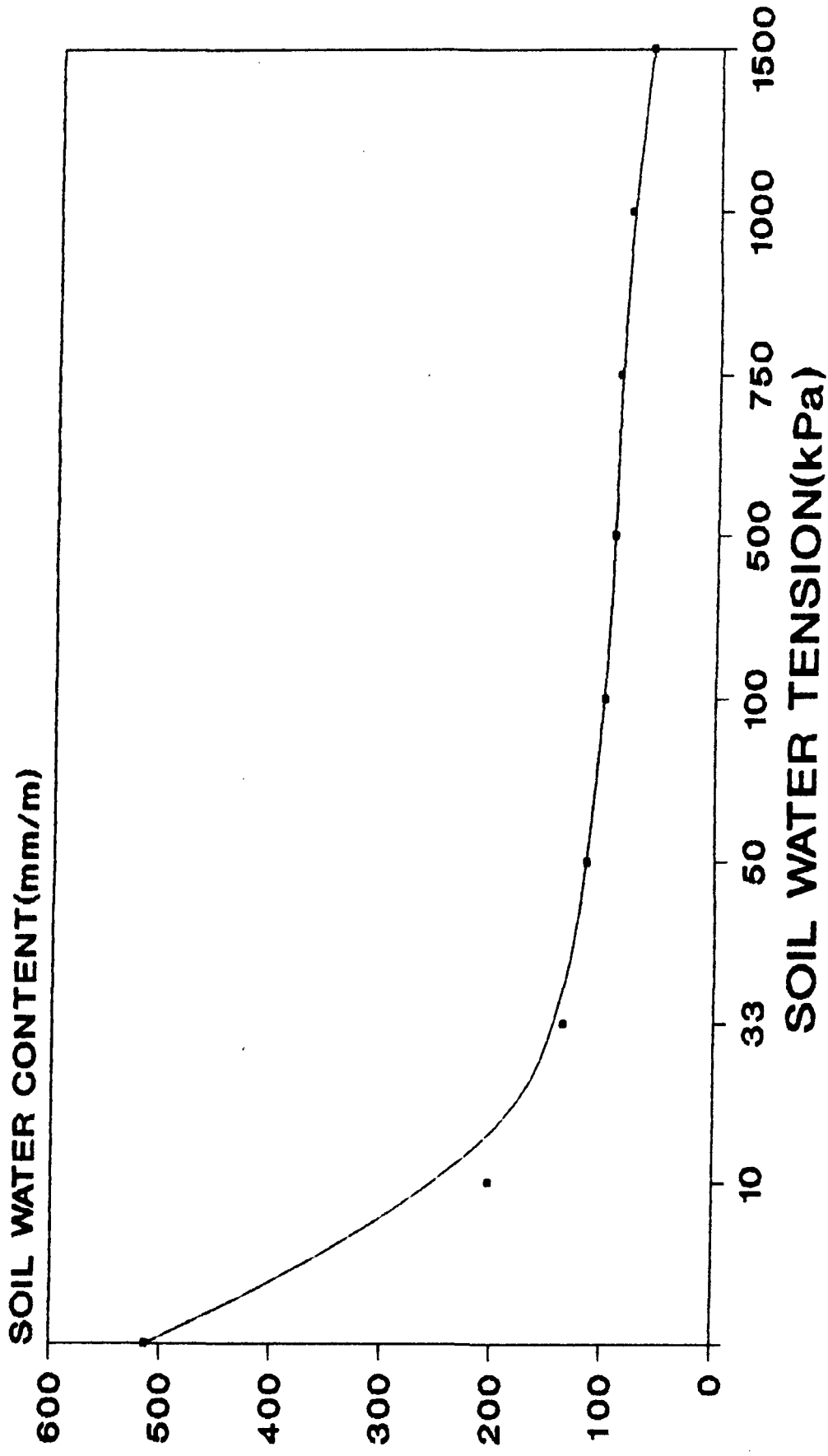


Fig. 4.1.16 : Moisture Retention Characteristics of WALMI Soil (Sandy Loam)

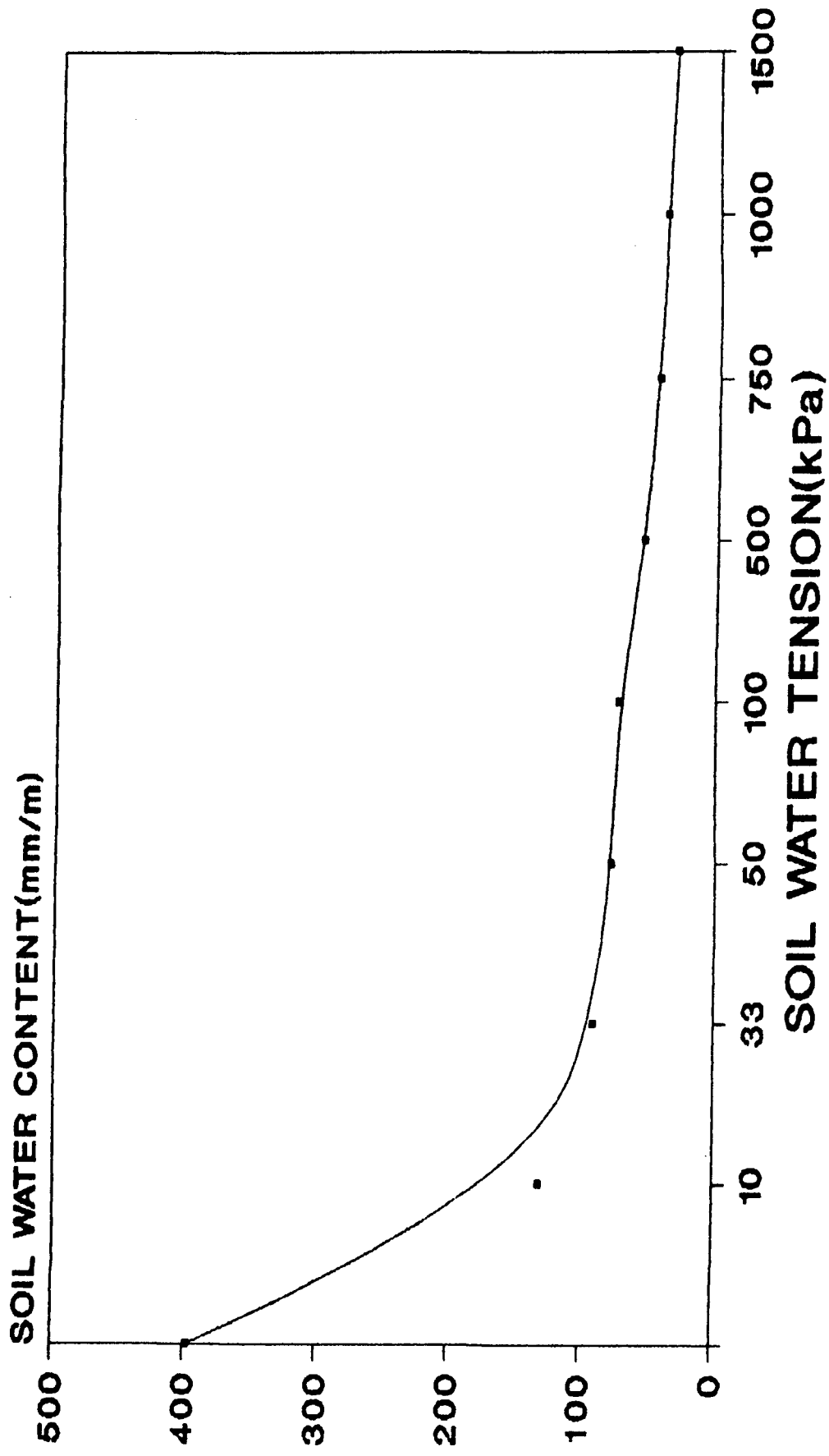


Fig. 4.1.16 : Moisture Retention Characteristics of 8K Nagar Soil (Loamy Sand)

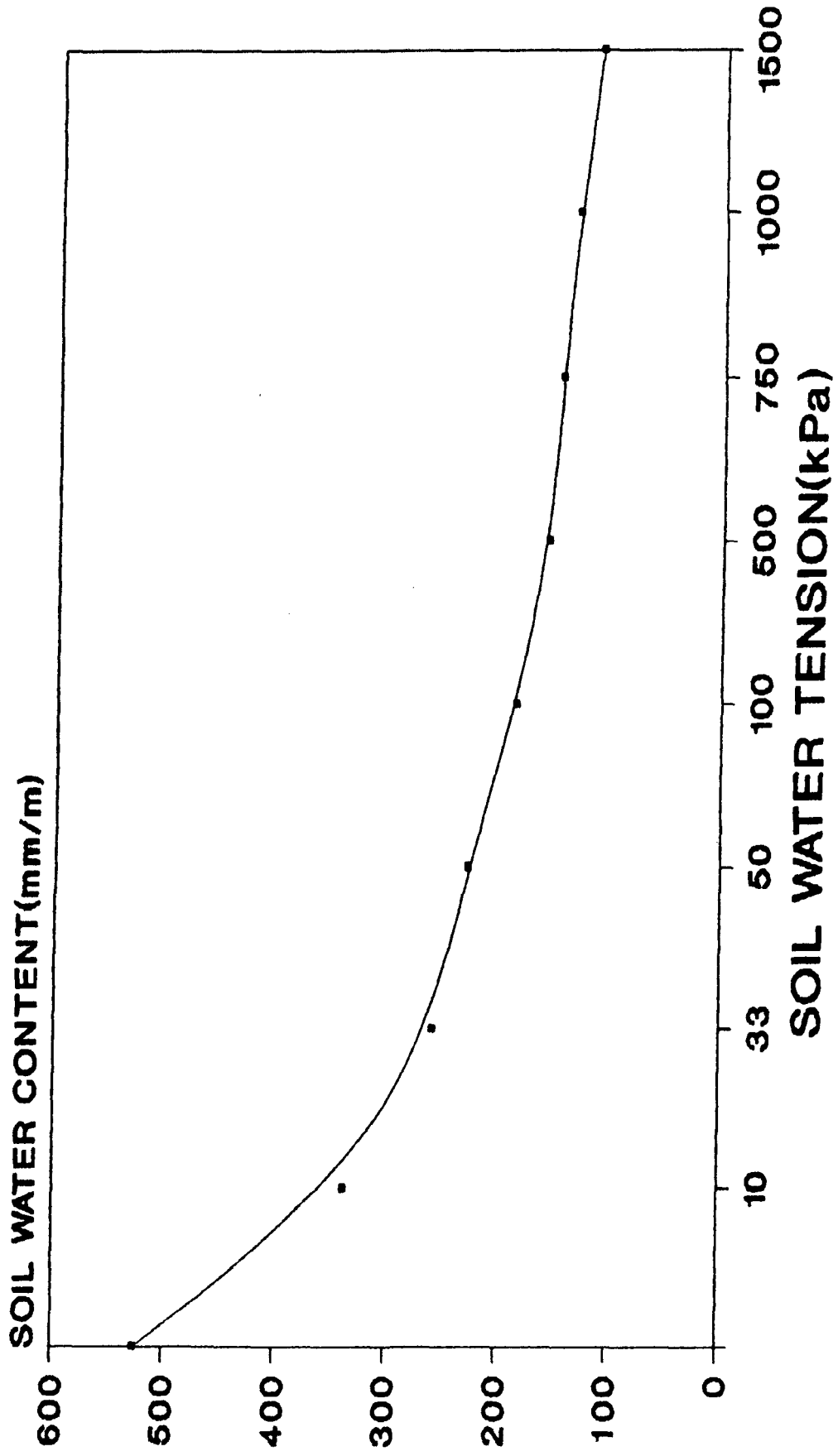


Fig. 4.1.17 : Moisture Retention Characteristics of Baohau Soil (Sandy Loam)

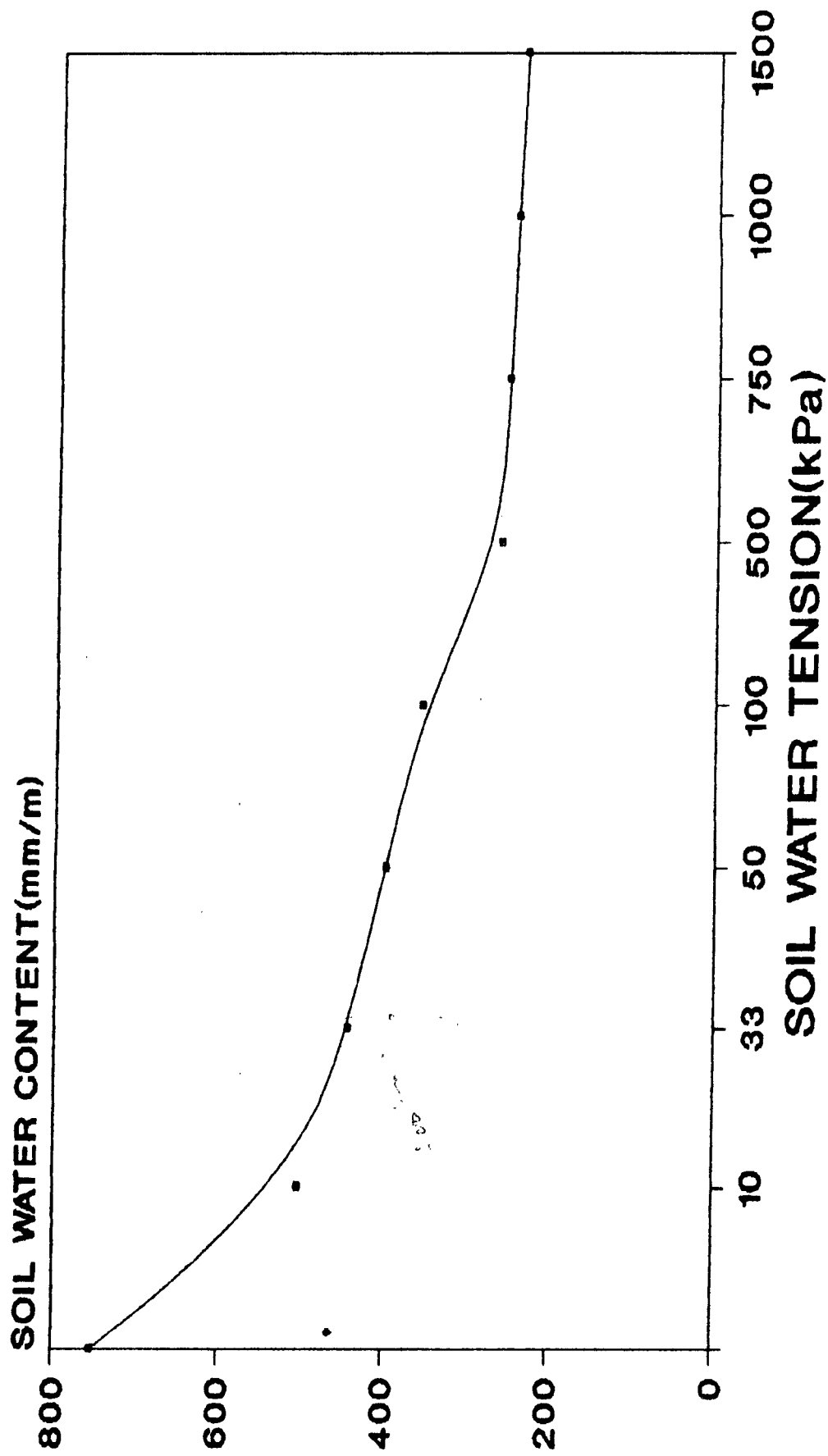


Fig- 4.1.18 : Moisture Retention Characteristics of Arnej Soil (Clay-Sodic)

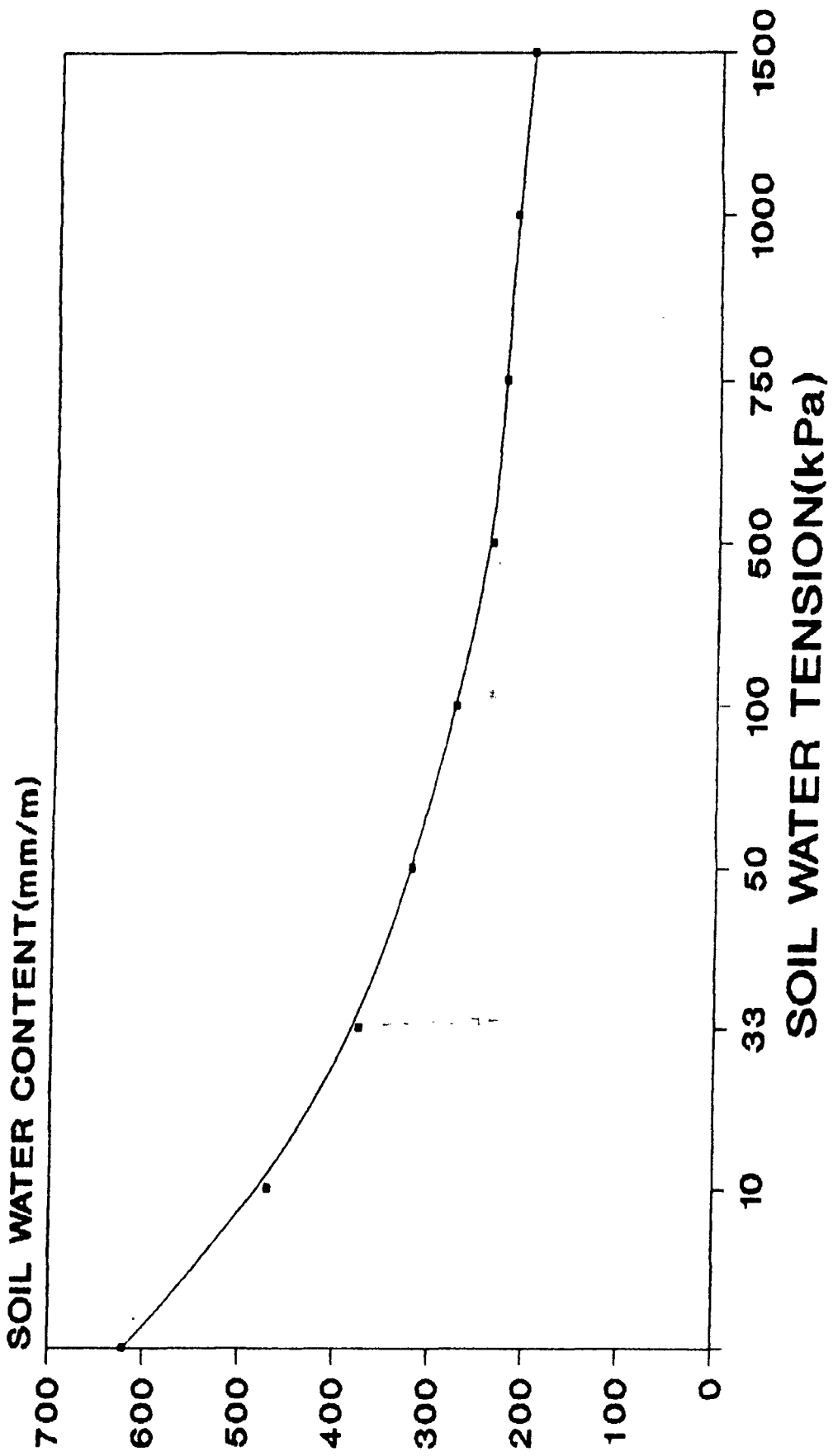


Fig. 4.1.19 : Moisture Retention Characteristics of Karjan Soil (Clay)

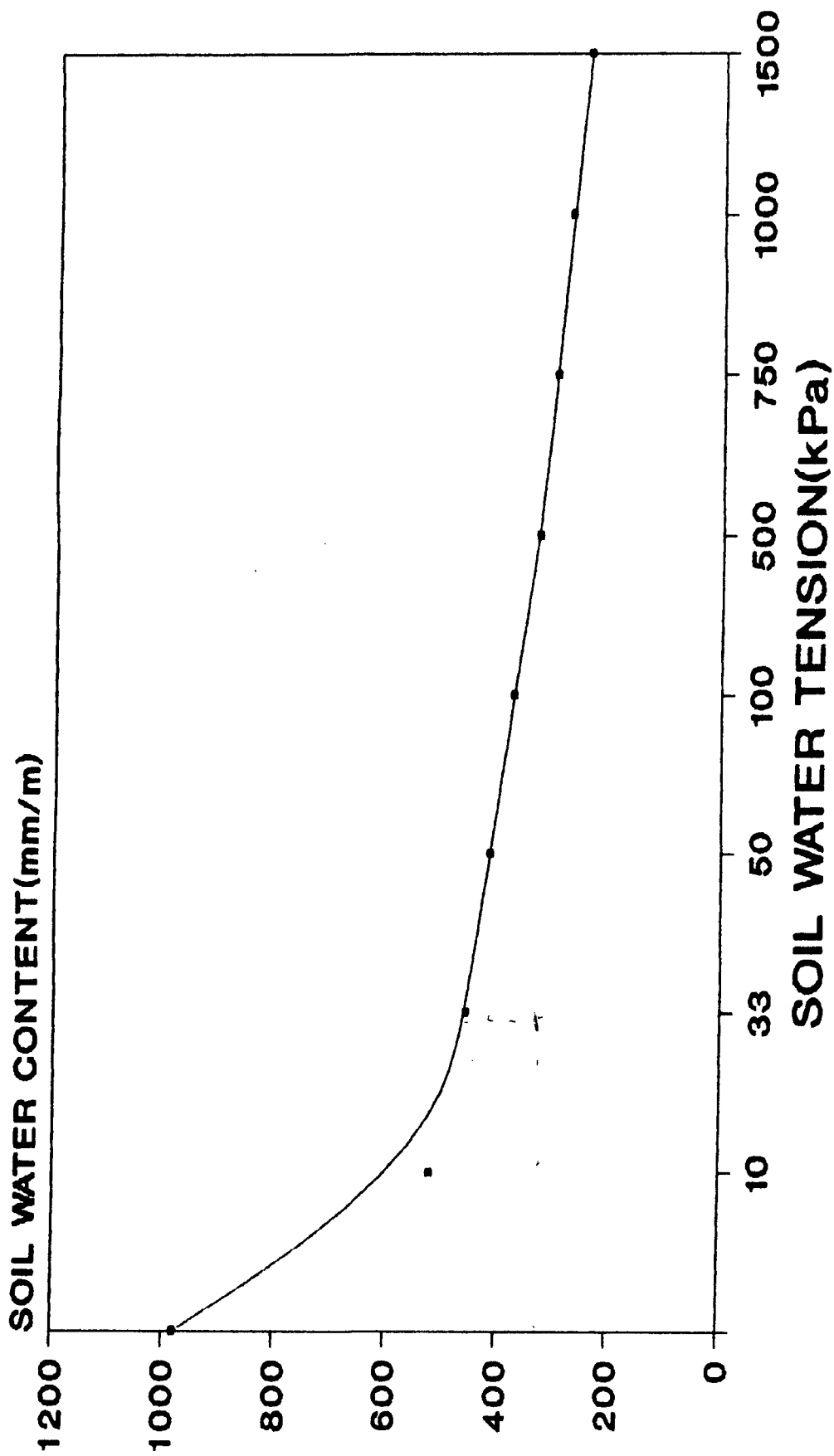


Fig. 4.1.20 : Moisture Retention Characteristics of Surat Soil (Clay)

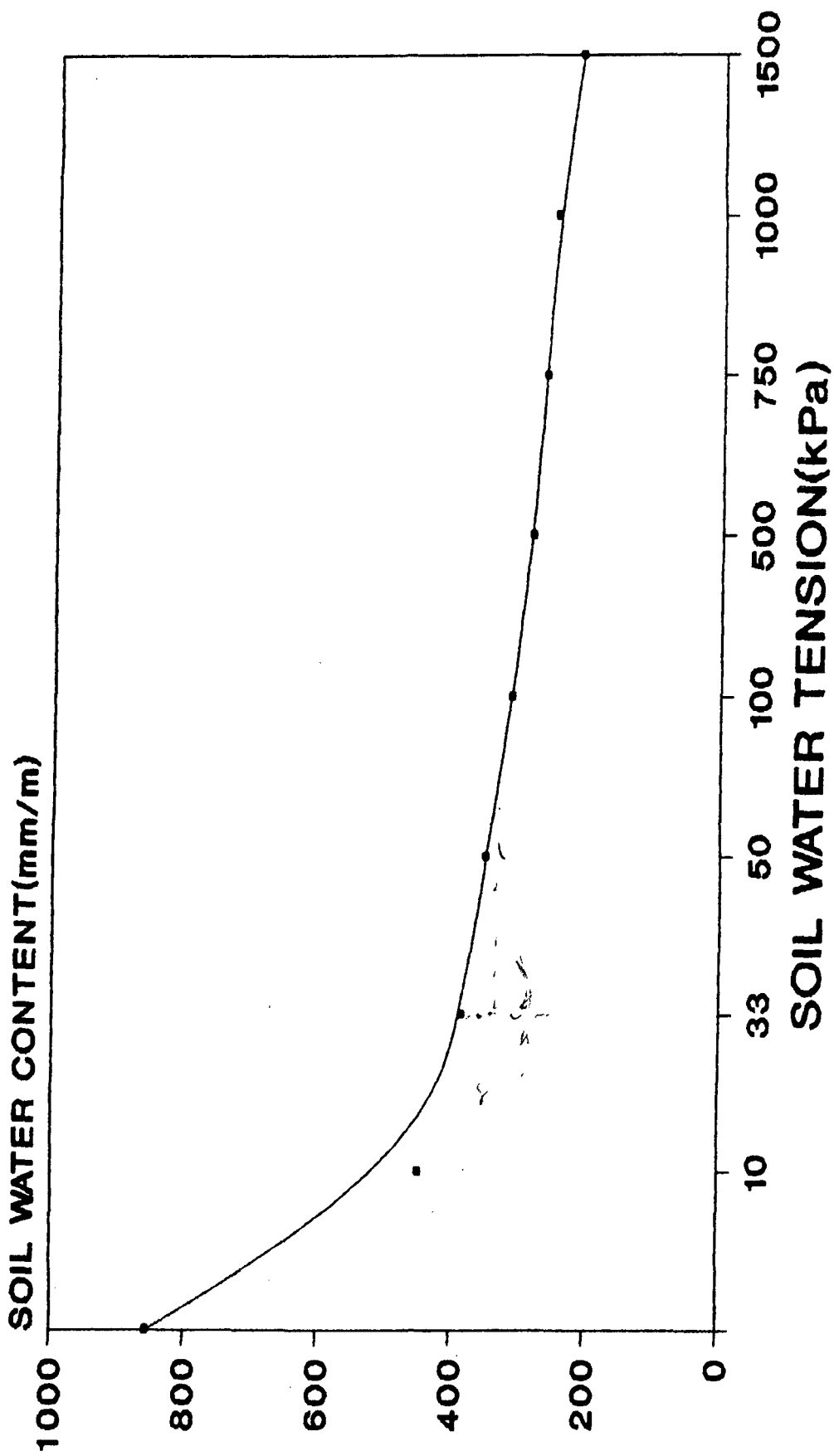


Fig. 4.1.21 : Moisture Retention Characteristics of Hansot Soil (Clay)

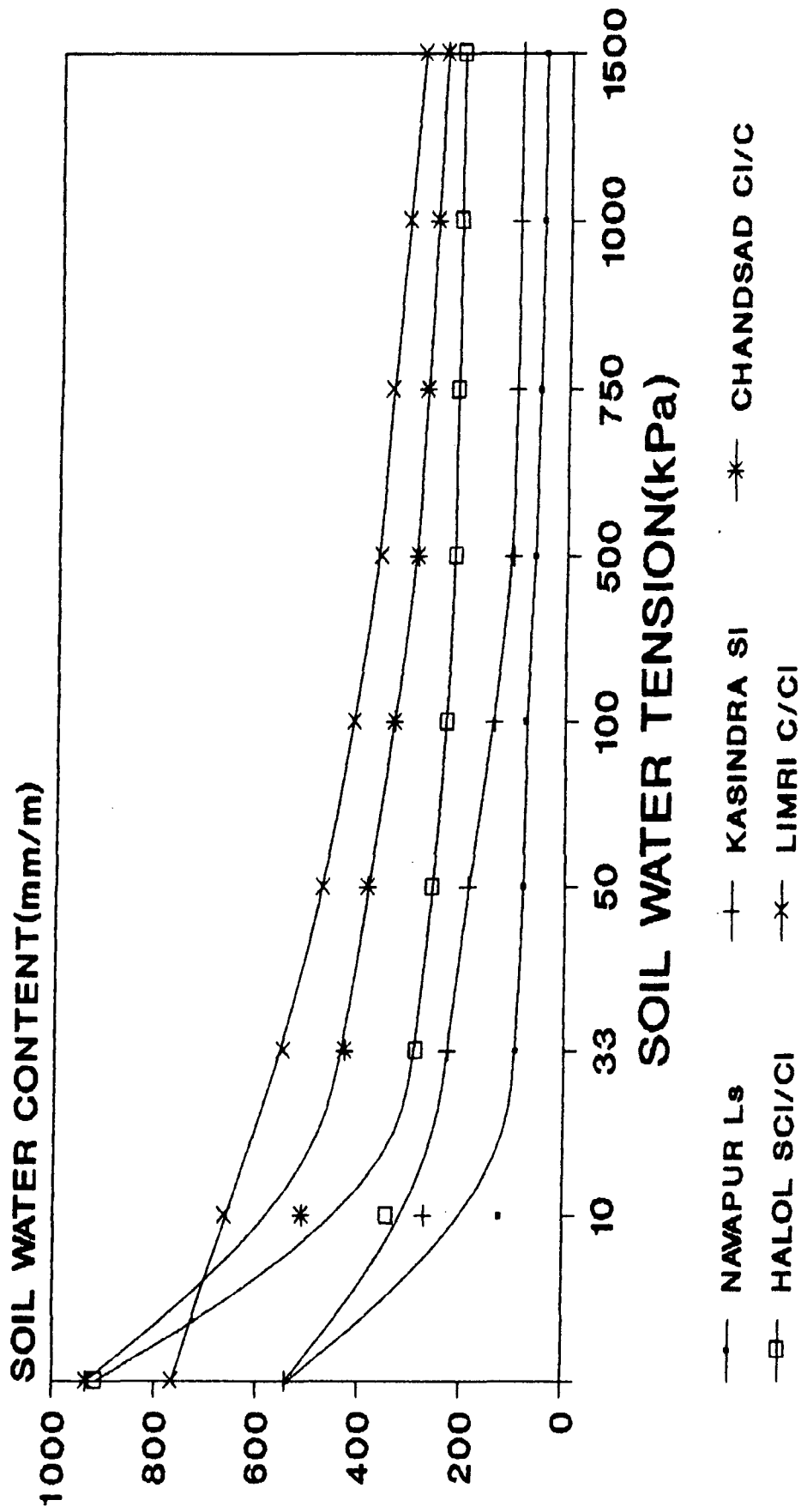


Fig. 4.1.22 : Water Retention Characteristics of Contrasting Particle Size Soils of Narmada Command

Table 4.1.1 : Physical and chemical properties of the soils of Haradja Command

Pedon No.	Depth (cm)	V.C. sand	C. sand	M. sand	F. sand	V.F. sand	Total sand	Silt	Clay	Text. class	B.C. g/cc	AWC mm/s	0.33 kPa	1500 kPa	pH	E.C. dSm <sup>-1</sup>	O.C. %	CaCO <sub>3</sub> %	CBC cmol kg <sup>-1</sup> clay	CBC/1500 clay	X pore space	
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	22.	23.	24.
1.	0-30	6.09	10.21	16.47	23.67	23.00	79.44	12.28	8.09	LS	1.36	19.2	5.46	2.96	8.57	0.44	0.16	4.80	7.88	0.98	0.37	48.68
	30-60	7.19	11.37	12.16	21.8	24.40	76.92	12.40	10.68	LS	1.40	13.48	6.84	3.63	9.04	0.41	0.09	5.13	9.22	0.86	0.34	47.17
	60-90	8.21	10.59	12.22	23.12	21.52	75.66	13.80	10.54	LS	1.42	14.1	7.14	3.83	8.96	0.42	0.09	4.75	10.00	0.95	0.36	46.41
	90-120	11.49	14.19	13.67	16.85	19.48	75.68	13.24	10.68	LS	1.42	20.4	8.67	3.89	8.87	0.46	0.05	4.25	10.66	0.99	0.36	46.41
2.	0-30	1.90	7.69	8.34	19.30	21.30	58.53	21.16	20.31	SL	1.32	31.6	13.45	5.48	7.74	0.29	0.21	5.13	20.40	1.00	0.27	50.19
	30-60	1.57	7.30	10.13	17.50	18.50	55.00	16.08	28.92	SCS	1.36	40.8	16.90	6.91	7.97	0.22	0.12	5.00	22.56	0.78	0.24	48.68
	60-90	1.38	6.62	12.18	17.80	21.32	59.53	15.19	25.28	SCS	1.43	44.2	18.36	8.05	8.06	0.20	0.16	4.75	23.52	0.93	0.32	46.03
	90-120	1.37	8.11	15.14	17.60	16.64	58.86	15.58	25.56	SCS	1.44	45.8	18.64	8.05	8.33	0.22	0.17	5.38	23.52	0.92	0.31	45.66
3.	0-30	-	0.13	14.09	14.38	43.40	72.00	14.54	13.48	SL	1.40	33.9	14.20	6.13	7.90	0.28	0.12	4.75	14.38	1.07	0.45	47.17
	30-60	-	-	0.78	17.84	49.38	68.00	14.88	17.12	SL	1.42	31.4	14.39	7.01	8.08	0.28	0.12	5.13	17.64	1.03	0.41	46.41
	60-90	-	-	0.10	20.96	50.94	72.00	9.20	18.80	SL	1.43	38.4	17.02	8.05	7.98	0.24	0.12	4.63	20.78	1.11	0.43	46.03
	90-120	-	-	0.04	24.27	51.69	76.00	7.28	16.72	SL	1.43	31.2	15.71	8.10	8.11	0.24	0.12	4.63	14.38	0.86	0.48	46.03
4.	0-30	-	5.18	10.08	15.92	40.43	71.61	15.41	12.48	SL	1.40	18.6	9.63	5.19	8.40	0.32	0.16	6.00	10.84	0.87	0.42	47.17
	30-60	-	5.05	10.15	16.97	32.68	64.85	18.47	16.68	SL	1.43	25.1	12.34	6.49	7.90	0.30	0.08	5.13	15.92	0.95	0.39	46.04
	60-90	-	-	3.05	17.60	37.48	58.13	17.20	24.67	SCS	1.43	32.0	18.10	10.63	7.90	0.32	0.13	5.13	22.36	0.91	0.43	46.04
	90-120	-	-	5.05	20.46	31.27	56.79	15.51	27.70	SCS	1.43	38.10	20.55	11.67	7.90	0.31	0.17	4.50	24.86	0.90	0.42	46.04
5.	0-30	1.17	2.15	6.34	14.00	18.00	41.66	19.88	35.46	CL	1.25	57.9	34.11	18.67	8.10	0.47	0.23	5.56	39.84	1.12	0.53	52.83
	30-60	1.03	1.73	7.14	15.20	16.20	41.30	21.68	37.02	CL	1.25	65.90	36.56	18.97	8.30	0.55	0.15	6.19	40.00	1.08	0.50	52.63
	60-90	1.02	1.89	5.16	11.85	13.60	33.52	24.48	42.00	C	1.27	65.70	37.24	20.00	7.90	1.15	0.16	5.31	47.32	1.13	0.48	52.07
	90-120	-	0.97	2.47	10.28	11.80	25.52	28.64	45.84	C	1.28	69.80	38.71	20.52	7.70	1.78	0.17	5.81	48.22	1.05	0.45	51.70
6.	0-30	0.52	2.24	5.30	20.65	28.53	57.24	18.10	24.66	SCS	1.39	28.9	18.68	13.66	8.00	0.28	0.19	9.54	24.16	0.98	0.55	47.55
	30-60	1.53	3.40	4.87	16.75	19.45	48.00	25.80	26.20	SCS	1.40	19.1	19.28	14.73	8.20	0.31	0.13	10.31	24.63	0.94	0.56	47.17
	60-90	0.58	1.69	4.43	12.34	26.96	46.00	22.84	31.16	CL	1.44	24.8	21.36	15.62	8.30	0.34	0.15	10.69	29.30	0.94	0.50	45.66
	90-120	1.62	3.15	5.31	12.42	17.30	40.00	21.84	38.16	CL	1.46	40.5	25.85	16.80	8.90	0.50	0.15	11.04	34.02	0.89	0.44	44.91

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	22.	23.	24.
7.	0-30	-	-	-	5.07	16.61	42.08	53.76	10.50	25.56	8CL	1.34	15.8	18.03	14.10	8.70	0.44	0.19	-	20.96	0.82	0.55	49.43
	30-60	-	3.14	8.08	10.06	40.40	51.68	10.36	27.96	8CL	1.37	18.4	19.00	15.41	8.50	0.41	0.24	-	23.77	0.85	0.55	48.30	
	60-90	-	-	8.02	20.50	35.47	53.99	8.53	27.48	8CL	1.42	22.01	21.03	15.87	8.50	0.55	0.16	-	23.91	0.87	0.58	46.41	
	90-120	-	5.05	10.14	15.56	36.50	57.25	10.36	22.39	8L	1.44	17.8	17.21	13.08	8.28	0.63	0.13	-	18.36	0.82	0.58	45.66	
8.	0-30	-	1.00	2.13	21.56	45.27	69.96	9.36	20.68	8CL	1.39	34.4	14.60	6.35	8.12	0.59	0.30	-	15.60	0.75	0.31	47.55	
	30-60	-	0.49	4.65	16.54	48.24	69.92	7.40	22.68	8CL	1.40	49.9	23.08	11.19	8.30	0.49	0.27	-	16.36	0.72	0.49	47.16	
	60-90	-	-	2.24	25.48	38.08	65.80	9.24	24.96	8CL	1.40	66.7	30.15	14.26	8.34	0.49	0.24	-	21.04	0.84	0.57	47.16	
	90-120	-	2.00	7.07	18.81	38.96	66.84	9.68	23.48	8CL	1.40	70.4	30.44	13.67	8.51	0.46	0.16	-	21.22	0.90	0.50	47.16	
9.	0-30	-	-	6.23	25.33	39.40	70.96	9.28	19.76	8L	1.41	41.4	20.78	10.99	8.30	0.56	0.24	1.63	16.36	0.83	0.66	46.79	
	30-60	-	2.08	6.27	15.87	39.78	64.00	12.76	23.24	8CL	1.35	39.0	22.28	12.64	8.80	0.49	0.19	10.52	19.28	0.83	0.54	49.06	
	60-90	-	1.72	8.33	20.23	39.28	69.56	10.00	20.44	8CL	1.40	41.2	20.59	10.78	8.70	0.44	0.19	7.65	16.56	0.81	0.53	47.16	
	90-120	1.05	1.37	4.58	22.69	43.17	72.86	9.20	17.94	8L	1.44	40.1	18.54	9.27	8.50	0.41	0.16	14.50	14.35	0.80	0.52	45.66	
10.	0-30	-	-	3.07	20.38	49.87	73.32	8.52	18.16	8CL	1.40	32.8	12.49	4.69	7.32	0.60	0.12	-	15.86	0.87	0.26	47.16	
	30-60	-	1.00	8.33	20.35	38.76	68.44	9.48	23.08	8CL	1.40	26.3	14.42	8.15	7.74	0.99	0.12	-	29.72	0.90	0.35	47.16	
	60-90	-	1.22	8.78	22.34	33.34	65.68	9.88	24.44	8CL	1.42	29.0	14.87	8.07	7.92	1.05	0.12	-	24.76	1.01	0.33	46.41	
	90-120	-	4.63	15.03	16.44	36.38	72.48	9.12	18.40	8L	1.44	31.3	15.59	8.34	8.10	0.72	0.13	-	16.36	0.89	0.45	45.66	
11.	0-30	0.60	1.31	3.84	12.68	14.85	33.28	32.88	33.84	CL	1.30	49.7	30.10	17.36	8.70	0.42	0.16	9.31	38.10	1.13	0.51	50.94	
	30-60	0.89	2.10	3.98	12.62	13.69	33.28	28.48	38.24	CL	1.30	64.6	36.45	19.88	9.40	0.47	0.16	9.54	48.91	1.07	0.52	50.94	
	60-90	0.54	1.08	2.42	11.77	19.93	35.74	23.60	40.66	C	1.31	76.7	40.40	20.89	9.30	0.78	0.19	9.25	41.27	1.02	0.52	50.37	
	90-120	-	0.63	0.98	12.70	17.70	32.01	28.36	39.63	CL	1.40	75.2	41.50	23.60	9.60	2.77	0.20	10.54	48.03	1.01	0.59	47.16	
12.	0-30	1.39	3.90	4.06	10.38	10.37	30.10	32.76	37.14	CL	1.26	59.0	35.10	19.49	8.80	0.41	0.24	6.98	36.39	0.98	0.52	52.45	
	30-60	2.15	3.75	4.19	11.77	8.26	30.12	29.68	40.29	C	1.26	59.8	36.67	20.85	9.00	0.55	0.24	5.91	41.21	1.01	0.51	52.45	
	60-90	1.11	2.67	4.64	11.70	10.38	30.50	26.36	43.14	C	1.30	81.9	42.25	21.24	9.30	1.10	0.20	6.94	42.71	0.99	0.49	50.94	
	90-120	2.24	5.24	7.66	10.64	9.83	35.61	33.08	41.31	C	1.31	69.4	39.55	21.89	9.40	1.85	0.15	9.41	40.90	0.99	0.53	50.37	
13.	0-30	1.64	3.23	6.54	9.16	8.56	29.13	28.24	42.63	C	1.25	68.7	40.10	21.79	8.80	0.39	0.19	6.75	46.47	1.09	0.51	52.63	
	30-60	1.03	2.09	5.13	11.24	9.16	28.65	30.16	41.19	C	1.32	88.30	44.90	22.62	9.30	0.88	0.21	6.75	45.30	1.10	0.55	50.19	
	60-90	0.14	2.12	5.68	11.52	9.57	29.03	34.17	36.80	CL	1.32	87.80	44.18	22.02	9.00	1.39	0.20	6.75	39.38	1.07	0.60	50.19	
	90-120	0.31	1.30	3.39	8.41	9.63	23.04	44.64	32.32	CL	1.35	81.31	41.93	21.85	9.00	2.02	0.13	10.19	32.37	1.02	0.68	49.06	

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	22.	23.	24.
14.	0-30	0.83	1.09	0.89	20.31	43.76	74.08	7.28	18.64	8L	1.36	24.6	11.21	5.16	7.99	0.54	0.23	-	17.90	0.96	0.28	47.16	
	30-60	2.49	10.42	10.14	11.37	42.02	76.44	6.84	16.72	8L	1.42	21.20	9.25	4.28	8.22	0.33	0.16	-	17.90	1.07	0.26	46.79	
	60-90	0.41	3.40	10.12	22.31	40.76	77.00	5.52	16.48	8L	1.44	21.30	8.94	4.01	8.32	0.32	0.02	-	13.56	0.82	0.24	46.41	
	90-120	-	0.68	11.16	18.46	47.70	78.20	5.64	16.16	8L	1.46	20.68	8.48	3.77	8.61	0.29	0.02	-	13.30	0.82	0.23	45.66	
15.	0-30	-	1.31	16.14	15.63	32.08	65.16	9.44	25.40	8CL	1.40	38.4	16.37	7.22	7.77	1.34	0.09	2.50	25.54	1.00	0.28	48.68	
	30-60	-	0.65	10.09	20.39	26.36	57.48	12.89	29.64	8CL	1.41	59.7	27.51	13.39	7.91	0.66	0.05	4.19	29.16	0.98	0.45	46.41	
	60-90	-	0.43	7.18	20.09	30.54	58.24	10.40	31.36	8CL	1.42	64.5	29.06	13.91	7.73	0.67	0.05	4.06	33.76	1.08	0.44	45.66	
	90-120	-	2.29	9.29	13.53	29.73	54.84	11.16	34.00	8CL	1.44	66.8	29.27	13.99	7.77	1.25	0.05	4.31	33.50	0.98	0.41	44.90	
16.	0-30	-	-	10.64	32.93	41.13	84.70	10.20	5.10	LS	1.40	19.00	6.68	2.40	8.40	0.40	0.18	5.20	4.50	-	-	47.17	
	30-60	-	3.11	10.15	30.39	41.25	84.90	10.10	5.00	LS	1.42	17.30	6.30	2.25	8.82	0.41	0.10	5.73	4.40	-	-	46.41	
	60-90	1.00	3.10	9.17	29.72	39.61	82.60	12.40	5.00	LS	1.44	17.30	6.30	2.30	8.46	0.43	0.10	5.05	4.60	-	-	45.66	
	90-120	2.00	2.26	9.71	28.27	38.26	80.50	14.60	4.90	LS	1.45	16.70	6.05	2.20	8.37	0.46	0.08	5.15	4.40	-	-	45.28	
17.	0-30	1.97	4.93	14.63	21.29	27.18	70.00	10.00	20.00	8L	1.40	39.1	14.60	5.37	8.20	0.92	0.20	6.82	19.57	-	-	47.17	
	30-60	0.82	2.69	15.41	22.31	28.27	69.50	8.00	22.50	8L	1.42	48.0	20.53	9.73	8.46	1.02	0.25	7.05	20.69	-	-	46.41	
	60-90	-	1.45	11.61	23.81	29.13	66.00	10.00	24.00	8L	1.45	43.9	18.60	8.50	8.59	1.24	0.30	9.30	22.36	-	-	45.28	
	90-120	1.8	5.35	13.81	21.91	24.13	67.00	10.00	23.00	9L	1.47	49.6	19.00	7.75	8.92	1.48	0.18	10.50	22.78	-	-	44.53	
18.	0-30	-	1.80	5.49	8.36	6.35	22.00	26.00	52.00	C	1.27	57.7	32.20	17.85	8.82	1.90	0.52	15.00	43.26	-	-	52.07	
	30-60	-	0.88	3.78	7.61	5.73	18.00	27.00	55.00	C	1.30	62.8	34.00	17.90	8.96	2.40	0.50	21.25	46.29	-	-	50.94	
	60-90	-	0.33	4.96	8.29	6.42	20.00	23.00	57.00	C	1.32	67.9	36.20	19.05	9.20	3.20	0.42	25.30	48.00	-	-	50.19	
	90-120	1.89	2.97	3.23	4.18	5.73	18.00	24.00	58.00	C	1.35	59.3	33.50	19.60	9.30	4.10	0.20	30.26	46.37	-	-	49.06	
19.	0-30	0.96	1.31	4.91	6.01	6.81	20.00	24.00	56.00	C	1.28	71.3	34.42	15.85	8.10	0.65	0.58	6.60	46.70	-	-	51.70	
	30-60	1.11	2.13	4.14	8.73	6.89	23.00	23.00	54.00	C	1.31	68.6	33.36	15.90	8.25	0.72	0.56	7.26	46.30	-	-	50.57	
	60-90	1.51	3.23	6.93	6.21	8.12	26.00	22.00	52.00	C	1.32	70.3	32.65	14.90	8.25	0.60	0.42	8.50	42.60	-	-	50.19	
	90-120	2.03	5.16	7.18	7.13	8.50	30.00	20.00	50.00	C	1.35	67.4	28.50	12.15	8.30	0.92	0.25	8.70	39.60	-	-	49.06	
20.	0-30	0.96	2.13	6.04	5.83	8.04	23.00	21.00	56.00	C	1.29	70.8	39.60	18.30	8.30	0.65	0.43	5.62	46.50	-	-	51.32	
	30-60	1.36	3.45	7.11	4.76	6.32	23.00	21.20	55.80	C	1.31	75.5	38.15	18.95	8.45	0.73	0.50	6.80	46.10	-	-	50.57	
	60-90	2.13	3.46	7.19	5.01	4.81	22.60	22.60	54.80	C	1.34	75.0	37.35	18.70	8.53	0.92	0.45	7.52	46.00	-	-	49.43	
	90-120	2.29	4.16	7.21	6.21	6.93	26.80	20.30	52.90	C	1.36	80.7	36.05	16.27	8.62	1.05	0.30	8.63	43.20	-	-	48.68	
21.	0-30	0.61	2.16	3.32	8.12	11.89	26.10	24.30	49.60	C	1.30	59.6	32.40	17.30	8.40	1.05	0.41	8.00	40.10	-	-	50.94	
	30-60	1.12	3.29	4.31	9.07	7.81	25.60	26.70	47.70	C	1.32	57.2	30.60	16.15	8.58	1.21	0.48	8.69	38.20	-	-	50.19	
	60-90	1.49	4.21	6.19	7.01	7.10	26.00	28.00	46.00	C	1.35	59.3	30.05	15.40	8.66	1.32	0.40	9.30	36.60	-	-	49.06	
	90-120	2.05	5.13	7.26	6.13	7.43	28.00	30.00	42.00	C	1.37	54.7	28.19	14.89	8.72	1.46	0.37	10.15	32.33	-	-	48.30	

figure that texture has a significant effect on the amount of moisture held by the soil. Soils that are coarse in texture have more macropores and therefore release large amounts of water at low tension, whereas those which are finer in texture having greater quantity of micropores release water gradually. Similar observations on the relationship between amount of water held and the tension at which it is held have been made by Ghuman and Prihar (1980) and Dent and Scammell (1981), while studying the moisture retention characteristics of soils differing widely in texture. The data on soil available water capacity was subjected to multiple regression analysis and stepwise regression using the various physical and chemical properties as variables. The stepwise multiple regression technique gave a  $r^2$  i.e. coefficient of determination value of 0.67. The regression equation developed was :

$$Y(\text{AWC}) = 7.1210 + 0.5617(\text{Silt}) + 1.0937(\text{Clay}) - 0.5618(\text{CaCO}_3)$$

The equation points out both silt and clay content individually or together have a positive effect on the AWC, while the  $\text{CaCO}_3$  content has a negative effect on AWC. However, the  $r^2$  value was slightly less and points out to the need to compare the AWC with larger number of variables as well as larger number of samples. The role of silt and clay in improving the AWC has also been reported by several workers (Oswal and Khanna, 1981; Mishra and Nanda, 1985).

The amount of water held by the soil expressed as per cent (weight by weight) and mm/cm depth of soil in soils of widely differing textural classes is presented in figure 4.1.23. It is seen from the figure that even a slight variation in the textural composition layerwise makes a significant difference in the moisture retention characteristics of soil as compared to the general relationship between texture and quantity of moisture held. The variation from the general pattern of relationship may be the change in the structure in the soil, at soil number 6. As a result of presence of clay loam texture which is decidedly more strongly structured than the sandy clay loam texture above. As a result of strong structure, the amount of moisture extracted might have reduced, probably because of greater force with which the moisture is held. Similar effect of strong structural layers on moisture extraction pattern have been observed by Boedt and Verheye (1986).

The figures at 4.1.24 to 4.1.28 show the effect of strongly contrasting particle sizes on the behaviour of the pattern of moisture held at various tensions. While the soils at figures 4.1.24 to 4.1.26 show a more or less definite pattern, the effect of change in particle size distribution with depth shows a significant effect on the moisture retention characteristics of soils at figures 4.1.27 and 4.1.28. There is a marked decrease in the water availability in those layers which have finer texture than

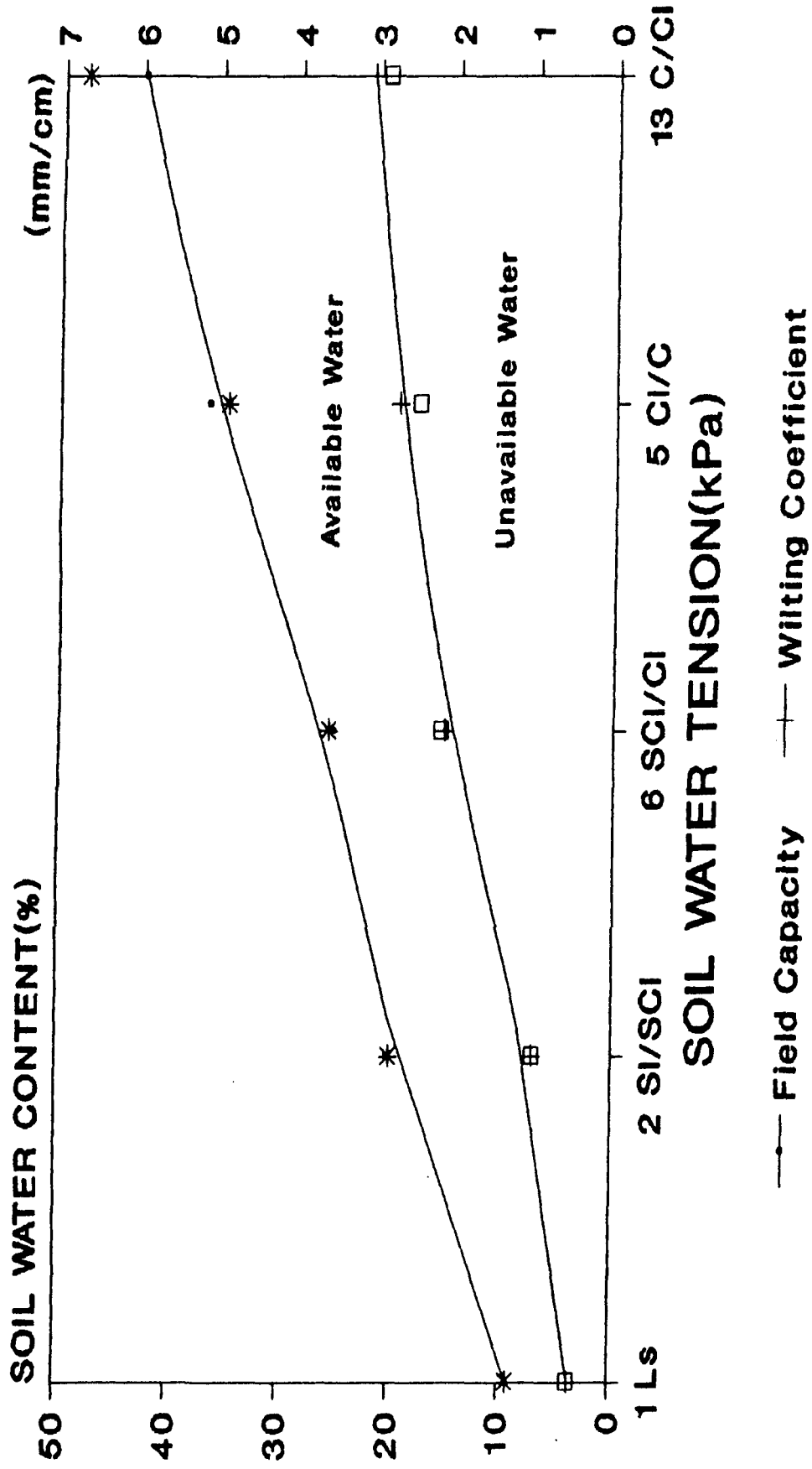


Fig. 4.1.29: Relationship between soil water characteristics (% moisture and mm/cm) and soil texture

those above. Greater moisture is held at corresponding tensions in finer texture soils than the medium texture soils but with lower availability. Similar observations on soil water availability-textural relationships have been observed by Petersen *et al.* (1968) in soils of Pennsylvania State, USA. These authors concluded that medium textured soils provided greater quantity of water than either the coarser or finer textured soils and hence have a great significance for irrigation. Another information that the figures 4.1.24 to 4.1.28 reveal is that in most of the soils, largest quantity of water is held between 0 and 10 kPa while the water held between 10 and 50 kPa is comparatively lower, while that between 50 and 100 kPa is still lower. Thus, it is very important that in coarser and medium textured soils a value of upper limit of field capacity should be definitely lesser than 33 kPa, probably around 5-10 kPa, while for finer texture this value may be at 33 kPa or even upto 50 kPa, depending upon the per cent content of clay. Similar observations have been made by Dent and Scammell (1981) while selecting the upper limit for soils with varying textures.

From the data presented in Table 4.1.1 it is quite clear that the Narmada command water supply will be tending to a wide range of soils which are different, both in their physical and chemical properties. It is, therefore, quite natural that the response to irrigation by these soils will

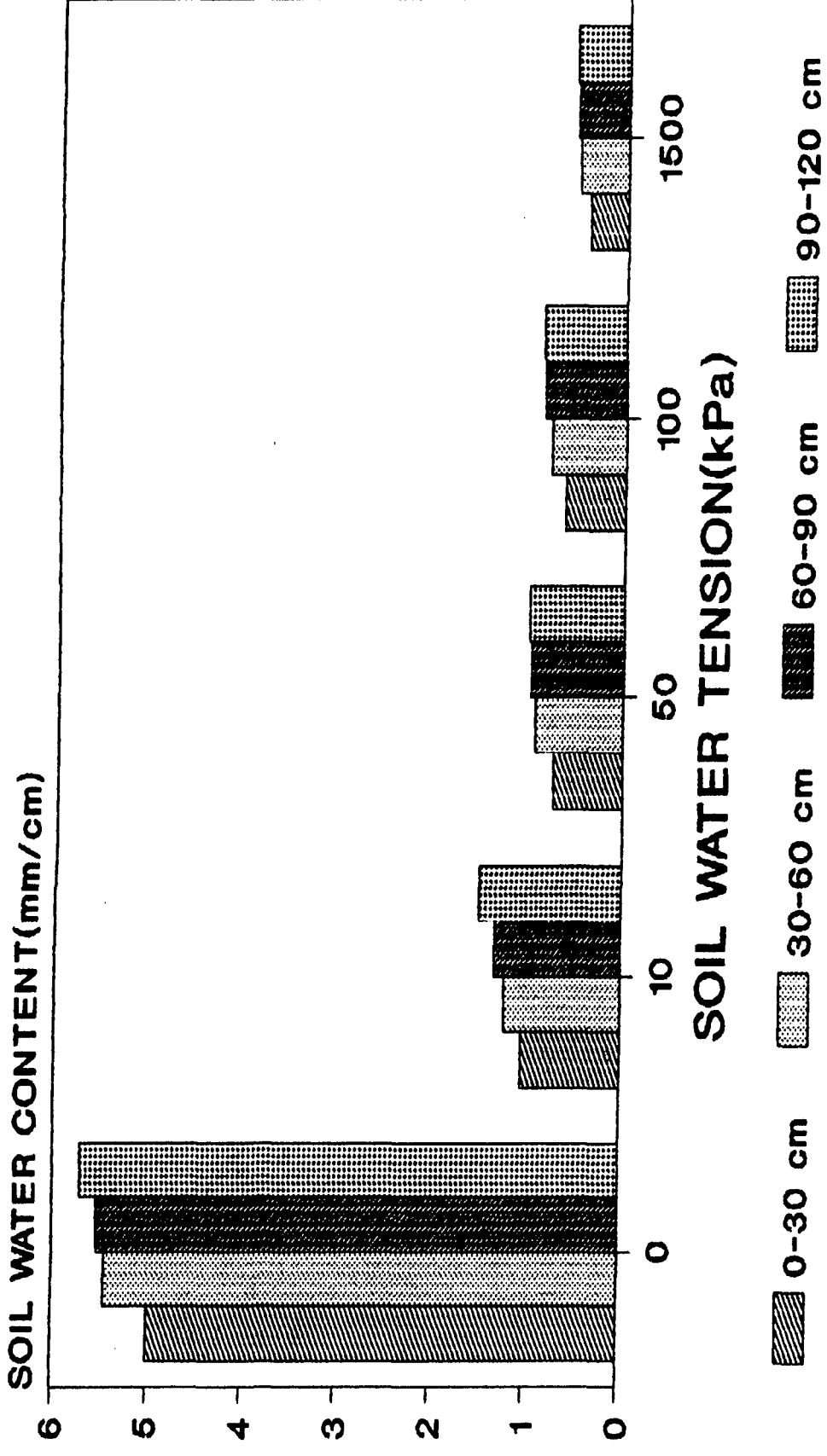


Fig. 4.1.24 : mm/cm of soil moisture held at different tensions and depth (Navapur Soil)

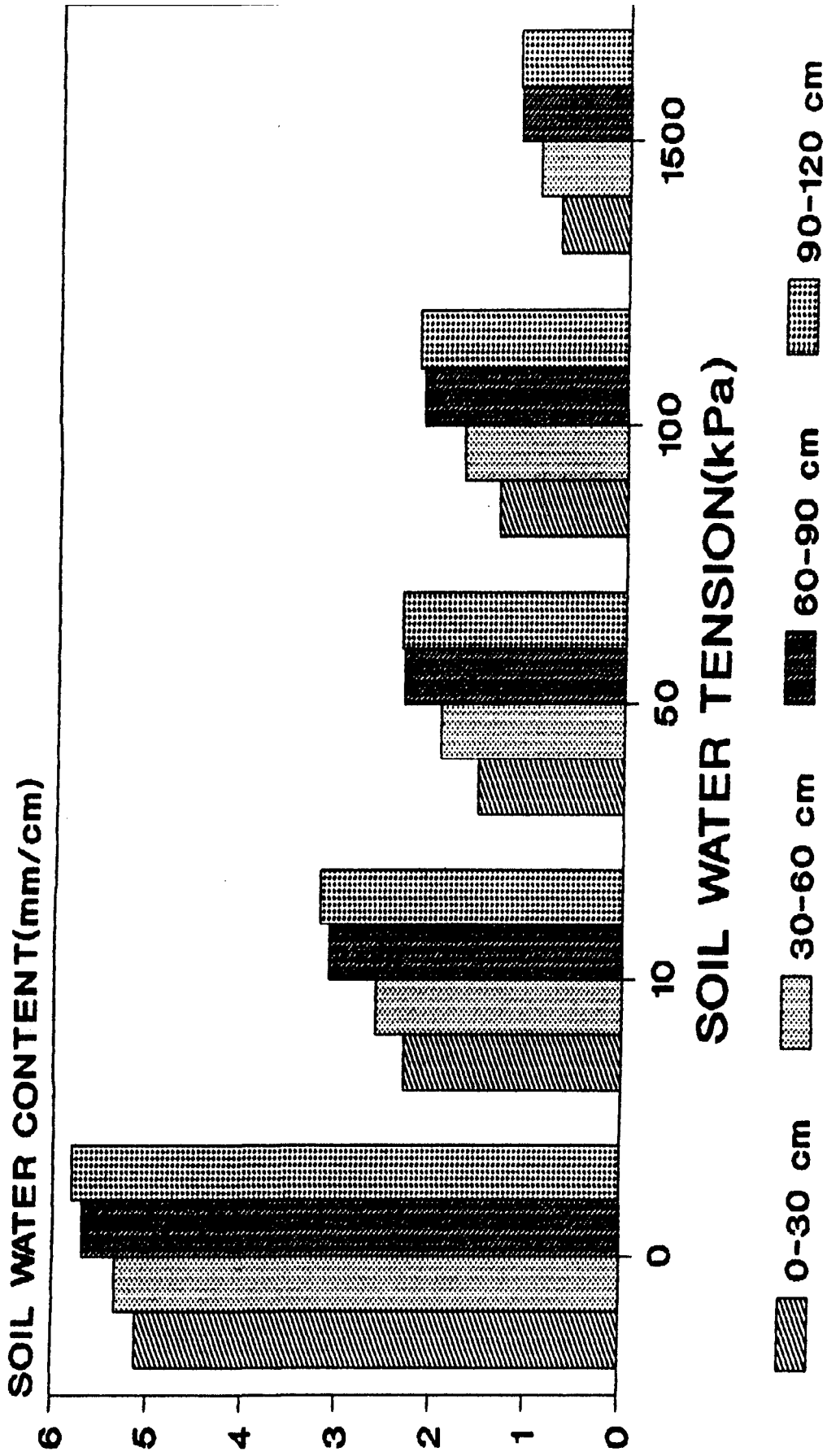


Fig. 4.1.25: mm/cm of Soil moisture held at different tensions and depth (Kasindra Soil)

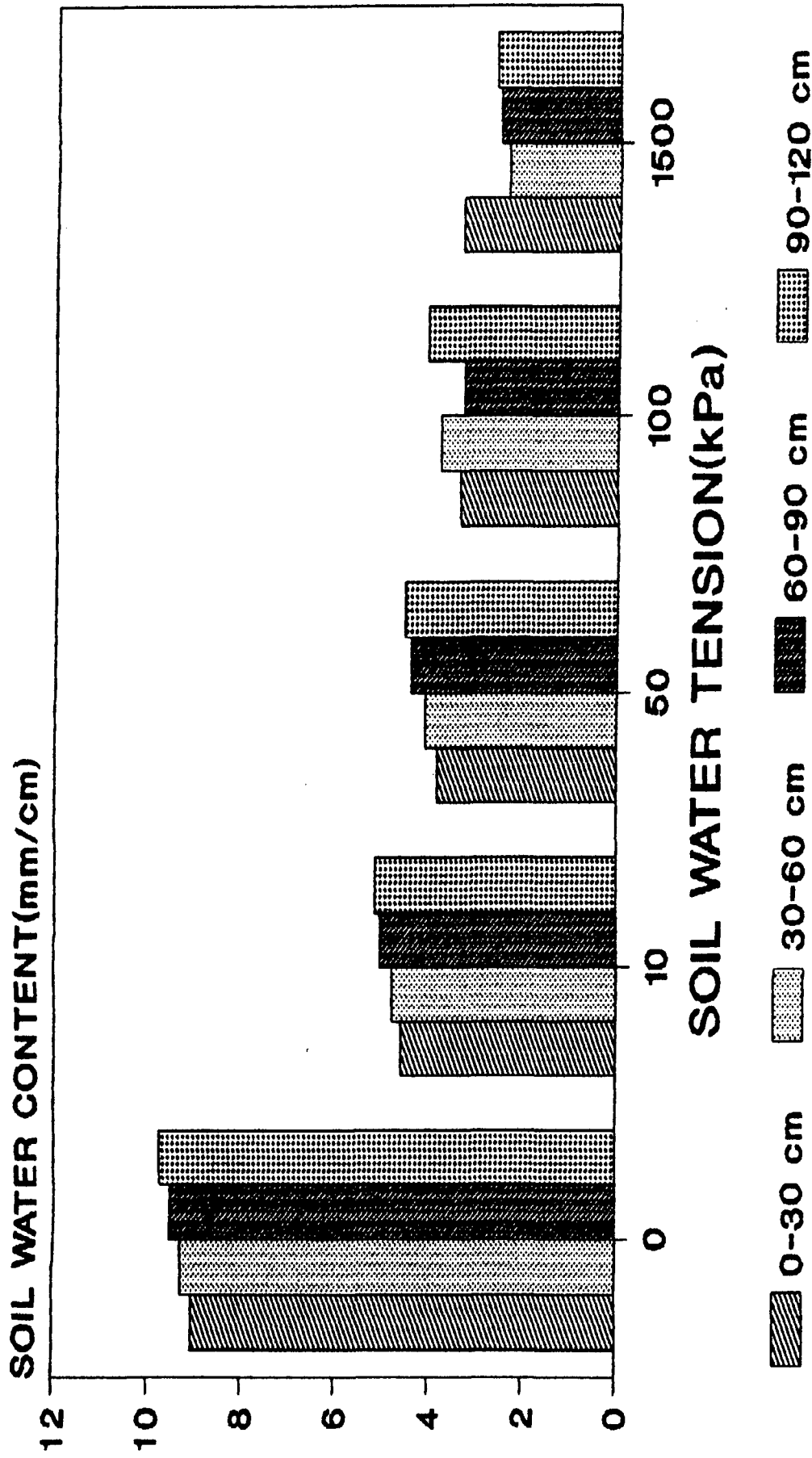


Fig. 4.1.26: mm/cm of Soil moisture held at different tensions and depth (Chandeed Soil)

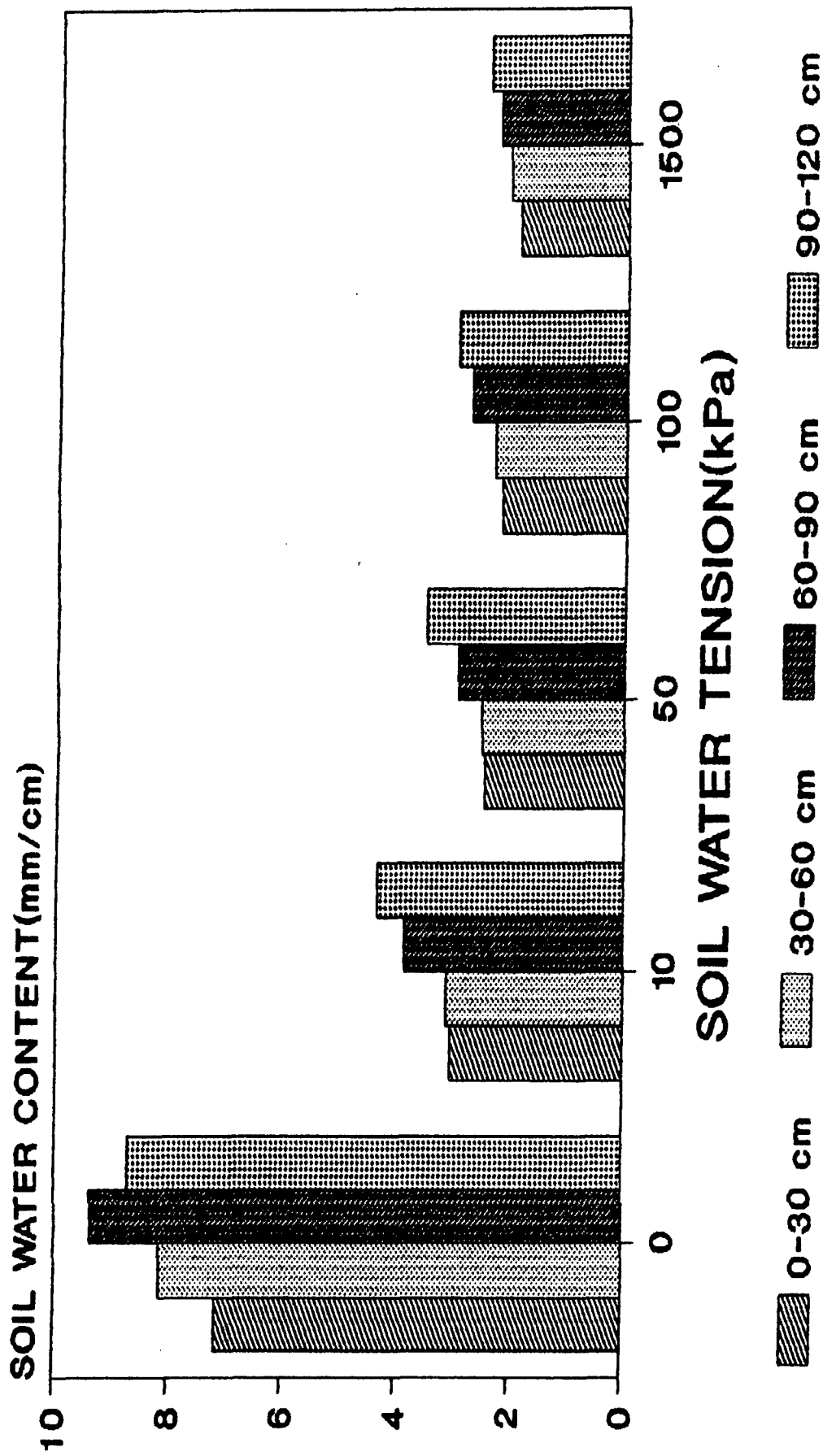


Fig. 4.1.27: mm/cm of Soil moisture held at different tensiome and depth (Halol Soil)

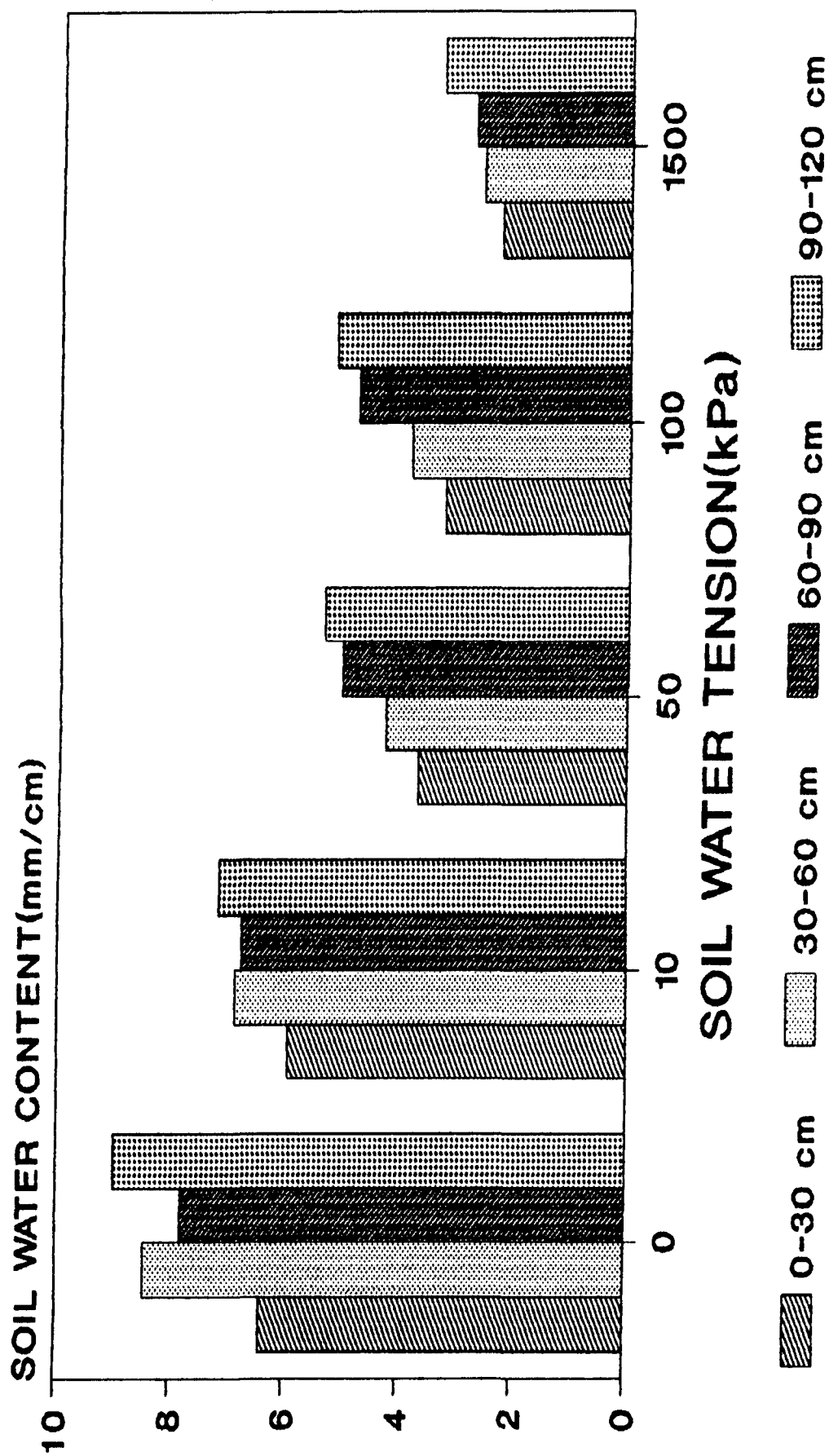


Fig. 4.1.28: mm/cm of Soil moisture held at different tensions and depth (Dahej Soil)

be widely differing. Also the wide variability of the soils will definitely have a bearing on the frequency of irrigation and the extent of irrigation i.e. quantity of irrigation water to be applied per irrigation. The plot of the water held(mm/m), against the tension (kPa) (Fig. 4.1.1 to 4.1.21) shows that while the soils differ in their capacity to hold water depending on the soil texture, yet all the soils show a similar trend. There is a sudden drop in the quantity of water held at 0 tension to that held at 33 kPa, and as the tension increases, the differences in the quantity of water held narrow down significantly. This fact implies that as the soil dries, the resistance to water movement towards the roots increases significantly. Similar observations have been made by Dent and Scammel (1981). According to these workers, as the soil becomes progressively drier, the resistance to water movement increases as the soil moisture films become thinner and thinner and the tension at which the remaining water is held increases substantially, causing moisture stress. The total space occupied by soil moisture expressed as per cent of soil volume is presented in table 4.1.2 for the different soil profiles of the Narmada command. It is seen from the table 4.1.2 that as much as 100 per cent to around 90 per cent of the soil volume is occupied by moisture held at 0 tension and it progressively decreases as the tension

Table 4.1.2 : Per cent of soil volume occupied by soil moisture in different soils

Profile No.	Kpa	Depth (cm)			
		0-30	30-60	60-90	90-120
1.	2.	3.	4.	5.	6.
Nawapur	0	88.03	92.89	92.57	93.81
	10	59.03	62.74	62.99	64.19
	100	55.95	59.61	59.61	59.72
	1500	54.28	57.59	57.41	57.47
Kasindra	0	88.57	94.33	97.53	96.86
	10	67.22	74.22	79.37	78.85
	100	60.04	67.76	72.69	71.88
	1500	55.29	62.00	65.79	64.65
Anand	0	99.15	98.11	98.68	100.00+
	10	63.33	67.09	70.99	70.36
	50	59.74	59.88	62.05	61.25
	500	53.51	54.58	56.18	55.73
	1500	53.30	53.42	53.04	54.08
Dabhasha	0	92.81	94.77	100.00+	100.00+
	10	65.70	69.40	77.29	78.93
	50	55.80	57.76	62.86	63.71
	500	53.70	55.04	57.79	59.57
	1500	52.36	52.53	56.67	57.71
Chandsad	10	91.52	95.28	98.96	100.00+
	50	85.37	89.61	93.89	97.63
	500	77.15	79.76	83.34	86.46
	1500	73.39	75.95	79.24	82.78
Halol	10	74.34	75.15	84.96	92.44
	50	70.20	70.85	78.45	86.56
	500	66.60	67.88	74.62	80.36
	1500	66.11	67.56	73.73	79.44
Asod	0	97.88	100.00+	100.00+	95.66
	10	73.39	73.52	74.21	67.93
	50	66.93	66.99	66.39	62.87
	500	64.59	64.99	64.15	61.41
	1500	63.53	63.71	62.28	58.74

1.	2.	3.	4.	5.	6.
Sunav	0	95.50	97.57	98.04	99.56
	10	66.59	75.45	81.26	81.83
	50	58.89	67.49	73.64	73.99
	500	57.34	61.80	65.11	65.24
	1500	53.90	58.35	61.42	60.83
Tarapur	0	94.30	100.00+	100.00+	93.88
	10	74.80	80.60	76.93	72.86
	50	65.15	69.47	66.45	62.10
	500	61.75	65.45	62.44	62.10
	1500	57.78	61.70	57.94	54.93
Dharmaj	0	92.68	100.00+	96.00	95.35
	10	65.90	68.75	70.72	70.85
	50	58.47	60.53	60.08	60.03
	500	55.58	57.50	57.87	57.99
	1500	51.85	55.31	54.48	54.00
Dahej	10	93.67	100.00+	100.00+	98.38
	50	79.14	83.60	88.91	85.58
	500	71.75	77.07	77.93	76.62
	1500	68.30	70.82	71.46	70.76
Rahiad	0	100.00+	100.00+	100.00+	100.00+
	10	98.18	100.00+	100.00+	100.00+
	50	80.65	85.11	89.28	88.99
	500	73.26	78.58	78.30	80.03
	1500	69.81	72.33	71.83	74.17
Limri	0	100.00+	100.00+	100.00+	100.00+
	10	100.00+	99.38	100.00+	100.00+
	50	88.97	92.78	93.15	87.90
	500	82.54	83.67	84.90	82.20
	1500	74.62	72.81	72.21	70.91
Lingda	0	93.43	100.00+	100.00+	100.00+
	10	70.83	78.52	79.33	77.63
	50	61.70	70.09	71.57	71.19
	500	57.73	66.36	66.80	66.32
	1500	54.38	60.18	60.32	59.65
WALMI	0	87.38	86.49	79.81	70.25
	10	68.32	60.09	56.87	55.70
	50	58.56	55.45	53.51	51.80
	500	56.36	52.92	51.64	49.94
	1500	53.86	50.69	49.67	48.67

1.	2.	3.	4.	5.	6.
S K Nagar	0	74.37	73.51	74.56	74.58
	10	56.92	55.81	54.51	53.63
	50	52.25	51.10	50.86	50.23
	500	51.05	49.81	49.26	48.70
	1500	49.57	48.66	47.96	47.48
Bachau	0	77.42	88.04	84.11	80.00
	10	66.24	73.38	69.18	70.63
	50	59.84	64.64	61.81	60.88
	500	55.57	59.24	56.68	55.93
	1500	52.54	56.14	53.78	52.28
Arnej	0	100.00+	100.00+	100.00+	100.00+
	10	88.05	89.04	90.99	90.36
	50	80.60	81.44	83.39	78.16
	500	70.69	70.69	69.94	69.74
	1500	69.12	68.84	69.24	67.91
Karjan	0	100.00+	98.02	97.14	93.75
	10	88.90	87.02	85.59	81.65
	50	77.13	75.17	74.54	71.00
	500	70.75	69.07	68.44	63.92
	1500	67.55	66.47	65.09	61.21
Surat	0	100.00+	100.00+	100.00+	100.00+
	10	91.70	89.92	88.53	87.48
	50	82.80	81.17	80.43	78.96
	500	77.02	75.82	74.33	70.87
	1500	69.70	69.52	68.13	64.95
Hansot	0	100.00+	100.00+	100.00+	100.00+
	10	86.19	84.44	82.41	77.58
	50	77.72	75.29	74.16	71.97
	500	73.19	71.59	70.06	67.90
	1500	68.32	66.34	64.46	63.19

increases and is around 50 per cent at 1500 kPa, soil moisture tension. In soils which have a high amount of clay the per cent space occupied exceeds 100 per cent as the inter layer-space of the clay particles is also available for the moisture to occupy. From these data it is quite clear that a soil which appears to be dry and not capable of sustaining the standing crop has nearly half as much space occupied by soil moisture, but this water is held so strongly that it is not available to the plants. Also the data in table 4.1.2 reveal that at the same tension soils vary greatly in the amount of soil volume occupied by soil water. Also within the same soil, there is variability in the amount of space occupied at various tensions. These data imply that in soils with a high percentage of occupancy, the ability of plants to extract water is less as compared to soils which have a wide variability of space occupancy as the soil moisture tension increase. Such soils are better as far as water availability is concerned. Similar observation have been made by Dent and Scammel (1981) while assessing the irrigation requirements of the mapped soils series of Norfolk in U.K. Another measure of the water retention capacity of soils is the data as mm water held per cm of soil profile. The data are presented in table 4.1.3. It is seen from the table 4.1.3 that the amount of the fine particle size fraction, i.e. clay and/or silt together or individually have a great effect on the amount of water

Table 4.1.3 : mm/cm soil moisture held at different tension and depths

Profile No./ Location	Kpa	Depth (cm)			
		0-30	30-60	60-90	90-120
1.	2.	3.	4.	5.	6.
Nawapur	0	4.99	5.45	5.54	5.71
	10	1.05	1.23	1.34	1.51
	50	0.73	0.93	0.98	1.00
	100	0.63	0.79	0.86	0.87
	1500	0.40	0.51	0.54	0.55
Kasindra	0	5.12	5.34	5.69	5.80
	10	2.30	2.60	3.10	3.20
	50	1.54	1.94	2.33	2.36
	100	1.35	1.72	2.14	2.20
	1500	0.72	0.94	1.15	1.16
Anand	0	7.27	7.34	7.53	8.12
	10	2.26	2.94	3.57	3.48
	50	1.76	1.91	2.29	2.18
	100	1.26	1.63	1.94	1.88
	1500	0.86	0.99	1.15	1.16
Dabhasha	0	6.39	6.97	8.65	8.62
	10	2.59	3.34	4.47	4.70
	50	1.21	1.68	2.41	2.53
	100	1.12	1.41	2.12	2.25
	1500	0.73	0.93	1.52	1.67
Chandsad	0	9.06	9.29	9.58	9.75
	10	4.60	4.79	5.04	5.15
	50	3.83	4.08	4.40	4.53
	100	3.35	3.77	3.92	4.07
	1500	2.33	2.37	2.54	2.63
Halol	0	7.17	8.16	9.37	8.71
	10	3.04	3.12	3.87	4.35
	50	2.47	2.52	2.93	3.49
	100	2.19	2.31	2.73	2.98
	1500	1.90	2.06	2.25	2.42
Asod	0	6.49	7.16	8.09	7.20
	10	3.21	3.46	3.95	3.20
	50	2.35	2.56	2.84	2.39
	100	2.15	2.41	2.63	2.30
	1500	1.89	2.11	2.25	1.88

1.	2.	3.	4.	5.	6.
Sunav	0	6.67	7.06	7.12	7.34
	10	2.65	3.96	4.77	4.85
	50	1.58	2.85	3.71	3.76
	100	1.49	2.70	3.28	3.30
	1500	0.88	1.57	2.00	1.91
Tarapur	0	6.70	7.65	8.31	6.94
	10	3.95	4.26	4.17	3.92
	50	2.59	2.75	2.70	2.34
	100	2.46	2.65	2.38	2.19
	1500	1.55	1.71	1.51	1.34
Dharmaj	0	6.37	7.62	7.04	7.16
	10	2.62	3.02	3.37	3.63
	50	1.58	1.87	1.94	2.04
	100	1.50	1.79	1.84	1.88
	1500	0.66	1.14	1.15	1.20
Dahej	0	6.41	8.45	7.81	8.99
	10	5.95	6.88	6.77	7.17
	50	3.67	4.25	5.02	5.34
	100	3.23	3.83	4.77	5.16
	1500	2.26	2.58	2.74	3.30
Rahiad	0	6.48	6.99	8.62	8.10
	10	5.46	5.94	6.23	6.67
	50	4.17	4.26	5.08	4.86
	100	3.72	3.81	4.74	4.83
	1500	2.46	2.63	2.76	2.87
Limri	0	6.55	7.83	8.37	8.33
	10	6.05	6.49	7.19	7.12
	50	4.52	5.62	5.67	5.24
	100	5.67	4.97	5.07	5.05
	1500	2.72	2.99	2.91	2.95
Lingda	0	6.48	8.08	8.21	8.35
	10	3.31	4.47	4.67	4.60
	50	2.04	3.29	3.57	3.68
	100	1.80	2.96	3.22	3.34
	1500	1.01	1.89	1.98	2.02
WALMI	0	5.26	5.69	4.92	3.70
	10	2.67	1.94	1.61	1.58
	50	1.34	1.28	1.13	1.01
	100	1.12	0.99	0.92	0.83
	1500	0.70	0.61	0.58	0.62

1.	2.	3.	4.	5.	6.
S K Nagar	0	3.81	3.85	4.16	4.25
	10	1.37	1.33	1.27	1.21
	50	0.77	0.79	0.78	0.74
	100	0.71	0.72	0.75	0.72
	1500	0.34	0.32	0.33	0.32
Bachau	0	4.23	5.91	5.63	5.21
	10	2.67	3.83	3.46	3.84
	50	1.77	2.59	2.40	2.40
	100	1.55	2.33	2.15	2.15
	1500	0.75	1.38	1.23	1.14
Arnej	0	6.88	7.35	7.95	8.72
	10	4.57	4.95	5.39	5.58
	50	3.62	3.96	4.38	3.93
	100	3.24	3.55	3.88	3.57
	1500	2.17	2.33	2.51	2.55
Karjan	0	6.28	6.22	6.19	6.03
	10	4.76	4.78	4.67	4.40
	50	3.26	3.22	3.21	2.96
	100	3.00	3.01	2.94	2.67
	1500	2.03	2.08	1.97	1.64
Surat	0	9.80	9.67	9.88	9.92
	10	5.21	5.16	5.24	5.28
	50	4.12	4.01	4.15	4.12
	100	3.76	3.71	3.73	3.76
	1500	2.37	2.48	2.51	2.21
Hansot	0	8.66	8.55	8.61	8.16
	10	4.58	4.52	4.50	4.01
	50	3.48	3.31	3.39	3.24
	100	3.18	3.16	3.13	2.87
	1500	2.26	2.13	2.08	2.04

held. Soils with greater clay and or silt hold greater quantity of water as compared to coarser soils at the same tensions. Similar observations have been made by Oswal and Khanna (1981), while studying the effect of soil physical and chemical properties on soil water functional relationship. While, soil texture is the dominant factor, other soil properties like the organic matter content, the calcium carbonate content, the salt content the amount of exchangeable sodium extent of compaction etc. are some factors which demand attention and may account for the variability within the same soil family. Inherent variability among soil samples of the same mapped soil series have also been observed by Dent and Scammel (1981).

Thus from the above discussion it is quite clear that once rainfall subsides or stops or between irrigation intervals, the soil acts a reservoir, and is the single source of moisture availability for the standing crop. However, the length of time to which soil can continue to supply water depends, in addition to its inherent characteristics, also on the climatic demand i.e. the potential evapotranspiration, the crop evapotranspiration (computed from PET using the crop coefficient factor), the effective rainfall the crop in question and the stage of crop growth.

#### 4.1.2 The Crop Factor

The demand for water by the crop is generated by the crop evapotranspiration need which is directly influenced by the local climatic parameters like, the daily maximum and minimum temperatures, relative humidity, amount of sunshine hours, the wind velocity, the atmospheric pressure, the altitude of the place, net solar radiation, etc. Much work has been devoted to the estimation of potential evaporation from meteorological data which include the empirical approach of Blaney and Criddle (1962), using data for air temperature and day lengths and the derivation of Penman's equation which incorporates data on radiation, humidity, wind related functions. Because of the need of data on a series of climatic parameters while computing PET by Penman's equation, several workers have tried a series of equations using a minimum number of climatic parameters. One such equation developed by Hargreaves and Samani (1982), involving only the collection of daily maximum and minimum temperature, has been found to be equally applicable over a large region and has since been proposed for adoption in the state (Sheikh, 1989). This equation has been used in the present study to compute the potential evapotranspiration of all the studied cropping seasons. Using empirical values of crop coefficients suggested by Doorenbos and Pruitt (1977) adjusted suitably to match the local climatic conditions, crop evapotranspiration needs have been computed and

reported standard week-wise. This crop evapotranspiration constitutes the actual crop water need for the specific crops studied. Deducting the values of effective rainfall (assumed to vary from 70 % to 80 % of actual rainfall, depending on rainfall intensity and quantity), from the crop evapotranspiration values (ETc), the actual irrigation need has been arrived at based on standard week. Irrigation is proposed to be initiated when 50 per cent of the ETc - eff. rainfall value expressed as mm was depleted. The level of 50 per cent depletion is tentatively selected to prevent the risk of desiccation and it was assumed that at this level of moisture availability crops will not suffer yield reduction. Similar level of depletion of AWC was used by Madsen and Holst (1990) while mapping irrigation need of spring sown cereals and grasses in Denmark. The crop water requirements and the irrigation requirement on standard week-wise have been computed for all the 12 districts of the Narmada command for the seven crops selected viz., groundnut (summer and monsoon crop), pearl millet (summer and monsoon crop), pigeonpea (monsoon crop), cotton (monsoon crop) castor (monsoon crop), mustard (winter crop) and wheat (winter crop). The data on the standard week-wise crop water requirements and the irrigation requirements and for the entire growing season of each of the seven crops for each of the 12 districts coming under the Narmada command are presented in Appendix 4.1.1. It is seen from the data that

with the help of information on soil water capacity and the climate and the type of crop, requirements for water by the crops and subsequent need for irrigation for these crops can be arrived at. The contributions of several workers using this aspect has been accounted for already in the review.

It is seen from the tables 4.1.4 to 4.1.6 that in general, for all the three growing seasons, the Net Irrigation Requirement values (NIR) are less than the computed Crop Water Requirement values (CWR). The difference between the CWR and NIR value is however, great during the monsoon season as compared to the small changes during the summer and winter season. This is because of the fact that during the monsoon season, much of the ET requirement is met through the rainfall and once the rain starts receding, its contribution towards meeting the ET needs also diminishes, thereby narrowing down the difference. Similar observations on the relationship between ET and NIR as a result of seasonal changes have been observed by Villalobos and Fereras (1989). These workers also found that soils with larger available water capacity had less NIR values than those with lower AWC, especially during the months of rainfall. Similar observations are made in the present study. As in the work of Villalobos and Fereras (1989), in the present study also this is because it is assumed that the profile is full of water at the start of the season. The data in table 4.1.4 to 4.1.6 also give the number of

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Table 4.1.4 : Crop water requirement, irrigation requirement, number of irrigations and quantity of irrigation water applied to pearl millet and groundnut (summer) in the districts under the Narmada Command.

Crop	Pearl millet				Groundnut			
	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIGATION APPLIED (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIGATION APPLIED (mm)
<b>Kheda</b>								
AWC 155 mm/m	617.55	605.72	7	606	552.13	547.07	7	606
<b>Ahmedabad &amp; Gandhinagar</b>								
AWC 200 mm/m	611.16	592.01	5	560	503.33	498.58	4	460
AWC 150 mm/m	611.16	592.01	8	660	503.53	498.58	6	510
<b>Baroda</b>								
AWC 150 mm/m	661.14	704.50	8	660	559.35	556.59	7	585
AWC 200 mm/m	661.14	704.50	6	660	559.35	556.59	5	560
<b>Panchmahals</b>								
AWC 150 mm/m	663.97	643.90	8	660	569.06	567.14	7	585
<b>Mehsana</b>								
AWC 150 mm/m	661.80	644.19	8	660	-	-	-	-
<b>Banaskantha</b>								
AWC 75 mm/m	639.79	613.40	15	622	-	-	-	-
<b>Bhavnagar</b>								
AWC 150 mm/m	-	-	-	-	568.09	564.06	7	585
AWC 200 mm/m	-	-	-	-	568.09	564.06	5	560
<b>Kutch</b>								
AWC 150 mm/m	-	-	-	-	543.06	543.06	7	585
<b>Rajkot</b>								
AWC 200 mm/m	630.83	611.67	6	660	548.11	545.68	5	560
<b>Surendranagar</b>								
AWC 175 mm/m	665.46	650.42	7	672.50	-	-	-	-

Table 4.1.5 : Crop water requirement, net irrigation requirement, number of irrigations and net irrigation water applied to mustard and wheat (Rabi) in the districts Narmada Command.

Crop	Mustard					Wheat						
	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRR. APPLIED (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRR. APPLIED (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRR. APPLIED (mm)
<b>Kheda</b>												
AWC 155 mm/m	428.58	400.08	5	450	-	-	-	-	425.95	437.34	7	466
AWC 116 mm/m	-	-	-	-	-	-	-	-	-	-	-	-
<b>Ahmedabad &amp; Gandhinagar</b>												
AWC 200 mm/m	429.45	411.15	4	460	458.92	444.78	4	460	458.92	444.78	4	460
AWC 150 mm/m	429.45	411.15	5	435	458.92	444.78	7	435	458.92	444.78	7	435
<b>Baroda</b>												
AWC 150 mm/m	448.52	422.64	5	435	470.00	451.58	6	510	470.00	451.58	6	510
AWC 200 mm/m	448.52	422.64	4	460	470.00	451.58	4	460	470.00	451.58	4	460
<b>Bharuch</b>												
AWC 200 mm/m	-	-	-	-	489.81	479.53	4	460	489.81	479.53	4	460
<b>Panchmahals</b>												
AWC 150 mm/m	-	-	-	-	465.63	453.57	6	510	465.63	453.57	6	510
<b>Mehsana</b>												
AWC 150 mm/m	448.59	440.67	6	510	464.00	458.02	6	510	464.00	458.02	6	510
<b>Banaskantha</b>												
AWC 75 mm/m	409.17	387.48	10	435	435.60	420.46	11	472.50	435.60	420.46	11	472.50
<b>Bhavnagar</b>												
AWC 150 mm/m	460.03	445.08	5	435	465.32	452.57	6	510	465.32	452.57	6	510
AWC 200 mm/m	460.03	445.08	4	460	465.32	452.57	4	460	465.32	452.57	4	460
<b>Kutch</b>												
AWC 150 mm/m	446.15	433.99	5	435	444.88	440.97	6	510	444.88	440.97	6	510
<b>Rajkot</b>												
AWC 200 mm/m	439.38	430.32	4	460	448.89	444.64	4	460	448.89	444.64	4	460
<b>Surendranagar</b>												
AWC 175 mm/m	451.47	441.01	4	400	466.01	457.29	5	497.50	466.01	457.29	5	497.50

Table 4.1.6 : Crop water requirement, net irrigation requirement, number of irrigations and net irrigation water applied to pearl millet, groundnut, cotton, pigeonpea and castor (Kharif) crops in different districts of Maranada Command.

Crop	Pearl millet				Groundnut				Cotton				Pigeonpea				Castor				
	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIG. APPLD. (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIG. APPLD. (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIG. APPLD. (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIG. APPLD. (mm)	CWR (mm)	NIR (mm)	IRRI. NO.	NET IRRIG. APPLD. (mm)	
<b>Kheda</b>																					
AVC 155 mm/m	-	-	-	-	-	-	-	-	773.51	634.37	7	606	766.44	627.55	7	606	941.47	850.51	11	918	
<b>Ahmedabad &amp; Gandhinagar</b>																					
AVC 200 mm/m	521.52	114.61	1	75	495.38	92.16	-	-	804.41	501.11	6	510	-	-	-	-	-	-	-	-	-
AVC 150 mm/m	521.52	114.61	-	-	495.38	92.16	-	-	804.41	501.11	5	560	-	-	-	-	-	-	-	-	-
<b>Baroda</b>																					
AVC 150 mm/m	-	-	-	-	525.32	118.72	1	135	793.93	486.86	6	510	-	-	-	-	-	-	-	-	-
AVC 200 mm/m	-	-	-	-	525.32	118.72	1	160	793.93	486.86	4	460	-	-	-	-	-	-	-	-	-
<b>Bharuch</b>																					
AVC 200 mm/m	500.88	69.60	-	-	-	-	-	-	810.48	483.68	4	460	843.89	551.09	6	560	-	-	-	-	-
<b>Panchabhals</b>																					
AVC 150 mm/m	517.51	85.73	-	-	507.05	84.02	-	-	796.41	472.62	6	510	-	-	-	-	-	-	-	-	-
<b>Mehsana</b>																					
AVC 150 mm/m	516.21	129.36	1	135	-	-	-	-	796.67	508.72	6	510	-	-	-	-	1003.17	788.41	10	810	-
<b>Rashtanthe</b>																					
AVC 75 mm/m	555.72	223.88	5	247.50	-	-	-	-	787.34	517.21	14	585	-	-	-	-	949.98	763.58	21	817.50	-
<b>Bhavnagar</b>																					
AVC 150 mm/m	525.28	184.96	1	135	449.81	157.76	1	135	815.27	459.77	7	585	-	-	-	-	1026.68	811.02	11	885	-
AVC 200 mm/m	525.28	184.96	1	160	449.81	157.76	1	160	815.27	459.77	5	560	-	-	-	-	1026.68	811.02	8	860	-
<b>Kutch</b>																					
AVC 150 mm/m	555.89	346.72	4	360	556.88	333.13	4	360	844.45	566.74	7	585	-	-	-	-	1020.11	884.65	11	885	-
<b>Rajkot</b>																					
AVC 200 mm/m	497.99	173.07	1	160	491.80	158.87	1	160	790.28	547.65	5	560	-	-	-	-	-	-	-	-	-
<b>Surendranagar</b>																					
AVC 175 mm/m	520.54	216.99	2	235	507.71	205.71	2	235	801.33	552.66	6	585	-	-	-	-	-	-	-	-	-

irrigations that will be required during the growing seasons. Though this data may have greater applicability for the summer and winter months, when the factor of rainfall occurrence is the minimum, yet during the monsoon season, the number of irrigations is expected to vary depending upon the distribution of rainfall, and the date of sowing of the crop. The data in appendices 4.1.1 to 4.1.11 show the number of days after sowing when the first irrigation will be required for each of the growing seasons, for each of the crops, for each of the districts and the soils with different AWC's. It is seen that in general, during the seasons of high ET, the irrigation requirement interval after sowing is shorter as compared to the seasons with low ET. Similarly, in soils with greater AWC the interval is comparatively longer. However, for the monsoon season, because of greater temporal and spatial variability any generalization is difficult, though not impossible. Generalisation can be made for monsoon seasons assuming a per cent probability of rainfall expectancy. Similar observations on the development of an irrigation schedule based on simulation models using the data on rainfall probability as an aid in predicting the days to first irrigation during the rainy season have been made by Villalobos and Fereras (1989). Madsen and Holst (1990) also observed irrigation need to drop substantially as the root zone capacity for moisture increased. Similar results have

been reported by Dent and Scammell (1981) for different soil series of Norfolk, UK. These workers found the soil type to exert a major influence on the irrigation requirements. They found the soil pattern and differences in water retention characteristics between soils to make a significant difference to the optimum provision of supplementary irrigation and the day to day scheduling of water application (Dent et al., 1978). Tripathi (1985) while using the data on soil-crop-climate for scheduling irrigation to wheat crop grown on soils of varying texture and levels of water table, observed that the timing of irrigations arrived at by the the use of soil-crop-climate data matched closely to that arrived at by direct measurement of crop water stress using leaf water potential (stress day index method) and canopy temperature by infrared thermometry. Soil texture was also found to significantly affect the number of irrigations required and the quantity of water required by the wheat crop.

#### **4.2 ASSESSMENT OF IRRIGATION REQUIREMENT OF NARMADA COMMAND USING SOIL-CROP-CLIMATE DATA**

The next step after development of an irrigation schedule based on the use of data on soil-crop-climate is its application to a large area like an irrigation command. Efficiency of an irrigation schedule depends on the extent of its applicability over a region. The wider it is

applicable the more is it efficient. In the present study, data on crop ET, and soil available water capacity have been used to compute the irrigation requirement of each crop of the 12 selected districts based on standard weeks. Almost similar methodology has also been used by Holst and Madsen (1988) for modeling the irrigation need of barley and grass in Denmark, using data on climate and soil. The monthly water requirement values for each crop in each district of the command and the quantity of water required calculated as million cubic meter per month are presented in Appendices 4.2.1 to 4.2.11. The data provide figures of the actual requirement for water by each crop in each of the district of the command.

It is seen from the data (Appendices 4.2.1 to 4.2.11) that there is a wide variability between the crops for the total water requirement, and crops with longer length of growing periods or those growing in the hot weather season for most part of their growing periods, require larger amount of water than those growing in the winter season or have most part of their growing periods during the monsoon season. Similar differences among crops for requirement for water have been observed by Madsen and Holst (1990) attributable to differences in growing periods. Also within crops growing in the same seasons, differences are observed between districts. Crops growing in the same season but on soils with comparatively lower AWC required

somewhat more water than those growing on soils with higher AWC. Similar observations have been made by Madsen and Holst (1990) for barley growing on sites with soils of different AWC's. Another additional information that is available from the data in Appendices 4.2.1 to 4.2.11 is, that the water requirement is higher in the months corresponding to flowering and seed setting. This can be attributable to the fact that during this stage of crop growth, maximum vegetative growth is attained and transpiration losses are greatest due to greater surface exposed to forces of radiation, wind, heat etc. Similar observations have been made by Kundu *et al.* (1982) while using a simulation model of crop growth to evaluate irrigation practices.

Suryavanshi and Reddy (1986) have used the zero-one integer programming model for optimal operation schedules and design specification for distributory 3 of the Meena branch canal in the Kukadi Irrigation Project in Maharashtra. These workers have also used the data on crop evapotranspiration as a basis (modified Penman method) of judging crop water needs for a specified area served by a minor distributory with a flow rate of 30 l/s at the nearest point, with the rate decreasing at an assumed percentage as the distance from the nearest point increases. However, the exercise, though a good attempt, suffers from the limitation that no allowance for the soil AWC capacity is made in the mathematical programme, probably because the

computations were for a small area of 155 ha where soil type uniformity is possible.

Rajput and Michael (1990) have used the data on crop evapotranspiration and soil available water capacity and a permissible level of depletion of AWC (40 to 60 per cent) to compute the irrigation requirement of the Sansad distributory of the Mahi Right Bank Canal, and have worked out the quantity of water that will be required on daily basis for the crops of the area, in millions cubic meters. The FAO (1992) have also developed a computer model to assess the irrigation requirements of Rajolibonda command in Kurnool district, AP, India, using data on crop evapotranspiration and available soil water capacity. The model also tries to carry out a seasonal evaluation of the assessment and it is observed that the actual requirement for water rarely exceeds the supply. Similar results have also been observed in the present study. The data on seasonal evaluation of the assessment of irrigation requirement based on soil-crop-climate data are presented in tables 4.2.1 to 4.2.11. The evaluation is based on the ratio between actual supply (expressed as M.Cu M/m) and the required supply (M.Cu.M/m) for each month in the season. The actual supply is computed on the basis of the proposed maximum flow through the sub-minors at the rate of 0.9 litres/second/hectare of the cultivable command area in each district of the Narmada command (Anon., 1985).





Table 4.2.3 : Evaluation of scheme water requirement (Baroda)

	Jan.	Feb.	March	April	May	June	Total				
Actual supply MCM	819.64	753.54	819.64	793.20	819.64	793.20	4798.86 MCM				
Net SWR, mm	53.94	36.77	41.85	13.80	12.71	5.40	164.47 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	107.88	73.54	83.70	27.60	25.42	10.80	328.94 mm				
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	ha				
Supply Req. MCM	366.79	250.04	284.58	93.84	86.43	36.72	1118.40 MCM				
Req./supply %	44.75	33.18	34.72	11.83	10.54	4.63	23.31 %				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	819.64	793.20	819.64	819.64	753.54	819.64	5618.50 MCM				
Net SWR, mm	47.74	51.30	44.02	53.94	36.77	41.85	275.62 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	95.48	102.60	88.04	107.88	73.54	83.70	551.24 mm				
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	ha				
Supply Req. MCM	324.63	348.84	299.34	366.79	250.04	284.58	1874.22 MCM				
Req./supply %	39.61	43.98	36.52	44.75	33.18	34.72	33.36 %				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	793.20	819.64	819.64	793.20	819.64	793.20	819.64	819.64	-	-	6477.80 MCM
Net SWR, mm	5.40	0.62	0.31	23.70	47.74	51.30	44.02	53.94	-	-	227.03 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	-	-	%
Gross SWR, mm	10.80	1.24	0.62	47.40	95.48	102.60	88.04	107.88	-	-	454.06 mm
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	340000	340000	-	-	ha
Supply Req. MCM	36.72	4.22	2.11	161.16	324.63	348.84	299.34	366.79	-	-	1543.80 MCM
Req./supply %	4.63	0.51	0.26	20.31	39.61	12.48	36.52	44.75	-	-	23.83 %

Table 4.2.4 : Evaluation of scheme water requirement (Bharuch)

	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	228.60	236.22	236.22	218.17	236.22	1154.43 MCM
Net-SWR, mm	54.81	48.58	51.06	27.59	26.04	208.08 mm
Irri.Eff. %	50	50	50	50	50	%
Gross SWR, mm	109.62	97.16	102.12	55.18	52.08	416.16
Irrig. Area, ha	98000	98000	98000	98000	98000	ha
Supply Req. MCM	107.43	95.22	100.08	54.08	51.04	394.49
Req./supply %	46.99	40.31	42.37	24.90	21.61	34.17 %

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Kharif											
Actual supply MCM	228.60	236.22	236.22	228.60	236.22	228.60	236.22	236.22	217.17	-	2084.07 MCM
Net SWR, mm	1.80	0.62	-	20.79	55.49	54.81	48.58	51.06	27.59	-	260.74 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	50	-	%
Gross SWR, mm	3.60	1.24	-	41.58	110.98	109.62	97.16	102.12	55.18	-	521.48 mm
Irrig. Area, ha	98000	98000	98000	98000	98000	98000	98000	98000	98000	-	ha
Supply Req. MCM	3.53	1.22	-	40.75	108.76	107.43	95.22	100.08	54.08	-	511.07
Req./supply %	1.54	0.52	0.0	17.83	46.04	46.99	40.31	42.37	24.90	-	24.52 %

Table 4.2.5 : Evaluation of scheme water requirement (Panchmahals)

	Jan.	Feb.	March	April	May	June	Total				
Actual supply MCM	24.18	22.23	24.18	23.40	24.18	23.40	141.57 MCM				
Net SWR, mm	52.08	33.92	37.20	13.80	12.71	8.70	158.41 mm				
Irrig. Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	104.16	67.84	74.40	27.60	25.42	17.40	316.82 mm				
Irrig. Area, ha	10000	10000	10000	10000	10000	10000	ha				
Supply Req. MCM	10.42	6.78	7.44	2.76	2.54	1.74	31.68 MCM				
Req./supply %	43.09	30.50	30.77	11.79	10.50	7.44	22.38 %				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	-	23.40	24.18	24.18	22.23	24.18	118.17 MCM				
Net SWR, mm	-	48.00	43.10	52.08	33.92	37.20	214.30 mm				
Irrig. Eff. %	-	50	50	50	50	50	%				
Gross SWR, mm	-	96.00	86.20	104.16	67.84	74.20	428.60 mm				
Irrig. Area, ha	-	10000	10000	10000	10000	10000	ha				
Supply Req. MCM	-	9.60	8.62	10.42	6.78	7.42	42.84				
Req./supply %	-	41.03	35.65	43.09	11.88	30.69	36.25%				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	23.40	24.18	24.18	23.40	24.18	23.40	24.18	24.18	-	-	191.1 MCM
Net SWR, mm	8.70	2.48	0.0	26.10	54.25	48.00	43.10	52.08	-	-	234.71 mm
Irrig. Eff. %	50	50	50	50	50	50	50	50	-	-	%
Gross SWR, mm	17.40	4.96	0.0	52.20	108.50	96.00	86.20	104.16	-	-	469.42 mm
Irrig. Area, ha	10000	10000	10000	10000	10000	10000	10000	10000	-	-	ha
Supply Req. MCM	1.74	0.496	0.0	5.22	10.85	9.60	8.62	10.42	-	-	46.95 MCM
Req./supply %	7.44	2.05	0.0	22.31	44.87	41.03	35.65	43.09	-	-	24.57 %
	Kharif										
Actual supply MCM	23.40	24.18	24.18	23.40	24.18	23.40	24.18	24.18	-	-	191.1 MCM
Net SWR, mm	8.70	2.48	0.0	26.10	54.25	48.00	43.10	52.08	-	-	234.71 mm
Irrig. Eff. %	50	50	50	50	50	50	50	50	-	-	%
Gross SWR, mm	17.40	4.96	0.0	52.20	108.50	96.00	86.20	104.16	-	-	469.42 mm
Irrig. Area, ha	10000	10000	10000	10000	10000	10000	10000	10000	-	-	ha
Supply Req. MCM	1.74	0.496	0.0	5.22	10.85	9.60	8.62	10.42	-	-	46.95 MCM
Req./supply %	7.44	2.05	0.0	22.31	44.87	41.03	35.65	43.09	-	-	24.57 %

Table 4.2.6 : Evaluation of scheme water requirement (Mehsana)

	Jan.	Feb.	March	April	May	June	Total				
Actual supply MCM	361.46	332.31	361.46	349.80	361.46	349.80	2116.29 MCM				
Net SWR, mm	54.56	35.06	32.24	7.80	8.06	16.80	154.52 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	109.12	70.12	64.48	15.60	16.12	33.60	309.04 mm				
Irrig. Area, ha	150000	150000	150000	150000	150000	150000	ha				
Supply Req. MCM	163.68	105.18	96.72	23.40	24.18	50.40	463.56 MCM				
Req./supply %	45.28	31.65	26.76	6.69	6.69	14.41	21.90 %				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	361.46	349.80	361.46	361.46	332.31	361.46	2127.95 MCM				
Net SWR, mm	81.22	58.50	49.60	54.56	35.06	32.24	311.18 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	162.44	117.00	99.20	109.12	70.12	64.48	622.36 mm				
Irrig. Area, ha	150000	150000	150000	150000	150000	150000	ha				
Supply Req. MCM	243.66	175.50	148.80	163.68	105.18	96.72	933.54 MCM				
Req./supply %	67.41	50.17	41.17	45.28	31.65	26.76	43.87 %				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	349.80	361.46	361.46	349.80	361.46	349.80	361.46	361.46	332.31	361.46	3550.47 MCM
Net SWR, mm	16.80	2.14	5.27	38.70	81.22	58.50	49.60	54.56	35.06	32.24	374.09 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	50	50	%
Gross SWR, mm	33.60	4.28	10.54	77.40	162.44	117.00	99.20	109.12	70.12	64.48	748.18 mm
Irrig. Area, ha	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	ha
Supply Req. MCM	50.40	6.42	15.81	116.10	243.66	175.50	148.80	163.68	150.18	96.72	1122.27 MCM
Req./supply %	14.41	1.78	4.37	33.19	67.41	50.17	41.17	45.28	31.65	26.76	31.61 %

Table 4.2.7 : Evaluation of scheme water requirement (Banaskantha)

	Jan.	Feb.	March	April	May	June	Total				
Actual supply MCM	754.54	693.69	754.54	730.20	754.54	730.20	4417.71 MCM				
Net SWR, mm	52.39	34.20	31.62	7.20	7.75	11.70	144.86 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	104.78	68.40	63.24	14.40	15.50	23.40	289.72 mm				
Irrig. Area, ha	313000	313000	313000	313000	313000	313000	ha				
Supply Req. MCM	327.96	214.09	197.94	45.07	48.52	73.24	906.82 MCM				
Req./supply %	43.46	30.86	26.23	6.17	6.43	10.03	20.53 %				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	754.54	730.20	754.54	754.54	693.69	754.54	4442.05 MCM				
Net SWR, mm	58.59	52.20	56.42	52.39	34.20	31.62	282.42 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	117.18	104.40	112.84	104.78	68.40	63.24	570.84 mm				
Irrig. Area, ha	313000	313000	313000	313000	313000	313000	ha				
Supply Req. MCM	366.77	326.77	353.19	327.96	214.09	197.94	1786.73 MCM				
Req./supply %	48.61	44.75	46.81	43.46	30.86	26.33	40.22 %				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	730.20	754.54	754.54	730.20	754.54	730.20	754.54	754.54	693.69	754.54	7411.53 MCM
Net SWR, mm	11.70	4.96	5.89	34.80	58.89	52.20	56.42	52.39	34.20	31.62	342.77 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	50	50	%
Gross SWR, mm	23.40	9.92	11.78	69.60	117.18	104.40	112.84	104.78	68.40	63.24	685.54 mm
Irrig. Area, ha	313000	313000	313000	313000	313000	313000	313000	313000	313000	313000	ha
Supply Req. MCM	73.24	31.05	36.87	217.85	366.77	326.77	353.19	327.96	214.09	197.74	2145.74 MCM
Req./supply %	10.04	4.12	4.89	29.83	48.61	44.75	46.81	43.46	30.86	26.23	28.95 %

Table 4.2.8 : Evaluation of scheme water requirement (Bhavnagar)

	Jan.	Feb.	March	April	May	Total					
Actual supply MCM	115.63	106.31	115.63	111.90	115.63	565.10 MCM					
Net SWR, mm	55.18	33.35	33.17	7.20	4.34	133.24 mm					
Irri.Eff. %	50	50	50	50	50	%					
Gross SWR, mm	110.36	66.70	66.34	14.40	8.68	266.48 mm					
Irrig. Area, ha	48000	48000	48000	48000	48000	ha					
Supply Req. MCM	52.97	32.02	31.84	6.91	4.17	127.91 MCM					
Req./supply %	45.81	30.12	27.54	6.18	3.61	22.63 %					
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	115.63	111.90	115.63	115.63	106.31	115.63	680.73 MCM				
Net SWR, mm	69.13	56.40	66.34	55.18	33.35	33.17	313.57 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	138.26	112.80	132.68	110.36	66.70	66.34	627.14 mm				
Irrig. Area, ha	48000	48000	48000	48000	48000	48000	ha				
Supply Req. MCM	66.36	54.14	63.69	52.97	32.02	31.84	301.02 MCM				
Req./supply %	57.39	48.38	55.08	45.81	30.12	27.54	44.22 %				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	111.90	115.63	115.63	111.90	115.63	111.90	115.63	115.63	106.31	115.63	1135.99 MCM
Net SWR, mm	11.40	5.27	3.44	3.21	69.13	56.40	66.34	55.18	33.35	33.17	336.89 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	50	50	%
Gross SWR, mm	22.80	10.54	6.88	6.42	138.26	112.80	132.68	110.36	66.70	66.34	673.78 mm
Irrig. Area, ha	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000	ha
Supply Req. MCM	10.94	5.06	3.30	3.08	66.36	54.14	63.69	52.97	32.02	31.84	323.40 MCM
Req./supply %	9.78	4.38	2.85	2.75	57.39	48.38	55.08	45.81	30.12	27.54	28.47 %

Table 4.2.9 : Evaluation of scheme water requirement (Kutch)

	Jan.	Feb.	March	April	May	Total
<b>Summer</b>						
Actual supply MCM	89.28	82.08	89.28	86.40	89.28	436.32 MCM
Net SWR, mm	46.81	31.92	31.93	5.70	4.03	120.39 mm
Irrig. Eff. %	50	50	50	50	50	%
Gross SWR, mm	93.62	63.84	63.86	11.40	8.06	240.78 mm
Irrig. Area, ha	37000	37000	37000	37000	37000	ha
Supply Req. MCM	34.63	23.62	23.63	4.22	2.98	89.08 MCM
Req./supply %	38.79	28.78	26.47	4.88	3.34	20.42 %
	Oct.	Nov.	Dec.	Jan.	Feb.	March
	89.28	86.40	89.28	89.28	82.08	89.28
	66.03	56.40	51.46	46.81	31.92	31.93
	50	50	50	50	50	50
	132.06	112.80	102.92	93.62	63.84	63.86
	37000	37000	37000	37000	37000	37000
	48.86	41.74	38.08	34.64	23.62	23.63
	54.73	48.31	42.65	38.80	28.78	26.47
	525.60 MCM					
	284.55					
	%					
	569.10					
	ha					
	210.57					
	40.06 %					
	June	July	Aug.	Sept.	Oct.	Nov.
	86.40	89.28	89.28	86.40	89.28	86.40
	24.0	6.91	12.4	53.70	66.03	56.40
	50	50	50	50	50	50
	48.0	13.02	24.8	107.40	132.06	112.80
	37000	37000	37000	37000	37000	37000
	17.76	4.82	9.18	39.74	48.86	41.74
	20.56	8.76	10.28	45.99	54.73	48.31
	876.96 MCM					
	381.16					
	%					
	762.32					
	ha					
	282.07					
	32.16 %					
	June	July	Aug.	Sept.	Oct.	Nov.
	86.40	89.28	89.28	86.40	89.28	86.40
	24.0	6.91	12.4	53.70	66.03	56.40
	50	50	50	50	50	50
	48.0	13.02	24.8	107.40	132.06	112.80
	37000	37000	37000	37000	37000	37000
	17.76	4.82	9.18	39.74	48.86	41.74
	20.56	8.76	10.28	45.99	54.73	48.31
	876.96 MCM					
	381.16					
	%					
	762.32					
	ha					
	282.07					
	32.16 %					

Table 4.2.10: Evaluation of scheme water requirement (Rajkot)

	Jan.	Feb.	March	April	May	June	Total				
Actual supply MCM	819.64	753.54	819.64	793.20	819.64	793.20	4798.86 MCM				
Net SWR, mm	50.34	35.34	36.27	12.90	11.78	8.99	155.62 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	100.68	70.68	72.54	25.80	23.56	17.98	311.24 mm				
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	ha				
Supply Req. MCM	342.31	240.31	246.64	87.72	80.10	61.13	526.53 MCM				
Req./supply %	41.76	31.89	30.09	11.06	9.77	7.71	10.97 %				
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total				
Actual supply MCM	819.64	793.20	819.64	819.64	753.54	819.64	4825.30 MCM				
Net SWR, mm	63.86	52.20	48.67	50.34	35.34	36.27	286.68 mm				
Irri.Eff. %	50	50	50	50	50	50	%				
Gross SWR, mm	127.72	104.40	97.34	100.68	70.68	72.54	573.36 mm				
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	ha				
Supply Req. MCM	434.25	354.96	330.96	342.31	240.31	246.64	1949.43 MCM				
Req./supply %	52.98	44.75	40.38	41.76	31.89	30.09	40.40 %				
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Actual supply MCM	793.20	819.64	819.64	793.20	819.64	793.20	819.64	819.64	-	-	6477.80 MCM
Net SWR, mm	8.99	3.41	2.79	38.4	63.86	52.20	48.67	50.34	-	-	268.66 mm
Irri.Eff. %	50	50	50	50	50	50	50	50	-	-	%
Gross SWR, mm	17.98	6.82	5.58	76.80	127.72	104.40	97.34	100.68	-	-	537.32 mm
Irrig. Area, ha	340000	340000	340000	340000	340000	340000	340000	340000	-	-	ha
Supply Req. MCM	61.13	23.19	18.97	261.12	434.25	354.96	330.96	342.31	-	-	1826.89 MCM
Req./supply %	7.71	2.83	2.31	32.92	52.98	44.75	40.38	41.76	-	-	28.20 %

Table 4.2.11: Evaluation of scheme water requirement (Surendranagar)

	Jan.	Feb.	March	April	May	June	Total
Actual supply MCM	-	673.74	732.84	709.20	732.84	709.20	3557.82 MCM
Net SWR, mm	-	31.07	29.14	7.80	8.37	20.10	96.48 mm
Irrig. Eff. %	-	50	50	50	50	50	%
Gross SWR, mm	-	62.14	58.28	15.60	16.74	40.20	192.96 mm
Irrig. Area, ha	-	304000	304000	304000	304000	304000	ha
Supply Req. MCM	-	188.91	177.17	47.42	50.89	122.21	683.08 MCM
Req./supply %	-	28.04	24.18	6.69	6.94	17.23	19.20 %
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Total
Summer							
Actual supply MCM	732.84	709.20	732.84	732.84	673.74	732.84	4314.30 MCM
Net SWR, mm	59.52	55.50	46.81	52.70	31.07	29.14	274.74 mm
Irrig. Eff. %	50	50	50	50	50	50	%
Gross SWR, mm	119.04	111.00	93.62	105.40	62.14	58.28	549.48 mm
Irrig. Area, ha	304000	304000	304000	304000	304000	304000	ha
Supply Req. MCM	361.88	337.44	284.60	320.42	188.91	117.17	1610.42 MCM
Req./supply %	49.38	47.58	38.84	43.72	28.04	15.99	37.33 %
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rabi							
Actual supply MCM	709.20	732.84	709.20	732.84	709.20	732.84	5791.8 MCM
Net SWR, mm	20.10	5.89	8.37	36.60	59.52	55.50	46.81
Irrig. Eff. %	50	50	50	50	50	50	50
Gross SWR, mm	40.20	11.78	16.74	73.20	119.04	111.00	93.62
Irrig. Area, ha	304000	304000	304000	304000	304000	304000	304000
Supply Req. MCM	122.21	35.81	50.89	222.53	361.88	337.44	284.60
Req./supply %	17.23	4.89	6.94	31.38	49.38	47.58	38.84
	Jan.	Feb.	March	April	May	June	Total
Kharif							
Actual supply MCM	-	-	-	-	-	-	5791.8 MCM
Net SWR, mm	-	-	-	-	-	-	285.49 mm
Irrig. Eff. %	-	-	-	-	-	-	%
Gross SWR, mm	-	-	-	-	-	-	570.98 mm
Irrig. Area, ha	-	-	-	-	-	-	ha
Supply Req. MCM	-	-	-	-	-	-	1735.78 MCM
Req./supply %	-	-	-	-	-	-	29.97 %

The data in the tables 4.2.1 to 4.2.11 show that there is substantial variation between the districts for the figures on the supply requirement for the three different seasons. It is observed that these variations are more in the case of the *kharif* season (monsoon). This variability can be attributed to the extent of contribution of rainfall to the seasonal crop water requirement (ETc). In those district where rainfall has greater contribution to the ETc, the required supply is correspondingly less. Similarly in <sup>the</sup> case of the hot weather and the *Rabi* season, when the contribution of rainfall to seasonal ETc is least, the variation in the values of the required supply among districts can be attributed to the differences in the soil moisture storage capacity. Soils with greater AWC values caused the required supply values to go down. Similar effect of rainfall and the soil AWC on the net irrigation requirements have also been observed by Villalobos and Fereras (1989) while preparing a simulation model for scheduling irrigation to corn grown under variable rainfall in Spain.

The data in the tables 4.2.1 to 4.2.11 also reveal that in all the districts of the command, the ratio between the computed actual supply and the required supply is less than 1.0 and, that it tends to exceed 0.5 only during the months when the evaporative demand is the highest. However, these figures should be viewed with caution because, only

seven crops of the many crops that are grown in the different areas are taken into account. Inclusion of the crops left out will definitely narrow down the ratio. But even then it is expected that the ratio will be substantial less than 1.0.

The ratio is the least during the months when rainfall is high and is in between during the winter months when the ground is fully covered with the crop. The implications of the findings are that during the months when the evaporative demands are low or when rainfall is adequate, the need for supplemental water is less frequent. During these periods of low demand, the flow of water can be reduced to the minimum. Such restriction to the flow of water, will lessen the danger of lateral seepage and the consequent rise in the water table and also reduced the danger of secondary salinization and alkalization.

Merriam (1977) has observed that water supplies with a low level of flexibility are the biggest cause of low efficiency. He has opined that farmers must have the ability to turn off the water. In fact he has discussed several of the improved techniques for effecting such control in water application. During the times of low supply, available ground water may be exploited to sustain the crops. Such a practice will also help in keeping the ground water level well below the root zone. Rajput and Michael (1990) have

also recommended the use of exploitable ground water in conjunction with the canal water while studying the scheduling of canal deliveries on a minor distributory of Mahi Right Bank canal command based on the soil moisture balance model. Similarly, the FAO (1992) while assessing the irrigation requirements of Rajolibonda command in Kurnool district, AP, have found the actual supply to exceed the required supply in most cases and pointed out the need to make adjustments in the cropping pattern and the scheme water supply so that greater efficiency in the use of this precious resource can be achieved.

In this respect, it is observed that to narrow down the gap between actual supply and required supply perennial crops like sugarcane, banana etc. can be introduced in the cropping pattern, especially in areas where rooting depth and soil properties are not a limitation to sustained water use.

#### **4.3 COMPARISON OF THE SOIL-CROP-CLIMATE BASED IRRIGATION SCHEDULE WITH OTHER COMMONLY PRACTICED IRRIGATION SCHEDULES**

The next step that is required, is to see the correspondence or compatibility of the proposed soil-crop-climate based irrigation schedule with the more commonly practiced irrigation schedules, so that decision on its applicability can be taken. The most commonly accepted

criterion is of course the economic yield of the crops, which are most widely grown in the area. In the present study, the validation of the soil-crop-climate irrigation schedule was carried out on the 7 main crops of the region viz., groundnut and pearl millet as hot weather crops; pigeonpea, cotton and castor as monsoon or *kharif* season crops and mustard and wheat as winter or *rabi* crops.

The first step in the evaluation of the proposed soil-crop-climate based irrigation schedule as against the commonly practiced irrigation schedules is its performance related to : (i) the number of irrigations required; (ii) the quantity of irrigation water applied per irrigation; and (iii) the total net irrigation water applied during the entire growth period of the crops grown.

#### 4.3.1.1 Effect of Irrigation Schedules on Number of Irrigations

It is seen from the data in table 4.3.1 that wide differences between treatments were observed for the number of irrigations required. In treatment T<sub>1</sub> (at 30 % depletion of AWC) the numbers of irrigation required for pearl millet were 12, for groundnut it was 15, for pigeonpea-17, for cotton-13, for castor-23, for mustard-14 and for wheat-21. For the treatment T<sub>2</sub> (at 50 % depletion AWC) the corresponding number of irrigations were 7, 9, 10, 8, 14, 9 and 12; for T<sub>3</sub> (at 70 % depletion of AWC) these were 5, 6,

Table 4.3.1 : Number of irrigations, quantity (mm) per irrigation and total net irrigation water applied under different irrigation schedules to the crops grown at Anand.

Treatments	Irrigation particulars	Pearl millet	G.nut	Pigeon pea	Cot- ton	Cas- tor	Mustard	Wheat
T1 30 % DP	No.Irri.	12	15	17	13	23	14	21
	Qty/Irri.	60	60	60	60	60	60	35**
	Total water appld.*	780	960	1189+	1015+	1921+	900	795
T2 50 % DP	No.Irri.	7	9	10	8	14	9	12
	Qty/Irri.	78	78	78	78	78	78	58**
	Total water appld.*	606	762	949+	938+	1233+	762	758
T3 70 % DP	No.Irri.	5	6	8	6	10	6	9
	Qty/Irri.	108	108	108	108	108	108	81**
	Total water appld.*	600	708	1033+	883+	1221+	708	789
T4 IW/CPE	No.Irri.	6	13	10	8	12	6	7
	Qty/Irri.	60	60	60	60	60	60	60
	Total water appld.*	420	840	769+	715+	871+	420	480
T5 Critical stage	No.Irri.	5	7	2	3	6	3	7
	Qty/Irri.	60	60	60	60	60	60	60
	Total water appld.*	360	480	289+	415+	511+	240	480
T6 Soil-Crop-Climate Model	No.Irri.	7	7	7	7	11	5	7
	Qty/Irri.	78	78	78	78	78	78	58**
	Total water appld.*	606++	606++	606++	606++	918++	450++	466++

\* Plus initial presowing irrigation of 60 mm in each case for each crop

\*\* AWC for wheat soil is 116 mm/m while for other crops the soil AWC is 155 mm/m

+ Includes 175 mm as effective rainfall for cotton, 109 mm for pigeon and 91 mm for casto

++ Less, effective rainfall.

8, 6, 10, 6 and 9, for T<sub>4</sub> (IW/CPE) 1.0) these were 6, 13, 10, 8, 12, 6 and 7, for T<sub>5</sub> (critical stages) the number of irrigations required were 5, 7, 2, 3, 6, 3, and 7, while for T<sub>6</sub> (soil-crop-climate model) the irrigation numbers required were 7, 7, 7, 7, 11, 5 and 7, respectively. It is seen from the data that within each treatment the length of growing period was the single factor controlling the number of irrigations and crops having a longer growing period (> 200 days) required more number of irrigations. But, in case of soil-crop-climate model however, the length of growing period had a marginal effect on number of irrigations required except in <sup>the</sup> case of castor where the number of irrigation required rose to 11, which was one less than the IW/CPE ratio schedule. The data also reveal that even in the case of wheat, where the soil was relatively coarser, yet the soil-crop-climate model showed a consistent number of irrigation and was at par with with the T<sub>4</sub> (IW/CPE ratio) and T<sub>5</sub> (critical stages approach). Except the critical stages approach, the least number of irrigations are required in the treatment T<sub>3</sub> (70 % depletion of AWC). Between T<sub>4</sub> and T<sub>6</sub>, which used a Epan reading of 60 mm and ETc reading of 78 mm respectively, lesser number of irrigation were required in T<sub>6</sub> (soil-crop-climate model) for most crops. Thus, it is clear that the number of irrigations required depends on the extent of depletion that is allowed before irrigation is initiated. Similar observations have

been made by Kundu *et al.* (1982) who while using the CONGRO model for evaluating irrigation practices, found number of irrigations applied to increase as the level of depletion was lessened. FAO (1992) have also found the number of irrigation to depend on the extent of depletion of AWC practiced in several crops grown in Rajolibonda command in Kurnool, A.P., India.

#### 4.3.1.2 Effect of Irrigation Schedule on Quantity of Water Applied

It is seen from the data in table 4.3.1 that the quantity of water applied varied as a result of differences in irrigation schedule. The quantity of water applied for pearl millet, groundnut, pigeonpea, cotton, castor, mustard and wheat for each of the treatments are as below :

T<sub>1</sub> (30 % depletion of AWC) it was 780, 960, 1189, 1015, 1521, 900 and 795 mm; T<sub>2</sub> (50 % depletion of AWC) water applied was 606, 762, 949, 938, 1233, 762 and 758 mm; T<sub>3</sub> (70 % depletion of AWC) it was 600, 708, 1033, 883, 1221, 708 and 789 mm; for T<sub>4</sub> (IW/CPE ratio 1.0) it was 420, 840, 769, 715, 871, 420 and 480 mm; for T<sub>5</sub> (critical stage approach) water applied was 360, 480, 289, 415, 511, 240 and 480 mm, while for T<sub>6</sub> (soil-crop-climate model) the water applied was 606, 606, 606, 606, 918, 450 and 466 mm, respectively. It is seen from the above figures that in general the quantity of water was more in <sup>the</sup> case of treatment

allowing the least depletion of AWC, while the least water was applied in <sup>the</sup> case of the critical stages approach. Because, the depth of water applied was made compatible with the extent of depletion, the differences between the treatments, T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> were not large, which would have been the case if constant depth were applied. The data also reveal that variation in the quantity of water applied for different crops was the least in the treatment T<sub>6</sub>, because this model predicted a more or less a near constant irrigation requirement, except in <sup>the</sup> case of castor where it predicted a larger NIR which was matched by a similar quantity of water applied. The data (Table 4.3.1) also reveal that between T<sub>4</sub> and T<sub>6</sub> treatments the quantity of water required was comparatively less in T<sub>4</sub> for crops pearl millet, castor and mustard, while the water required by T<sub>6</sub> treatment was less than T<sub>4</sub> for crops groundnut, pigeonpea, cotton and wheat. The fact that the quantity per irrigation applied was less in T<sub>4</sub> the three crops, viz., pearl millet, castor and mustard may be attributed to the fact that these crops have an inherently low water requirement. In <sup>the</sup> case of T<sub>6</sub>, the inherent efficiency of the model can be attributed for its lower water requirement for the other crops. Tripathi (1985) have also found net saving of 40 % in the water applied when the soil-crop-climate model was used to schedule irrigation in wheat at Pantnagar, U.P. Another redeeming feature of the soil-crop-climate

model is that it takes into account the contribution of effective rainfall in its calculation for irrigation scheduling, which the depletion treatments, the IW/CPE treatment or the critical stages approach ignore. It is also observed from the table 4.3.1 that inspite of the fact that the treatment T<sub>2</sub> and T<sub>6</sub> employ the same level of depletion i.e. 50 % AWC, yet the water applied and the number of irrigations is higher in T<sub>2</sub> than T<sub>6</sub>. This is because while T<sub>6</sub> takes into consideration the water lost to drainage, the depletion treatment does not take this into account, thereby the deep percolation losses are also added into the calculation. This fact is all the more clear in the considerably large difference in water applied in wheat between T<sub>2</sub> and T<sub>6</sub> treatments. The loss to deep percolation is greater in these soils due to coarser texture which have gone into the calculations in the depletion treatment, causing the observed variability.

#### 4.3.1.3 Effect of Irrigation Schedule on Quantity of Water Applied per Irrigation

The data in table 4.3.1 show that depending upon the treatment, the quantity of irrigation applied per irrigation varied. For treatment T<sub>1</sub> the quantity per irrigation was 60 mm for all crops except 35 mm for wheat; T<sub>2</sub> it was 78 mm and 58 mm for T<sub>3</sub> it was 108 mm and 81 mm, for T<sub>4</sub> and T<sub>5</sub> it was 60 mm for all crops including wheat,

while for T<sub>6</sub> it was 78 mm for all crops and 58 mm for wheat. Thus, it is seen that while treatment T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>6</sub> take the AWC into account, the treatment T<sub>4</sub> and T<sub>5</sub> donot take this fact into account and hence T<sub>4</sub> causes greater quantity of water to be applied in most of the crops. It is because of this fact that a blanket application of IW/CPE ratio cannot be made for a whole region. Again since it is based on the cummulative evaporation loss, local climatic disturbances and sources of advection may cause the IW/CPE ratio to be varied from place to place or season to season. Hanks *et al.* (1971) and Shouse *et al.* (1980) have also pointed out the limitation of using pan evaporation data for scheduling irrigation when forces of advection are active. This is all the more likely in the semi-arid and arid regions where large areas in pockets may remain uncropped and hence add to the forces of advection, thereby lowering the efficiency of IW/CPE ratio ratio as a tool for predicting irrigation requirement over a large region. The wide applicability of this method of soil water budgeting for irrigation scheduling has been found to be beneficial by Morey *et al.* (1980). So also, Dent and Scammell (1981) found the soil-crop-climate model to have a good predictability value for different soil series of Norfolk, UK growing a variety of crops under variable climate (PET and rainfall).

#### 4.3.2 Effect of Different Irrigation Schedules on Yield of Straw and Grain, Water Use Efficiency and Moisture Extraction Pattern

##### 4.3.2.1 Straw Yield

The data on the effect of different irrigation schedules on the yield of straw of different crops are given in table 4.3.2. It is seen from the data that straw yields of all the crops except castor and groundnut were significantly affected by irrigation schedules. In <sup>the</sup> case of pearl millet the yield (kg/ha) recorded under the different treatments were T<sub>1</sub> (7073.70), T<sub>2</sub> (6007.80), T<sub>3</sub> (4360.50), T<sub>4</sub> (6104.70); T<sub>5</sub> (4651.20) and T<sub>6</sub> (5232.60), respectively. Except treatments T<sub>3</sub> and T<sub>5</sub> rest of the treatment were at par with each other. Even the treatments T<sub>3</sub> and T<sub>5</sub> gave significantly lower yield of straw only with respect to treatment T<sub>1</sub>. The greater frequency of irrigation and the higher quantity of water applied in <sup>the</sup> case of treatment T<sub>1</sub> might have resulted in greater vegetative growth as the plants were rarely under stress, resulting in greater yield of straw. Patel et al. (1994) in case <sup>the</sup> of pearl millet (cv.GHB 30) and Vyas et al. (1994) in summer grown pearl millet in south Saurashtra region of Gujarat, while comparing different IW/CPE ratios also found, ratios giving greater frequency of water application to promote higher straw yields. Lower yield of straw in <sup>the</sup> case of T<sub>3</sub> when compared to

Table 4.3.2 : Effect of different irrigation schedules on straw and grain yield, water use efficiency (kg/ha-mm) and per cent moisture extraction pattern by different crops grown at Anand

Treatment	Parameter	Pearl millet (kg/ha)	Groundnut (g/ha)	Pigeonpea (kg/ha)	Cotton (kg/ha)	Castor (kg/ha)	Mustard (kg/ha)	Wheat (kg/ha)	Pearl millet B.M. C.D. † at 5%
T1 30 X DP	Straw yield	7073.70	61.53	6790.30	6751.50	7777.78	1611.11	8539.18	639.99 1929.20
	Grain yield	3759.75	33.23	1199.11	2461.24	3257.62	1995.91	3957.50	334.18 1087.35
	WUE	4.82	3.46	1.01	2.42	2.14	2.04	4.98	-
	Av. % Moist. ext. †	-	-	-	-	-	-	-	Groundnut
T2 50 X DP	Straw yield	6007.80	51.88	6327.32	5979.90	8437.51	1537.03	8096.51	15.57 MS
	Grain yield	2945.78	39.73	854.96	2538.38	3055.61	1892.59	4088.67	2.73 MS
	WUE	4.86	5.31	0.90	2.71	2.48	2.09	5.39	-
	Av. % Moist. ext.	-	-	-	-	-	-	-	Pigeonpea
T3 70 X DP	Straw yield	4360.50	58.14	4938.40	4436.70	7361.12	2111.11	6690.59	441.32 1330.31
	Grain yield	2102.72	36.82	760.88	2342.01	2958.77	2095.55	3901.34	116.32 350.63
	WUE	3.50	5.20	0.76	2.65	2.42	2.90	4.94	-
	Av. % Moist. ext.	-	-	-	-	-	-	-	Cotton
T4 IW/CPE	Straw yield	6104.70	69.63	5864.35	4218.80	8194.45	1814.82	6506.17	363.95 1097.07
	Grain yield	3439.92	33.72	946.01	2566.35	2842.80	2129.63	3022.45	191.71 MS
	WUE	8.19	4.01	1.23	3.59	3.26	5.07	7.96	-
	Av. % Moist. ext.	1)49.98 3)53.37 2)55.36 4)58.80	1)30.12 3)51.40 2)37.09 4)50.24	1)37.60 3)50.37 3)39.16 4)49.33	1)39.70 3)53.76 2)41.61 4)50.93	1)39.21 3)57.88 2)45.51 4)54.71	1)32.25 3)47.28 2)40.16 4)50.16	1)35.50 3)43.69 2)39.16 4)54.76	1)32.25 3)47.28 2)40.16 4)50.16
T5 Critical stage	Straw yield	4651.20	48.84	3858.12	4243.80	7569.45	1333.33	7103.97	1087.31 MS
	Grain yield	2605.62	39.34	854.96	2385.02	2930.33	1166.88	3874.24	194.76 MS
	WUE	7.24	8.20	2.96	5.74	5.73	4.86	8.07	-
	Av. % Moist. ext.	1)56.32 3)63.40 2)55.84 4)63.56	1)60.23 3)65.88 2)55.19 4)61.64	1)45.50 3)58.97 3)51.26 4)58.64	1)47.52 3)55.37 2)50.16 4)54.42	1)36.15 3)57.39 2)49.14 4)59.64	1)36.26 3)56.71 2)47.28 4)59.25	1)36.26 3)56.71 2)47.28 4)59.25	Mustard
T6 Soil-Crop-Climate Model	Straw yield	5332.60	78.33	4629.75	5019.40	8125.01	1481.48	8912.14	119.83 361.22
	Grain yield	2829.45	39.15	1126.57	2707.16	3055.19	1907.40	4057.21	186.62 562.64
	WUE	4.67	6.46	1.86	4.47	3.33	4.24	8.71	-
	Av. % Moist. ext.	1)52.75 3)66.33 2)51.28 4)59.74	1)50.18 3)66.41 2)49.14 4)60.91	1)35.50 3)53.79 2)41.14 4)54.86	1)37.50 3)55.97 2)43.24 4)56.68	1)39.21 3)57.88 2)45.51 4)58.71	1)34.29 3)53.29 2)42.78 4)56.16	1)34.29 3)53.29 2)42.78 4)56.16	Wheat

† For depths 0-30, 30-60, 60-90 and 90-120 cm averaged over the entire growth period.

T<sub>2</sub> inspite of marginal drop in water applied (606 mm vs. 600 mm) can be explained by the fact that the interval between two irrigation in T<sub>3</sub> were comparatively longer than T<sub>2</sub> as a result of which the plants suffered moisture stress serious enough to cause reduction in the dry matter production. Similar effect of longer irrigation interval on straw yield of summer pearl millet has been observed by Patel et al. (1994) and Vyas et al. (1994).

The effect of irrigation schedule on groundnut shows that in <sup>the</sup> case of haulm yields the treatment were at par with each other. The treatment yields (q/ha) were : T<sub>1</sub> (61.53); T<sub>2</sub> (51.88); T<sub>3</sub> (58.14), T<sub>4</sub> (69.63), T<sub>5</sub> (48.84) and T<sub>6</sub> (78.33). Highest haulm yield is being obtained in the treatment T<sub>6</sub> (soil-crop-climate model). Patel et al. (1988) also observed differences in irrigation scheduling intervals to have no significant effect on straw yields, in <sup>the</sup> case of groundnut.

In <sup>the</sup> case of pigeonpea, the data in table 4.3.2 reveal that irrigation scheduling methods had significant effects on pigeonpea stalk yield. The treatment of critical stages yielded the lowest stalk yield (T<sub>5</sub> = 3858.12 kg/ha) which was significantly lower than T<sub>1</sub>, T<sub>2</sub> and T<sub>4</sub>. The next lowest yield was obtained with the treatment T<sub>6</sub> (4629.75 kg/ha) which was significantly lower than treatment T<sub>1</sub> and T<sub>2</sub>, while the treatment T<sub>3</sub> (4938.40 kg/ha) also yielded

significantly lower than T<sub>1</sub> and T<sub>2</sub>. The treatments T<sub>1</sub> (6790.30 kg/ha), T<sub>2</sub> (6327.32 kg/ha) and T<sub>4</sub> (5864.35 kg/ha) were at par with each other in <sup>the</sup> case of stalk yields. The low yields in treatment T<sub>5</sub> and T<sub>6</sub> may be attributed to the fact that the amount of water applied as compared to T<sub>1</sub>, T<sub>2</sub> and T<sub>4</sub> was considerably less and also at longer intervals as a result of which, the vegetative growth suffered causing straw yields to go down. Soil water stress is known to inhibit leaf expansion and stem irrigation through lowered relative humidity (Slayter, 1955) which might have caused the yield reduction in <sup>the</sup> case of treatments T<sub>3</sub>, T<sub>5</sub> and T<sub>6</sub>.

The data on the effect of different irrigation schedules on stalk yield of cotton (Table 4.3.2) show that yields were significantly affected as a result of differences in irrigation schedule. The lowest stalk yield was found with the treatment T<sub>4</sub> (IW/CPE ratio 1.0) which yielded significantly less (4218.80 kg/ha) than at T<sub>1</sub> (6751.50 kg/ha) and T<sub>2</sub> (5979.90 kg/ha) while it was at par with treatments T<sub>3</sub> (4436.70 kg/ha), T<sub>5</sub> (4243.80 kg/ha) and T<sub>6</sub> (5015.40 kg/ha). The treatment T<sub>5</sub> which was the next lowest in yield also differed significantly from T<sub>1</sub> and T<sub>2</sub>, followed by T<sub>3</sub>. Treatment T<sub>6</sub> differed significantly for the straw yield with treatment T<sub>1</sub> only. Treatment T<sub>1</sub> and T<sub>2</sub> were at par with each other for straw yields. The effect of low moisture supply as well as longer interval in <sup>the</sup> case of T<sub>3</sub>, can be attributed for this effect, though the total

water applied was not substantially less than T<sub>1</sub> and T<sub>2</sub> treatments.

Stockton et al. (1961) have found infrequent irrigation to restrict vegetative growth severely. Marani and Devi (1973) found no significant differences in vegetative yield between treatment receiving regular and excessive irrigations. Delaying the first irrigation and irrigating cotton at longer intervals has also been found to adversely affect the growth of cotton by Guinn et al. (1981).

The data in table 4.3.2 on the yield of castor stalk under different irrigation schedules revealed that all the treatments were ~~at~~ par with each other. The deep rooting characteristics of the crop might have offset the effect of low moisture supply by sending the roots deeper for water. Also excessive irrigation in <sup>the</sup> case of treatment T<sub>1</sub> (7777.78 kg/ha) might have caused depletion of nutrient to lower layers and caused the roots to remain comparatively at shallow depths thereby affecting dry matter production. The lowest yields were recorded in treatment T<sub>3</sub> (7361.12 kg/ha). Though this treatment received quantity of water, comparable to that received by T<sub>2</sub> (8437.57 kg/ha) yet the longer interval might have caused negative effect on dry matter production. The next treatment to follow was T<sub>5</sub> (7569.45 kg/ha) followed by T<sub>6</sub> (8125.01 kg/ha) and T<sub>4</sub> (8194.45 kg/ha). Thus, while scheduling irrigation, the type of crop

and the interval between two irrigations need to be considered for better dry matter production and yield.

The data on the effect of irrigation on yield of mustard (Table 4.3.2) reveal that stalk yield was significantly affected as a result of irrigation schedule. It is observed that the yields in treatment T<sub>5</sub> (1333.33 kg/ha) were significantly less than T<sub>4</sub> (1814.82 kg/ha) and T<sub>3</sub> (2111.11 kg/ha). The stalk yield at treatment T<sub>6</sub> (1481.48 kg/ha) was significantly lower than T<sub>3</sub>. Similarly, the yield at T<sub>2</sub> (1537.03 kg/ha) and T<sub>1</sub> (1611.11 kg/ha) were significantly lower than T<sub>3</sub>. The yield under treatment T<sub>4</sub> (1814.82 kg/ha) was at par with T<sub>3</sub>. Significant effect of irrigation scheduling intervals on straw yields have also been observed by Malaviya et al. (1988) at Junagadh, Gujarat. Though the treatment at T<sub>6</sub> used more water than T<sub>4</sub> yet, the longer interval might have caused a depressing effect on dry matter production. Again, mustard being a crop which is inherently a low consumer of water might have reacted negatively to heavier supply of water.

The effect of different irrigation schedules on wheat straw (Table 4.3.2) was observed to be significant. Among the treatments, the lowest yield of straw was obtained in <sup>the</sup> case of treatment T<sub>4</sub> (6506.17 kg/ha) which was significantly lower than T<sub>3</sub> (7103.97 kg/ha), T<sub>2</sub> (8096.51 kg/ha), T<sub>1</sub> (8539.18 kg/ha) and T<sub>6</sub> (8912.14 kg/ha). The yield

at T<sub>4</sub> was at par with T<sub>3</sub> (6690.59 kg/ha) only. In spite of the fact that the treatment T<sub>6</sub> (soil-crop-climate model) used the least quantity of water, yet it caused the maximum yield of the straw points out to the fact that higher irrigation quantity of water applied in the other treatments might have caused the nutrients to leach down, beyond the root zone of the wheat crop. Also because of availability of water at greater frequency, the roots might have remained in the top few centimeters only. The data on the effect of frequency of irrigation shows a definite pattern in the depletion treatment, wherein with successive increase in irrigation frequency and amount, straw yield increased and the increase in yield at T<sub>3</sub> was significantly less than T<sub>1</sub> and T<sub>2</sub>, while though T<sub>1</sub> and T<sub>2</sub> were at par, the straw yield at T<sub>1</sub> was greater than T<sub>2</sub>. This may be attributable to greater vegetative growth in response to greater quantity of water applied. Panda *et al.* (1988) and Singh *et al.* (1990) have also observed straw yield to increase with increase in frequency and quantity of irrigation water.

#### 4.3.2.2 Grain Yield, Water Use Efficiency and Moisture Extraction Pattern

##### Pearl millet

The yield of grain or seed is the portion of the plant that is of economic importance to the cultivator. Efficiency of any treatment is ultimately decided by the

seed yield, especially in crops where seed is the economic end product. The effect of different irrigation schedules on the yield of grain in pearl millet (Table 4.3.2) reveal that irrigation scheduling intervals had significant effect on grain yield. The treatment at T<sub>3</sub> (70 % depletion of AWC, 2102.72 kg/ha) caused the least grain yield and it was significantly lower than T<sub>1</sub> (30 % of depletion, 3759.75 kg/ha) and T<sub>4</sub> (IW/CPE ratio 1.0, 3439.92) while it was at par with T<sub>2</sub> (50 % depletion, 2945.78 kg/ha) T<sub>5</sub> (critical stage approach, 2606.62 kg/ha) and T<sub>6</sub> (soil-crop-climate model, 2829.45 kg/ha). It is observed from the table 4.3.2 that the irrigation schedule based on soil-crop-climate model was at par with all the treatments. It is also seen from the data that the T<sub>4</sub> treatment caused the greatest WUE (8.19 kg/ha-mm), followed by T<sub>5</sub> (7.24 kg/ha-mm), T<sub>2</sub> (4.86 kg/ha mm), T<sub>1</sub> (4.82 kg/ha-mm), T<sub>6</sub> (4.67 kg/ha-mm) and T<sub>3</sub> (3.5 kg/ha-mm). Similar increase in WUE with less water have been observed by Dancette (1980) in <sup>the</sup> case of short and medium duration pearl millets. Similarly Patel et al. (1994) found higher IW/CPE ratio to give higher grain yield, while Vyas et al. (1994) found WUE of pearl millet to be highest at IW/CPE ratio of 1.0. Though in <sup>the</sup> case of pearl millet, IW/CPE ratio has performed better, the soil-crop-climate model has given yield at par with IW/CPE ratio and also IW/CPE ratio may become inefficient in conditions of high advection. This limitation is not found in the soil-crop-climate model and

hence can work equally well as an indicator of water need over a regional basis, which is not the case in IW/CPE ratio.

### Groundnut

The effect of irrigation schedule on groundnut kernel yield (Table 4.3.2) shows that the treatments were on par with each other. The highest yield was obtained with treatment T<sub>2</sub> (50 % depletion, 39.73 q/ha) followed by T<sub>5</sub> (critical stage, 39.34 q/ha), T<sub>6</sub> (soil-crop-climate model 39.15 q/ha), T<sub>3</sub> (70 % depletion, 36.82 q/ha), T<sub>4</sub> (IW/CPE ratio 1.0 33.72 q/ha) and T<sub>1</sub> (30 % depletion, 33.23 q/ha). Siva Kumar and Sarma (1986) are of the opinion that groundnut can yield higher without much harm with less number of irrigations. Saini et al. (1973) also observed the pod yield to be highest when irrigation was given at 50 % depletion of AWC. The data in table 4.3.2 reveal that the highest WUE (8.2 kg/ha/mm) was attained when irrigation was scheduled at critical stages (T<sub>5</sub>) followed by T<sub>6</sub> (soil-crop-climate, 6.46 kg/ha/mm), T<sub>2</sub> (50 % depletion, 5.31 kg/ha-mm), T<sub>3</sub> (70 % depletion 5.20 kg/ha-mm), T<sub>4</sub> (IW/CPE ratio, 4.01 kg/ha-mm) and T<sub>1</sub> (30% depletion 3.46 kg/ha-mm). In situation, of water constraints, treatments giving higher WUE are desirable while under adequate supply, irrigation schedules like T<sub>6</sub> (soil-crop-climate) and T<sub>2</sub> (50 % depletion) are better for higher yields. Though both T<sub>2</sub> and T<sub>6</sub> apply the

same quantity of water per irrigation, yet, frequency of irrigation at T<sub>2</sub> is greater, as the depletion measurement also includes water that is lost to deep percolation, while the T<sub>6</sub> treatment, requires less number of irrigations because it considers that aspect also. Also, the crop water need is modified due to crop factor (K<sub>c</sub>). The moisture extraction pattern shows that greatest quantity of moisture was extracted under the treatment T<sub>5</sub> from all the layers while in T<sub>6</sub> greater quantity was extracted from the lower layers (60-90 and 90-120 cm), while the least quantity was extracted under T<sub>4</sub> treatment from all layers. This differences in moisture extraction pattern appears to have made the difference in WUE under these treatments.

#### **Pigeonpea**

The response of pigeonpea to different irrigation schedules (Table 4.3.2) shows that, yields of pigeonpea seed were significantly affected. The lowest seed yield (780.88 kg/ha) was obtained under T<sub>3</sub> treatment which was significantly lower than T<sub>1</sub> (1199.11 kg/ha). Rest of the treatments were ~~ab~~ par with each other. The T<sub>6</sub> treatment was the next best (1126.57 kg/ha) followed by T<sub>4</sub> (946.01 kg/ha), T<sub>2</sub> and T<sub>5</sub> (854.96 kg/ha), respectively. Patel and Patel (1994) also observed irrigation scheduling intervals at different IW/CPE ratios to have no statistically significant effect on yield of pigeonpea seed. The highest WUE efficiency was observed under T<sub>5</sub> (2.96 kg/ha/mm) followed by

T<sub>6</sub> (1.86 kg/ha-mm), T<sub>4</sub> (1.23 kg/ha-mm), T<sub>1</sub> (1.01 kg/ha-mm), T<sub>2</sub> (0.9 kg/ha-mm) and T<sub>3</sub> (0.76 kg/ha-mm). The moisture extraction pattern reveals, that it was highest under treatment T<sub>5</sub> from all the layers, followed by T<sub>6</sub> and T<sub>4</sub>, respectively. Since the least quantity of water was applied under T<sub>5</sub>, the roots appear to have penetrated deeper in greater numbers and this might be the probable reason for greater extraction of moisture.

The effect of irrigation scheduling methods on cotton lint yield (Table 4.3.2) reveal that it was not significantly affected and that all the treatments were *q̄t* par. The highest seed lint yield was recorded under the treatment T<sub>6</sub> (soil-crop-climate model, 2707.16 kg/ha) followed by T<sub>4</sub> (IW/CPE ratio 1.0, 2566.35 kg/ha), T<sub>2</sub> (50 % depletion, 2538.38 kg/ha), T<sub>1</sub> (30 % depletion 2461.24 kg/ha), T<sub>5</sub> (critical stages approach, 2385.02 kg/ha) and T<sub>3</sub> (70 % depletion, 2342.01 kg/ha). It is observed that as the frequency of irrigation increased (T<sub>6</sub>, 7, T<sub>4</sub>, 8, T<sub>2</sub>, 8 and T<sub>1</sub>, 13) the lint yield decreased, thus suggesting that frequent irrigation in cotton are not necessary. Similar observation on the effect of irrigation frequency on lint yield have been observed by Bordovsky *et al.* (1992), Ayars *et al.* (1991) and Cull *et al.* (1981). The data on WUE (Table 4.3.2) show that the highest WUE was recorded with T<sub>5</sub> (critical stages, 5.74 kg/ha-mm) followed by T<sub>6</sub> (soil-crop-climate model, 4.47 kg/ha-mm); T<sub>4</sub> (IW/CPE ratio, 1.0, 3.59

kg/ha-mm), T<sub>2</sub> (50 % depletion 2.71 kg/ha-mm), T<sub>3</sub> (70 % depletion, 2.65 kg/ha-mm) and T<sub>1</sub> (30 % depletion, 2.42 kg/ha-mm). Thus, under limited supply of moisture, the treatment T<sub>5</sub> appears to be the best, while under adequate water supply, treatment T<sub>6</sub> is the best. The moisture extraction pattern follows the same trend with the greatest moisture from all layers under T<sub>5</sub>, followed by T<sub>6</sub> and the least under T<sub>4</sub>. The progressive decrease in moisture supply in T<sub>5</sub> might have caused the roots to utilize moisture from deeper layers.

#### Castor

The data on the castor seed yield (Table 4.3.2) reveal that irrigation treatments did not have any significant effect and that all treatments were ~~ok~~ par with each other. Maximum castor seed yield was recorded under the treatment T<sub>1</sub> (30 % depletion, 3257.62 kg/ha) followed by T<sub>2</sub> (50 % depletion, 3055.61 kg/ha), T<sub>6</sub> (soil-crop-climate model, 3055.19 kg/ha), T<sub>3</sub> (70 % depletion 2958.77 kg/ha), T<sub>5</sub> (critical stages, 2930.33 kg/ha) and T<sub>4</sub> (IW/CPE ratio 1.0, 2842.80 kg/ha). It appears from the data that low amount of water has caused negative effect on seed yield. This might be because of lesser seed setting, shattering losses due to early desiccation and smaller size of seeds. As far as WUE is concerned, the treatment at T<sub>5</sub> gave the highest WUE (5.73 kg/ha-mm) followed by T<sub>6</sub> (3.33 kg/ha-mm), T<sub>4</sub> (3.26 kg/ha-mm), T<sub>2</sub> (2.48 kg/ha-mm), T<sub>3</sub> (2.42 kg/ha-mm) and T<sub>1</sub> (2.14 kg/ha-

mm). The moisture extraction follows the same pattern as observed for the other crops discussed so far.

### Mustard

The <sup>data on</sup> effect of irrigation schedule on seed yield of mustard are presented in the table 4.3.2. It is seen from the table that significant differences between treatments on yield of mustard seed, exist. The lowest seed yield was observed in treatment T<sub>5</sub> (1166.66 kg/ha) which was significantly less than treatment T<sub>6</sub> (1907.40 kg/ha), T<sub>1</sub> (1925.91 kg/ha), T<sub>3</sub> (2055.55 kg/ha) and T<sub>4</sub> (2129.63 kg/ha). Treatment T<sub>6</sub> was on par with rest of the treatment. It is seen from the data that increasing irrigation frequency from 3 to 6 caused increase in yield of mustard seed, but beyond 6 irrigations (table 4.3.1), the yield was lesser. Dobariya and Mehta (1995) have also observed the beneficial effect of greater frequency of irrigation of mustard seed yield when comparing between 0.4 and 0.6 IW/CPE ratio. Similar effect of increasing frequency of irrigation on seed yield of mustard has been reported by Prasad and Ehsanullah (1990), Sharma and Arvind Kumar (1991) and Begum and Paul (1993) among other workers. The effect of irrigation on WUE reveals that it was highest in the treatment T<sub>4</sub> (5.07 kg/ha-mm) followed by T<sub>5</sub> (4.86 kg/ha-mm), T<sub>6</sub> (4.24 kg/ha-mm), T<sub>3</sub> (2.90 kg/ha-mm), T<sub>2</sub> (2.09 kg/ha-mm) and T<sub>1</sub> (2.04 kg/ha-mm). Since mustard is a crop which is inherently a low consumer of water, higher WUE at lower irrigation frequencies is

expected. The data on moisture extraction pattern reveals that it was greater in all the layers under T<sub>5</sub> treatment while T<sub>4</sub> and T<sub>6</sub> showed more or less similar moisture extraction from all the layers.

#### Wheat

The data in table 4.3.2 reveal that in <sup>the</sup> case of wheat grain yield, the treatments differed non significantly with each other. The highest grain yield was obtained under the treatment T<sub>2</sub> (4088.67 kg/ha), followed by T<sub>6</sub> (4057.21 kg/ha), T<sub>1</sub> (3957.50 kg/ha), T<sub>3</sub> (3901.34 kg/ha), T<sub>5</sub> (3874.24 kg/ha), and T<sub>4</sub> (3822.45 kg/ha). Patel and Upadhyay (1993) also observed 12 irrigations and 9 irrigations to be *q<sub>6</sub>* par with each other for grain yield, but yield was significantly higher than 6 irrigation or IW/CPE ratio of 0.8. Similar beneficial effect of increasing frequency of irrigation on wheat grain yield have been observed by Sud *et al.* (1990), Singh *et al.* (1990) and Rathore *et al.* (1991). As far as WUE is concerned the highest WUE was observed under treatment T<sub>6</sub> (8.71 kg/ha-mm), followed by T<sub>5</sub> (8.07 kg/ha-mm), T<sub>4</sub> (7.96 kg/ha-mm), T<sub>2</sub> (5.39 kg/ha-mm), T<sub>1</sub> (4.98 kg/ha-mm) and T<sub>3</sub> (4.94 kg/ha-mm). The data on moisture extraction pattern show it to be the greatest in all layers under T<sub>5</sub> treatment followed by T<sub>6</sub> and T<sub>4</sub>, respectively.

From the above results it is quite clear that the soil-crop-climate model compares very favourably with other

irrigation schedules as far as the economic output viz., the grain yield, is concerned and in many crops performs better than other irrigation treatments. The computation of the model requires minimum number of data sets and takes into consideration the three important factors of climate-soil and crop into consideration. Another redeeming feature is, that it takes into account the effective rainfall and hence gives a truer picture of the irrigation requirement of crops. Yet another advantage is that it predicts the need for irrigation atleast 3 days in advance, which other irrigation schedules are unable to do. Though IW/CPE ratio is the most practiced scheduling technique, yet it needs to be borne in mind that it varies with soils and crops. Also under sources of advection the depletion predicted by it may be larger than is actually occurring. Because of these several advantages the soil-crop-climate model appears to be a better tool in predicting irrigation requirement of crops on a regional basis involving a variability of soils, crops and climate.

#### **4.4 ALTERNATIVE IRRIGATION PRACTICES IN AREAS SUBJECT TO PROBLEMS OF RISING WATER TABLE**

The ultimate consequence of unrestricted availability of water for irrigation under intensive agriculture generally carried out in the command areas is the incidence of rising water table along the areas in

close proximity to the canals and those areas downstream. Similarly, unrestricted irrigation cannot be practiced in areas where the soils are inherently shallow or have a root limiting layer at shallow depth like a clay pan or a calcic layer etc. Also another most prevalent problem in areas under canal irrigation is the development of secondary salinity and alkalinity.

In an effort to find alternative irrigation management practices, in areas subjected to rising water table, that would keep the water table at manageable depths as well as assure good yields, a field experiment was conducted using sprinkler system as an alternative irrigation management strategy. It was compared with flood irrigation and no irrigation practices followed in such areas, for its efficiency.

The results of the study in terms of effect on kernel and haulm yield and moisture extraction pattern are presented in table 4.4.1.

It is seen from the data that under situations of shallow water table, irrigation with sprinkler has given the maximum kernel yield (5.71 and 5.70 t/ha). No irrigation has also resulted into realization of good yield of kernel (4.7 t/ha). However, irrigating the crop through flood irrigation has given the least yield (2.6 t/ha). The adverse effect of extra water on root aeration may be attributed for

Table 4.4.1 : Yield of groundnut haulm and kernels (q/ha) water use efficiency and consumptive use under different irrigation practices on farmers' field at Lingda village

Treatment	Yield (q/ha)		WUE (kg/ha-mm)	CU (mm)
	Haulm	Kernel		
T1 No Irri	50.80	47.00	7.83	606
T2 Sprinkler irri. @ 2.5 cm on 55 and 85 DAS with 1.5 m WT.	63.40	57.10	8.78	606
T3 Sprinkler irri. @ 2.5 cm on 55 and 1.0 m WT.	63.10	57.20	8.80	606
T4 4 Irri. @ 5cm on 0, 55, 85 and 100 DAS	50.40	26.0	4.33	606
S.Em.	0.30	0.18		
CD at 5%	1.10	0.60		
C.V. %	12.42	6.04		

% Moisture extraction pattern under no irrigation is : 0-30 = 56.02 %; 30-60 = 38.68 %; 60-90 = 35.52 % and 90-120cm = 29.10 %.

the poor development of kernels. The negative effect of rising water table depths on root aeration has also been mentioned as one of the factors for poor crop performance on such soils by Alvino and Zerbi (1986). Similar negative effect of irrigation has been reported by Yadav et al. (1995) in<sup>the</sup> case of wheat grown on soils with shallow under ground water table. These workers observed wheat yield to decrease when more than two irrigations were given to the crop. Kruse et al. (1993) while studying the response of corn, alfalfa and winter wheat to irrigation on soils with shallow water table have also concluded that under such situations number of irrigation should be reduced. In the present study the data reveal the beneficial effect of sprinkler irrigation over the rest of the treatments. Similar beneficial effects of sprinkler system of irrigation have been observed by Suryavanshi and Pampattiwar (1985) in<sup>the</sup> case of chilli, groundnut and sunflower, as well as significant savings in water use. In<sup>the</sup> case of potato, Jaggi et al. (1991) also observed sprinkler system of irrigation to result in greater efficiency of water use.

Irrigating groundnut through sprinklers under both 1.0 and 1.5 m water table depths, gave significantly higher yields of kernels probably because of congenial micro-climatic condition created as a result of sprinkling water over the crop and the moistening of the surface soil layer. The moistening of soil at the critical juncture of peg entry

and pod development (55 and 85 DAS respectively) might have resulted in this beneficial effect and resultant better crop performance. Sivakumar and Sarma (1986) have also found these two phases as crucial for getting higher yields of groundnut pods. The importance of irrigating crop at certain critical stages only, in soils with high water table conditions has also been stressed by Tripathi *et al.* (1989). These workers observed that under shallowest water table conditions (0.4 - 0.8 m) only one irrigation to wheat at crown root irrigation stage gave similar yields as that obtained with higher number of irrigations. Two irrigations one at CRI and the other at flowering stage yielded the same as more number of irrigations when the water table depth was between 0.66 to 1.4 and 1.8-2.4m.

Effort was also made to study the contribution of ground water towards the ET in <sup>the</sup> case of non irrigated treatment. Using the equation given by Cook and Dent (1990) and taking average values for unsaturated hydraulic conductivity ( $\text{mm day}^{-1}$ ; Patel *et al.* 1992), difference between potential at root zone and at the water table (kPa) and difference between root zone and depth of water table (cm) and applying it in the equation, it was observed that about 70 per cent of the total evapotranspiration (ETc) was contributed by the underground water table (Table 4.4.2). It may be because of this shortfall in the contribution to the total water use, that the yield of pods is comparatively

lower than the sprinkler treatment. This is all the more clear from the data presented in table 4.4.2 which shows that around 55 DAS, when peg entry and pod development starts, the potential at which moisture is held is around 100 kPa and the available water content has reduced by 60 per cent (Fig. 4.4.1). Also the hydraulic conductivity (unsaturated) falls down considerably (Table 4.4.2). This development might have affected the pod yield to some extent, with the result that the yield are less as compared to the sprinkler irrigation. These results clearly point out that under situations of rising water table or under situations which do not permit flood irrigation, good yields can yet be achieved by restricting the irrigation number and quantity by adopting other techniques of irrigation like the sprinkler system. The adaptability of sprinkler system to other crops and its economic viability and ease of adoption are aspects which however, need to be studied in detail.

#### **4.5 EFFECT OF DIFFERENT IRRIGATION SCHEDULES ON THE NUTRIENT CONTENT AND UPTAKE BY DIFFERENT CROPS**

The final objective of the study was to see the effect of the soil-crop-climate irrigation schedule on the nutrient content in and uptake by the different crops and also how it compares with other irrigation schedules.

Before proceeding with the discussion on the concentration of nutrients in the straw and the grain

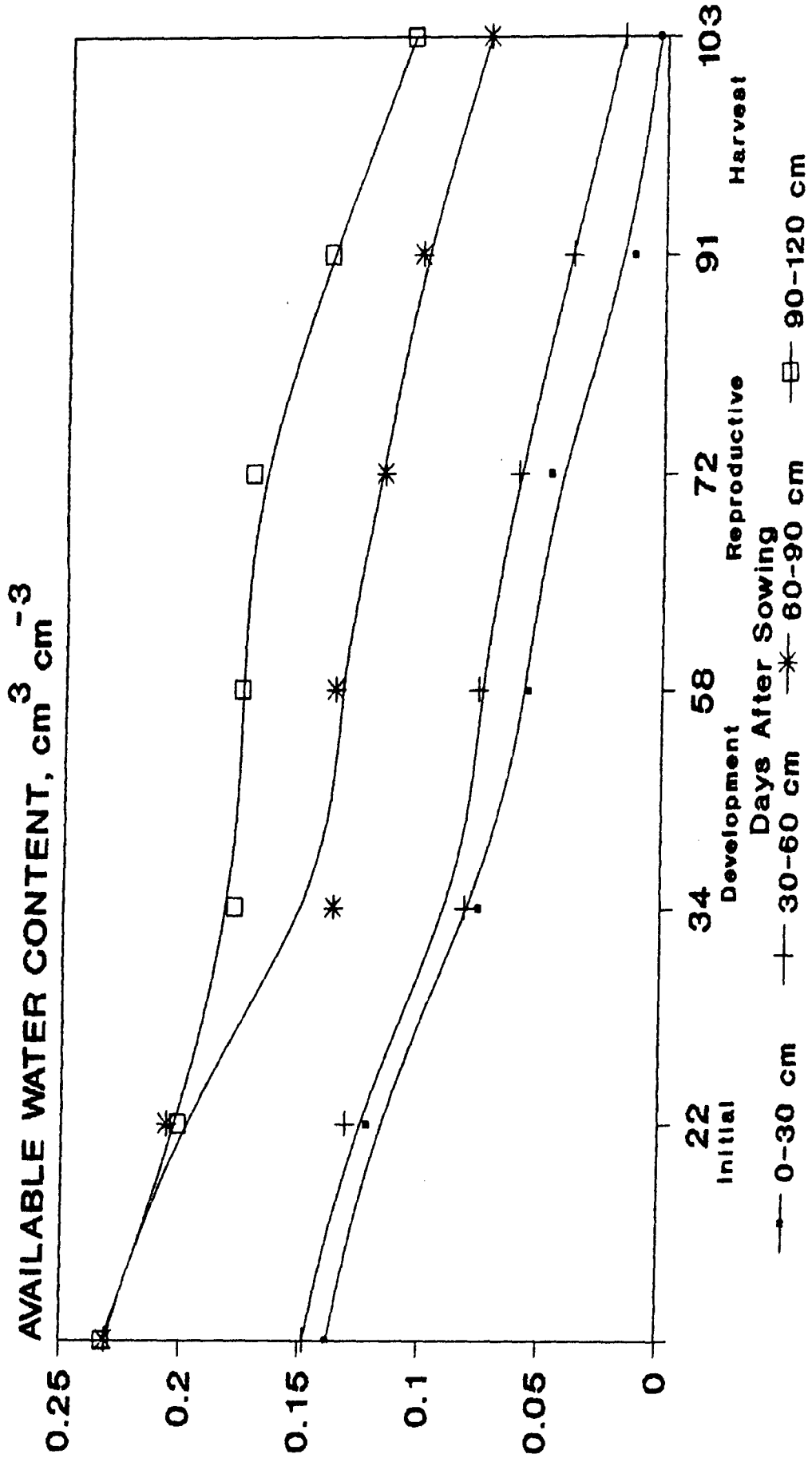


Fig. 4.4.1 : Available Water Content, cm<sup>3</sup> cm<sup>-3</sup> at different depths at Lingda at different Crop Growth Stages

Table 4.4.2 : The depth of water table (cm), unsaturated hydraulic conductivity (mm/day), the depth of root-zone, potential at root zone (kPa), potential at the water table with time (days after sowing) in groundnut grown without irrigation

Date	DAS	WT Depth (cm) (Z wt)	Root-zone depth(cm) (Zrz)	$\phi$ at rootzone (kPa)	$\phi$ at wt (kPa)	$\phi_{rz}$ - $\phi_{wt}$	Zwt - Zrz (cm)	Ku mm day <sup>-1</sup>
29.2.96	22	60	15	38	0	38	45	1.9
12.3.96	34	75	24	75	0	75	51	0.84
5.4.96	58	90	28	100	0	100	62	0.80
19.4.96	72	90	30	190	0	190	60	0.49
8.5.96	91	105	45	580	0	580	60	0.33
20.5.96	103	120	56	775	0	775	64	0.13

Average Ku = 0.75 mm day<sup>-1</sup>  
 Average depth = 57 cm

Average potential = 273 kPa  
 Average upward flux = 0.75 x 273 = 3.86 mm day<sup>-1</sup>

57

Length of growing period = 110 days  
 Total consumptive use = 606 mm

Total upward flux = 425 mm  
 % contribution from ground water = 70.01 %

For sprinkler irrigation:

Total water applied = 150 mm  
 % of Cu applied as irrigation water=25 %  
 Net deficit 606 - 575 = 31 mm=5 %

Total consumptive use = 606  
 % of Cu from underground water table = 70%

For Flood irrigation :

Total water applied = 200 mm  
 % of Cu applied as irrigation water=33 %  
 Net excess 625 - 606 = 19 mm=3 %

Total consumptive use = 606  
 % of Cu from underground water table = 70%

portions of the different crops subjected to different irrigation schedules, it is pertinent to point out that the uptake of nutrients is an indication of the extent of depletion that each nutrient undergoes as a result of the treatment it is subjected to. The depletion pattern assumes special significance when any one or a group of essential nutrients are marginal in content. The prolonged depletion of such nutrient may cause them to become deficient or cause nutritional imbalances causing the plants to yield below their potential. The study of uptake of nutrients is thus of great importance in deciding the fertilizer schedule. The concentration of nutrients in the different plant parts is also of importance as their relative distribution vis-a-vis other nutrients have a great bearing on the ultimate performance of the crops, since all nutrients considered to be essential, perform their role in the vital functions of the plants. The following paragraphs discuss the effect of different irrigation schedules on the content of nutrients in, and their uptake by the individual crops studied.

#### 4.5.1 Effect of Different Irrigation Schedules on the Nutrient Contents in and Their Uptake by Pearl millet (cv. GHB 235)

The data are presented in table 4.5.1. It is seen from the table 4.5.1 that as far as the content of nutrients, as affected by different irrigation schedules is concerned,

Table 4.5.1 : Effect of different irrigation schedules on content and uptake of nutrients in pearl millet (cv.GHB 236), grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																			
		N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		Ca		Mg		Na		Cu		Fe		Zn		Mn	
		%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	ppm	kg/ha	ppm	g/ha	ppm	g/ha
T <sub>1</sub> 30 % DP	STRAW	1.50	106.11	0.75	52.84	4.69	332.34	0.46	32.17	0.70	49.52	0.22	15.93	17.00	120.35	370.50	2.61	26.50	187.99	39.50	279.56
	GRAIN	1.50	56.49	1.02	37.97	0.99	37.34	0.38	14.37	0.21	7.90	0.08	2.87	18.00	66.71	184.50	697.14*	48.00	180.31	17.00	63.72
T <sub>2</sub> 50 % DP	STRAW	1.65	99.18	0.79	47.83	5.26	314.99	0.53	32.02	0.76	44.93	0.27	16.12	13.00	79.55	381.50	2.27	23.00	137.50	34.00	203.78
	GRAIN	1.65	48.52	1.00	29.56	0.91	26.89	0.45	13.21	0.23	6.80	0.08	2.52	18.00	52.97	290.00	852.71*	38.50	113.23	18.00	52.96
T <sub>3</sub> 70 % DP	STRAW	1.75	74.95	0.87	37.54	5.59	242.81	0.79	33.41	0.79	34.07	0.33	14.33	19.50	84.11	438.50	1.92	30.50	132.17	44.00	196.61
	GRAIN	1.73	36.25	1.41	29.20	1.59	32.91	0.55	11.49	0.27	5.51	0.10	2.01	21.25	44.70	400.00	850.25*	60.00	127.50	20.50	43.37
T <sub>4</sub> IV/CPE	STRAW	1.54	94.03	0.81	49.17	5.29	322.59	0.42	25.54	0.72	43.99	0.27	16.18	13.50	82.66	308.00	1.89	21.50	131.78	35.25	215.50
	GRAIN	1.55	53.36	0.99	34.12	1.57	54.63	0.40	13.72	0.22	7.54	0.08	2.75	17.75	61.30	335.50	1154.73*	44.00	151.69	17.00	58.20
T <sub>5</sub> Critical stages	STRAW	1.85	85.93	0.85	39.28	5.07	233.10	0.75	35.62	0.77	36.26	0.31	14.65	17.75	82.17	410.00	1.92	27.50	128.49	42.00	195.74
	GRAIN	1.85	48.16	1.21	31.18	1.53	39.79	0.47	12.38	0.25	6.45	0.09	2.25	20.00	52.08	372.25	957.49*	40.00	105.00	18.00	46.84
T <sub>6</sub> Soil-Crop -Climate Model	STRAW	1.70	89.04	0.83	44.00	5.23	273.73	0.77	40.25	0.74	38.33	0.30	15.65	19.00	102.91	355.00	1.87	27.50	146.81	40.50	212.79
	GRAIN	1.60	45.28	0.99	28.00	1.06	29.98	0.48	13.57	0.26	7.36	0.09	2.40	19.00	53.76	366.50	1038.35*	40.00	113.32	18.50	52.46
		S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.
		at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%
STRAW	CONTENT	0.046	0.139	0.063	ns	0.289	ns	0.088	0.264	0.032	ns	0.011	0.032	0.392	ns	42.751	ns	3.707	ns	2.808	8.466
	UPTAKE	10.274	ns	6.211	ns	32.677	98.501	7.133	ns	5.193	ns	2.081	ns	19.974	ns	0.356	ns	30.817	ns	34.971	ns
GRAIN	CONTENT	0.02	0.061	0.066	0.200	0.173	0.520	0.026	0.077	0.011	0.032	0.003	0.01	0.860	2.591	31.910	96.190	3.964	11.950	0.757	2.313
	UPTAKE	5.514	16.620	3.063	ns	6.307	19.012	1.713	ns	0.807	ns	0.306	ns	5.811	17.515	124.466	375.191	19.657	59.255	5.965	18.041

\* g/ha

significant differences in concentrations of nutrients were found in <sup>the</sup> case of nitrogen, calcium, sodium and manganese while for other nutrients their differences in concentration were statistically non significant. In <sup>the</sup> case of uptake of nutrients by straw, the differences among treatment were significant in <sup>the</sup> case of potassium only.

It is seen from the pattern of nutrient concentration that as the quantity of water applied increased the concentration of nutrients decreased. This may be attributed to the dilution effect of increased growth on nutrient concentration. The increase in nutrient concentration as a result of decreasing soil moisture supply has also been observed by Kidambi et al. (1990) in their study on alfalfa and sainfoin. Similar observation in case of other nutrients has also been observed though the treatment effects are non-significant. In case of nutrient uptake the order of difference in the uptake was significant for potassium only. Similar trend, though non significant, for other nutrients was also observed in <sup>the</sup> case of uptake, as a result of increasing supply of water. This may be attributed to the increase in the dry matter production as a result of increasing moisture. Similar results have been reported by Bashir-Al-Ithawi et al. (1980) in <sup>the</sup> case of soybean, Wahab and Singh (1983) in <sup>the</sup> case of barley and Seiffert et al. (1993) in <sup>the</sup> case of maize. In <sup>the</sup> case of grain, it is observed from the data (Table 4.5.1) that

grain, it is observed from the data (Table 4.5.1) that irrigation scheduling treatments differed significantly for all the nutrients as far as their concentration is concerned. It is observed that the treatments receiving less water has higher concentration of nutrients while the treatment receiving the highest quantity of water (i.e. T<sub>1</sub>) had the lowest nutrient concentrations. This is attributable to the increase in the dry matter production as a result of which there is dilution of the concentration, of the nutrients (Kidambi et al., 1990). In case of uptake of nutrients by the grain except, phosphorus, calcium, magnesium and sodium, all the nutrients differed significantly in their uptake by pearl millet grain as a result of irrigation treatments. It is observed from the data (Table 4.5.1) that when the frequency of irrigation was highest (T<sub>1</sub>), the uptake of N, Cu, Zn and Mn were the highest while in case of K it was observed that the IW/CPE schedule (T<sub>4</sub>) gave significantly higher K uptake than the rest of the treatment. Since K nutrition is attributed to the diffusion process, leaching to lower layers might have caused its lower concentration in the plant while at lower moisture though the concentration was high yet the overall dry matter production was reduced enough to result into lower uptake. Similar effect of higher moisture level on K leaching was observed by Reddy and Sastry (1983) in case of K movement in soil. Seiffert et al. (1995) while studying

observed lower moisture content to decrease K uptake by maize roots which they attributed to reduced K influx toward the root. Similar effect of increasing frequency of irrigation on N and P uptake by summer pearl millet was observed by Vyas *et al.* (1994) in south Saurashtra region of Gujarat. In <sup>the</sup> case of Fe, the highest uptake was observed in T<sub>4</sub> treatment while the lowest uptake was observed in T<sub>1</sub> treatment receiving the maximum quantity of water. In <sup>the</sup> case of Zn, the highest uptake was observed in T<sub>1</sub> which was significantly greater than T<sub>4</sub>. This behaviour may be attributable to the mutual antagonistic relationship between these two nutrients. Tiwari *et al.* (1976) while studying the effect of moisture regimes on the uptake of Fe and Zn, have observed Zn to restrict Fe at moisture contents below submergence or field capacity. In the present study also the moisture content was always maintained around field capacity but never as high as submergence. The rest of the treatments were found to be statistically at par as far as the uptake of these nutrients was concerned.

#### 4.5.2 Effect of Different Irrigation Schedules on the Nutrient Concentration in and Their Uptake by Groundnut (cv. GG-2)

The data on nutrient content in and uptake by the haulm and kernels of groundnut (cv. GG 2) are presented in table 4.5.2. It is observed from the data that in <sup>the</sup> case of

haulm except sodium and iron, all nutrients differed significantly in their concentration as a result of differences in irrigation schedule. However, none of the nutrients differed significantly as far as their uptake by haulm was concerned. Since the concentration of nutrient element is affected by the extent of growth, treatments promoting higher dry matter production caused lower concentration attributable to the dilution effect. In the present case in most of the nutrients the concentration was lowest in the treatment T<sub>6</sub>, which has given the highest haulm dry matter production. However, as far as the uptake of nutrients is concerned, the treatments were found to be statistically at par, as the effect on yield was offset by a higher concentration of nutrients, causing the overall uptake to differ non significantly. However, greater uptake of nutrients is observed in treatment promoting greater dry matter production. Similar relationship of dry matter production to nutrient uptake have been observed by several workers (Akbari et al., 1983; P uptake in groundnut; Zalawadia and Patel (1983), P uptake in groundnut; Prasad and Prasad, (1988), N uptake in winter maize, Singh et al. (1994), P uptake in groundnut). In <sup>the</sup> case of nutrient concentration and their uptake in groundnut kernels, the data (Table 4.5.2) reveal that except for the concentration of sodium, all the nutrients differed significantly in their

Table 4.5.2 : Effect of different irrigation schedules on contents and uptake of nutrients in groundnut (cv. GG 2) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																			
		N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		Ca		Mg		Na		Cu		Fe		Zn		Mn	
		%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	ppm	g/ha	ppm	g/ha	ppm	g/ha	ppm	g/ha
T <sub>1</sub> 30 % DP	STRAW	2.66	163.77	0.56	34.28	1.23	75.14	1.88	115.80	0.95	58.23	0.23	14.33	15.75	99.12	494.75	2992.43	46.00	282.94	36.50	225.62
	GRAIN	7.74	257.19	1.39	46.07	1.73	57.54	0.20	6.88	0.24	7.94	0.16	5.23	20.50	68.31	388.00	1288.20	17.50	57.94	22.50	74.65
T <sub>2</sub> 50 % DP	STRAW	2.71	140.39	0.59	30.17	1.38	71.75	2.02	104.87	1.00	52.11	0.24	12.64	26.50	136.20	508.50	2630.10	61.00	315.80	47.00	242.73
	GRAIN	8.08	321.07	1.04	41.40	1.48	58.88	0.28	10.88	0.17	6.75	0.14	5.52	10.50	41.92	249.50	1061.43	12.00	47.50	13.50	53.43
T <sub>3</sub> 70 % DP	STRAW	2.95	171.62	0.64	36.94	1.35	78.96	2.01	116.67	0.99	57.74	0.24	14.34	22.00	128.41	505.00	2915.73	59.00	343.11	39.50	229.06
	GRAIN	8.52	313.68	1.31	48.41	1.71	62.80	0.27	9.76	0.20	7.27	0.16	5.77	14.75	54.30	357.50	1316.18	15.50	57.19	16.50	60.83
T <sub>4</sub> IW/CPE	STRAW	2.76	191.53	0.58	40.63	1.07	74.34	1.80	123.72	0.93	65.41	0.23	15.73	13.75	94.83	450.00	3148.15	45.50	319.36	35.00	242.19
	GRAIN	8.42	283.28	1.37	46.12	1.73	58.46	0.22	7.25	0.24	7.91	0.16	5.40	18.50	62.98	350.50	1219.42	16.00	54.69	19.50	66.75
T <sub>5</sub> Critical stages	STRAW	2.79	136.17	0.55	26.90	1.44	70.45	2.07	101.90	1.15	56.09	0.27	13.17	27.00	131.75	510.50	2488.98	63.50	313.00	49.50	242.28
	GRAIN	8.23	323.83	1.18	46.89	1.60	62.71	0.27	10.44	0.18	7.17	0.15	5.71	11.00	42.95	308.50	1211.47	12.50	49.48	15.00	59.15
T <sub>6</sub> Soil-Crop -Climate Model	STRAW	2.78	215.76	0.45	35.27	1.00	78.64	1.73	135.58	0.82	64.33	0.22	17.65	13.00	99.05	447.50	3478.40	36.50	288.87	27.50	215.24
	GRAIN	8.08	316.35	1.18	46.11	1.64	64.20	0.27	10.39	0.19	7.44	0.15	6.01	12.50	49.34	333.00	1305.94	14.00	54.58	15.00	58.95
		S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.
		at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%
STRAW	CONTENT	0.045	0.134	0.023	0.070	0.042	0.126	0.05	0.151	0.028	0.085	0.017	NS	1.529	4.610	26.122	NS	3.541	10.674	1.027	3.097
	UPTAKE	40.751	NS	8.909	NS	17.032	NS	27.054	NS	14.936	NS	3.982	NS	22.825	NS	700.451	NS	78.598	NS	50.683	NS
GRAIN	CONTENT	0.049	0.148	0.094	0.284	0.053	0.160	0.016	0.045	0.011	0.033	0.011	NS	1.394	4.202	10.109	30.472	1.376	4.149	1.054	3.177
	UPTAKE	21.816	NS	5.603	NS	5.372	NS	0.897	2.703	0.610	NS	0.654	NS	8.304	25.032	109.086	NS	7.209	NS	7.708	NS

concentration as a result of irrigation treatments and as a general rule, concentration of nutrient was lower in those treatment causing greater dry matter production. In the present study concentration of nutrient was generally lower in T<sub>2</sub> treatment which has been found to promote higher dry matter production of kernels. As far as uptake of nutrients is concerned, except for the uptake of calcium and copper, all the treatments promoted similar uptake of nutrients. Since calcium forms an integral part of the kernel husk its higher uptake is expected as a result of higher dry matter production. This is reflected in its concentration also, because inspite of higher yield of kernels in T<sub>2</sub> treatment the so called dilution effect was not noticed in <sup>the</sup> case of calcium concentration in kernels. Similar behaviour was also observed in <sup>the</sup> case of Cu concentration vis-a-vis yield of kernels.

#### 4.5.3 Effect of Different Irrigation Schedules on the Nutrient Concentration in and Uptake by Pigeonpea (cv. BDN 2)

The concentration of nutrients and their uptake as a result of different irrigation schedules are presented in table 4.5.3. Except for potassium concentration, significant differences among treatments on the concentration of nutrients in pigeonpea straw have been observed. As far as uptake of nutrients by the straw portion is concerned,

Table 4.5.3: Effect of different irrigation schedules on contents and uptake of nutrients in pigeonpea (cv. BDM-2) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																			
		N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		Ca		Mg		Na		Cu		Fe		Zn		Mn	
		%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	ppm	g/ha	ppm	kg/ha	ppm	g/ha	ppm	g/ha
T <sub>1</sub>	30 % DP	2.71	190.26	0.48	32.82	1.42	96.00	1.56	106.21	0.34	22.81	0.16	11.00	21.50	146.76	755.50	5.15	23.00	167.72	72.00	485.12
	GRAIN	5.19	62.19	0.91	10.95	2.54	30.47	0.62	7.42	0.08	0.97	0.12	1.40	9.50	11.40	57.50	69.70*	20.50	24.64	17.00	20.30
T <sub>2</sub>	50 % DP	2.76	174.66	0.53	34.06	1.46	92.75	1.57	99.48	0.34	21.54	0.17	10.85	26.25	166.21	832.00	5.28	26.50	166.52	81.00	512.51
	GRAIN	5.48	46.89	1.05	9.07	2.74	23.28	0.70	6.08	0.14	1.17	0.12	1.03	22.75	19.57	157.00	131.96*	27.00	23.19	19.50	16.71
T <sub>3</sub>	70 % DP	3.00	148.15	0.56	27.64	1.51	74.63	1.64	80.68	0.36	17.64	0.17	8.49	32.50	160.81	895.50	4.14	30.00	149.08	87.00	429.33
	GRAIN	5.51	43.03	1.13	8.83	2.89	22.56	0.85	6.68	0.16	1.23	0.14	1.05	30.00	23.52	218.00	170.32*	48.00	36.65	25.00	19.52
T <sub>4</sub>	IW/CPE	2.90	169.66	0.54	31.59	1.46	86.25	1.62	94.88	0.36	21.34	0.17	10.04	28.00	165.44	835.50	4.90	29.50	172.07	85.00	501.40
	GRAIN	5.38	50.90	1.04	9.70	2.67	25.23	0.64	6.04	0.13	1.22	0.12	1.13	22.50	21.25	110.50	104.02*	23.50	22.33	17.50	16.66
T <sub>5</sub>	Critical stages	3.39	125.95	0.61	23.81	1.54	59.03	2.11	82.53	0.42	16.27	0.18	6.87	36.50	139.35	918.50	3.57	31.50	120.68	97.00	374.24
	GRAIN	5.48	46.84	1.07	9.21	2.75	23.56	0.84	7.15	0.16	1.39	0.12	1.05	28.00	23.96	174.50	148.99*	27.50	23.52	21.50	18.37
T <sub>6</sub>	Soil-Crop Model	3.01	139.31	0.60	27.76	1.54	71.19	1.77	81.73	0.42	19.14	0.17	8.07	35.25	161.58	893.00	3.91	31.00	142.91	91.25	424.55
	GRAIN	5.28	59.49	1.02	11.56	2.67	30.11	0.65	7.30	0.12	1.41	0.12	1.34	17.00	19.36	96.50	112.60*	22.50	25.21	17.50	19.64

		S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.	S.Em.t	C.D.
		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%	
STRAW	CONTENT	0.033	0.099	0.033	0.098	0.042	NS	0.093	0.250	0.013	0.039	0.006	0.020	2.918	8.797	42.827	129.098	1.790	5.397	2.335	7.040
	UPTAKE	11.438	34.478	3.355	NS	6.337	19.103	10.072	NS	1.961	5.911	0.801	2.415	19.498	NS	0.432	1.273	16.722	NS	40.69	122.656
GRAIN	CONTENT	0.028	0.083	0.044	0.133	0.050	0.150	0.029	0.086	0.012	0.036	0.005	0.015	1.564	4.775	21.989	66.282	1.312	3.956	0.955	2.877
	UPTAKE	6.231	18.784	1.190	NS	3.134	NS	0.900	NS	0.161	NS	0.155	0.469	2.864	8.634	22.616	68.173	3.277	9.879	2.188	NS

\* g/ha

treatments differed significantly with respect to N, K, Mg, Na, Fe and Mn, while they were at par for nutrients like P, Ca, Cu and Zn. In case of pigeonpea grain however, treatments differed significantly among themselves with respect to concentration of all the nutrients while they differed significantly with respect to the uptake of nutrients like N, Na, Cu, Fe and Zn. It is observed from the data (Table 4.5.3) that in almost all the nutrients, their concentration was the least in T<sub>1</sub> treatment which received the highest number of irrigations and net water applied. The yield of straw was also the highest. Thus, it appears that the lowest concentration of nutrients in this treatment could be attributed to the dilution effect as a result of high dry matter production. The relationship of yield with uptake is also amply demonstrated because the uptake of almost all the nutrients was the lowest in treatment T<sub>5</sub> which recorded the lowest yield. This treatment also received the lowest irrigation water. The poor growth and consequent poor uptake of nutrient may be attributed to the less amount of water received. The low water application might have restricted the proliferation of roots, low vigour and lesser solubility of nutrients. Similar reasons have been attributed by Akbari *et al.* (1983) in case of green gram, Zalawadia and Patel (1983), Prasad and Prasad (1988) and Singh *et al.* (1994) all in case of groundnut. Bashir-Al-Ithawi (1980) in case of soybean also observed greater

uptake of nutrient as the moisture level increased. In <sup>the</sup> case of pigeonpea grain also, similar trend of nutrient concentration and nutrient uptake as a result of differences in irrigation water applied have been noticed (Table 4.5.3).

#### 4.5.4. Effect of Different Irrigation Schedules on Nutrient Concentration in and Uptake by Cotton (cv.GCH 8)

The effect of different irrigation schedules on the concentration of nutrients in both stalk and lint and their uptake in <sup>the</sup> case of cotton is presented in table 4.5.4. It is seen from the data that in both cotton lint and stalk, except for the concentration of sodium, irrigation schedules did cause significant differences in nutrient concentration. In <sup>the</sup> case of uptake of nutrients, it is seen from the data (Table 4.5.4) that in cotton stalk, irrigation schedules were on par with each other as far as uptake of magnesium and zinc is concerned while uptake of nutrients in cotton lint, irrigation schedules were on par with respect to nitrogen, potassium, magnesium and sodium. It is observed from the data (Table 4.5.4) on nutrient concentration that in almost all the nutrients, the concentration was highest in the stalk of cotton in the treatment of irrigation on the basis of IW/CPE ratio. This treatment incidentally caused the lowest of stalk yield, while the concentration of almost all the nutrient was

Table 4.5.4 : Effect of different irrigation schedules on content and uptake of nutrients in cotton (cv. GCH-8) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																			
		N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		Ca		Mg		Na		Cu		Fe		Zn		Mn	
		%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	ppm	g/ha	ppm	kg/ha	ppm	g/ha	ppm	g/ha
T <sub>1</sub> 30 % DP	STRAW	3.53	238.38	0.70	47.26	1.58	106.33	1.64	111.03	0.63	42.38	0.95	64.18	7.50	50.91	420.00	2.83	18.00	122.06	32.00	216.23
	GRAIN	5.52	135.79	1.24	31.13	1.84	45.42	0.46	11.26	0.30	7.35	0.41	10.00	25.50	62.12	295.00	729.39*	91.50	224.00	20.50	50.56
T <sub>2</sub> 50 % DP	STRAW	3.63	216.97	0.91	54.04	1.61	96.35	1.78	106.10	0.65	38.72	0.98	57.87	13.50	81.25	450.00	2.69	19.00	112.34	37.50	224.77
	GRAIN	5.28	134.00	1.25	31.85	1.83	46.50	0.45	11.42	0.30	7.68	0.41	10.49	19.50	48.95	294.00	746.77*	86.50	218.55	15.50	39.41
T <sub>3</sub> 70 % DP	STRAW	4.07	180.47	0.96	42.82	1.69	75.38	1.96	86.84	1.01	44.79	0.99	43.52	13.50	59.69	662.00	2.94	25.00	111.08	42.00	185.92
	GRAIN	5.90	138.18	1.29	30.33	2.01	47.10	0.72	16.86	0.36	8.40	0.45	10.54	49.00	114.47	490.00	1102.43*	111.75	261.19	21.00	49.22
T <sub>4</sub> IW/CPE	STRAW	4.45	187.59	0.99	41.98	1.92	80.83	2.02	85.16	1.08	45.44	1.04	43.84	36.00	152.56	971.00	4.11	28.50	120.58	67.50	285.10
	GRAIN	5.03	129.10	1.15	29.43	1.83	46.85	0.44	11.33	0.28	7.08	0.40	10.29	18.50	46.85	294.00	754.72*	75.00	191.95	13.50	34.79
T <sub>5</sub> Critical stages	STRAW	4.16	176.59	0.97	41.20	1.83	77.64	2.00	85.10	1.06	44.70	1.00	42.36	22.00	93.42	827.00	3.51	26.00	110.39	49.50	210.01
	GRAIN	5.57	132.87	1.29	30.56	1.98	47.20	0.54	12.71	0.32	7.60	0.43	10.33	38.50	91.99	387.00	924.13*	103.50	247.00	21.00	50.00
T <sub>6</sub> Soil-Crop -Climate Model	STRAW	3.87	194.17	0.94	47.42	1.66	83.51	1.78	88.76	0.88	44.45	0.99	49.77	13.50	66.83	572.00	2.86	22.00	109.64	38.00	190.50
	GRAIN	4.84	130.78	0.84	22.87	1.81	49.10	0.43	11.75	0.27	7.16	0.39	10.62	17.50	47.56	286.00	773.94*	56.50	154.28	12.50	33.92

	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.	S.E.m. <sup>†</sup>	C.D.															
	at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%		at 5%														
STRAW CONTENT	0.036		0.109		0.049		0.099		0.117		0.067		0.203		0.025		0.076		0.05		NS	1.216		3.664		23.199		69.93		1.493		4.499		1.293		3.898	
STRAW UPTAKE	13.969		42.107		3.256		9.815		6.589		19.862		6.86		20.679		3.30		NS	4.25		12.81	10.836		32.664		0.248		0.746		10.853		NS	16.895		50.93	
GRAIN CONTENT	0.058		0.175		0.043		0.131		0.025		0.076		0.023		0.069		0.016		0.047		0.019	NS	2.684		8.052		8.659		26.102		5.891		17.756		0.882		2.658
GRAIN UPTAKE	9.547		NS	2.368		7.139		3.693		NS	0.894		2.696		0.697		NS	0.921		NS	6.742		20.323		76.424		230.373		18.898		56.362		4.392		13.441		

\* g/ha

the lowest in the stalk of cotton in the treatment of irrigation where in the highest quantity of water was applied. The yield of stalk in this treatment was incidentally the highest. The dilution effect as a result of greater dry matter production is evident. In case of lint it is observed from the data (Table 4.5.4) that a similar pattern of nutrient concentration versus yield was followed. However, as far as nutrient uptake in straw and lint is concerned, no such definite trend was observed, as uptake is the result of both the nutrient concentration and yield. It also points out to the fact that though greater dry matter production caused dilution effect, yet it was not to the extent to affect the overall uptake of the nutrients, leading to such inconsistency. The inherent characteristic of the crop variety and the inherent variability in nutrient availability pattern can also be among the reasons for this inconsistency. Similar inconsistency in the pattern of uptake of K in hulled and hullless barley varieties under different irrigation regimes has been observed by Wahab and Singh (1983), at IARI, New Delhi.

#### **4.5.5 Effect of Different Irrigation Schedules on the Concentration of Nutrients in and Uptake by Castor (cv. GCH 4)**

The data on the effect of different irrigation schedules on the nutrient concentration in the stalk and

seed of castor and their uptake are presented in table 4.5.5. It is seen from the table 4.5.5. that the treatment giving the greatest dry matter production in case of stalk (T<sub>2</sub>) and in seed (T<sub>1</sub>) had the lowest content of almost all the nutrients. Only in case of sodium, the treatments did not differ significantly in case of castor stalk while in case of castor seed, the treatment differed significantly for all the nutrient concentrations. In case of nutrient uptake in castor stalk, it is seen from the data (table 4.5.5) that the treatments were at par with each other for all the treatments except copper. The treatment which yielded the least (T<sub>3</sub>) has been found to give the highest uptake of copper and it differed significantly from treatment which yielded on the higher side. The relatively greater concentration of Cu in the stalk when compared to other treatments might have resulted in this pattern of uptake. In case of uptake of nutrients by grain, it is observed (table 4.5.5) that treatments differed significantly among themselves for the 4 micronutrients, while for the major nutrient they were at par with each other. This may be attributed to rather larger variation in the concentration of these nutrients compared to the variation in yield. It is observed that treatments T<sub>4</sub> and T<sub>5</sub> which received less water than the other treatments, resulted in substantially larger accumulation of these nutrients, while the differences in yield were not

Table 4.5.5 : Effect of different irrigation schedules on content and uptake of nutrients in castor (cv.GCH-4) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																			
		N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O		Ca		Mg		Na		Cu		Fe		Zn		Mn	
		%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	ppm	g/ha	ppm	kg/ha	ppm	g/ha	ppm	g/ha
T1 30 % DP	STRAW	3.10	240.80	0.71	55.21	1.58	122.96	2.95	229.75	0.77	59.77	0.20	21.75	23.25	183.61	765.50	6.00	24.25	189.72	99.50	775.14
	GRAIN	3.39	110.45	1.50	48.86	1.03	33.48	0.17	5.38	0.43	14.09	0.28	9.16	21.50	69.69	103.00	334.87*	24.50	79.85	27.50	89.77
T2 50 % DP	STRAW	2.18	184.01	0.63	53.33	1.06	89.81	2.32	195.94	0.75	63.34	0.27	22.80	15.50	130.42	578.50	4.86	19.25	163.19	76.00	642.53
	GRAIN	3.44	105.11	1.52	46.29	1.05	32.24	0.19	5.80	0.44	13.37	0.28	8.71	27.50	83.24	173.25	527.21*	34.25	104.76	27.75	84.75
T3 70 % DP	STRAW	3.29	242.33	0.80	59.55	1.60	118.34	3.00	220.44	0.81	59.68	0.29	21.90	41.00	299.93	925.75	6.80	30.50	225.55	106.50	783.54
	GRAIN	3.68	108.87	1.58	46.73	1.12	33.30	0.21	6.20	0.46	13.61	0.30	8.91	38.00	112.36	264.25	784.93*	39.50	117.27	36.00	106.20
T4 IV/CPE	STRAW	2.42	198.21	0.67	54.92	1.25	102.81	2.49	204.18	0.76	62.03	0.27	22.33	15.75	128.40	683.25	5.63	22.00	180.21	83.50	684.31
	GRAIN	3.87	110.03	1.60	45.50	1.30	36.88	0.23	6.54	0.51	14.44	0.31	8.73	48.25	137.19	375.75	1067.47*	48.75	138.59	52.50	149.11
T5 Critical stages	STRAW	3.19	241.32	0.74	55.93	1.60	120.81	2.96	224.22	0.80	60.46	0.28	21.63	27.25	209.86	770.75	5.83	30.00	227.01	102.50	776.60
	GRAIN	3.77	110.47	1.59	46.74	1.16	33.90	0.22	6.33	0.49	14.39	0.30	8.86	42.50	124.57	353.75	1043.47*	42.25	123.35	51.50	150.62
T6 Soil-Crop -Climate Model	STRAW	2.86	232.22	0.68	55.06	1.57	126.96	2.58	209.33	0.76	62.03	0.27	22.12	23.00	186.04	742.00	6.01	22.25	181.04	84.25	686.11
	GRAIN	3.63	109.15	1.54	46.33	1.08	32.41	0.21	6.23	0.46	13.68	0.30	8.92	36.50	110.80	217.00	655.66*	37.00	110.91	35.75	107.62
		S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.
		at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%
STRAW	CONTENT	0.021	0.062	0.018	0.053	0.014	0.042	0.036	0.109	0.016	0.048	0.012	NS	2.169	6.538	32.202	97.068	1.364	4.111	1.167	3.579
	UPTAKE	32.50	NS	8.618	NS	16.598	NS	30.674	NS	9.152	NS	3.462	NS	37.956	114.415	0.891	NS	32.759	NS	109.938	NS
GRAIN	CONTENT	0.014	0.043	0.011	0.035	0.011	0.032	0.009	0.028	0.013	0.038	0.005	0.014	3.662	11.039	24.947	75.199	2.096	6.318	1.352	4.076
	UPTAKE	7.25	NS	0.061	NS	2.136	NS	0.512	NS	0.932	NS	0.582	NS	13.337	40.202	104.466	314.899	9.287	27.994	9.365	28.290

\* g/ha

correspondingly larger (Table 4.5.5). Singh *et al.* (1971) have found no significant effect on uptake of N and P in wheat, when the frequency of irrigation was increased. Similar non significant results for uptake of major nutrients as a result of different irrigation levels have been reported for mustard by Bhati and Rathore (1982) and for wheat by Dubey and Sharma (1996).

#### 4.5.6 Effect of Different Irrigation Schedules on the Concentration of Nutrients in and Their Uptake by Mustard (cv. GM-1)

The data on the effect of different irrigation schedules on the concentration of nutrients in and their uptake by the straw and grain portions of mustard (cv. GM 1) are presented in table 4.5.6. It is seen from the results that while significant differences in the concentration of all nutrients was noticed in the seed of mustard as a result of differences in irrigation schedule, in <sup>the</sup> case of straw the influence of irrigation schedule with respect to sulphur was found to be non significant. In <sup>the</sup> case of uptake of nutrients, in ~~the~~ straw, except for N, P and sodium, the differences in the uptake of other nutrients as a result of differences in irrigation schedule were statistically significant (Table 4.5.6). Similarly in <sup>the</sup> case of uptake of nutrients in seed of mustard, it is observed that except for Ca Mg and Na, the differences in the uptake of the nutrients

Table 4.5.6 : Effect of different irrigation schedules on content and uptake of nutrients in mustard (cv.GH-1) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																					
		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	Mg	Na	Cu	Fe	Zn	Mn	%	kg/ha	ppm	g/ha								
T <sub>1</sub> 30 % DP	STRAW	3.24	52.20	0.91	14.62	3.19	51.33	2.25	36.25	0.63	10.16	0.40	6.35	43.50	70.07	749.25	1.21	37.50	60.32	71.00	114.58		
	GRAIN	6.10	117.74	1.92	36.90	1.46	28.00	0.22	4.16	0.47	9.11	0.09	1.66	29.00	55.41	411.26	792.25*	38.75	74.19	48.50	93.41		
T <sub>2</sub> 50 % DP	STRAW	3.29	50.56	1.06	16.24	3.27	50.28	2.63	40.32	0.68	10.46	0.40	6.12	44.40	67.84	999.75	1.54	38.00	58.44	76.50	117.46		
	GRAIN	6.53	103.98	1.96	31.30	1.59	25.37	0.24	3.80	0.50	7.97	0.10	1.67	44.25	70.26	422.76	674.53*	41.75	66.46	52.00	82.89		
T <sub>3</sub> 70 % DP	STRAW	2.81	59.34	0.88	18.52	2.95	62.26	1.45	30.57	0.60	12.69	0.31	6.49	29.50	61.65	507.50	1.07	33.50	70.90	62.50	131.83		
	GRAIN	5.81	119.33	1.89	38.74	1.44	29.61	0.19	3.91	0.45	9.30	0.09	1.78	19.50	40.09	360.75	741.79*	37.50	77.11	45.25	92.85		
T <sub>4</sub> IW/CPE	STRAW	2.90	52.64	0.90	16.41	2.99	54.16	1.79	32.36	0.62	11.35	0.32	5.80	32.00	57.92	709.50	1.29	37.00	67.04	66.00	119.76		
	GRAIN	5.57	118.59	1.75	37.33	1.42	30.29	0.17	3.54	0.44	9.37	0.08	1.66	19.00	41.22	355.75	762.25*	37.00	78.78	47.50	101.37		
T <sub>5</sub> Critical stages	STRAW	3.77	50.29	1.15	14.90	3.72	49.60	3.92	52.22	0.71	9.54	0.44	5.89	55.50	73.95	1237.50	1.65	55.75	74.33	112.00	149.45		
	GRAIN	6.53	76.12	2.04	23.80	1.61	18.80	0.30	3.44	0.58	6.73	0.11	1.28	48.75	57.22	428.25	500.20*	46.25	54.11	52.50	61.16		
T <sub>6</sub> Soil-Crop -Climate Model	STRAW	3.44	50.96	1.11	16.52	3.35	49.72	2.99	44.31	0.70	10.55	0.44	6.48	46.00	68.16	1045.25	1.55	49.00	72.51	84.00	124.51		
	GRAIN	6.29	120.68	1.92	36.70	1.64	29.30	0.23	4.29	0.48	9.13	0.09	1.77	38.50	73.69	420.75	801.39*	39.75	75.91	50.50	96.24		
		S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.
		at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%
STRAW	CONTENT	0.015	0.045	0.025	0.076	0.026	0.078	0.059	0.179	0.019	0.057	0.01	0.031	1.451	4.374	117.991	355.674	1.282	3.864	2.049	6.178		
	UPTAKE	3.62	MS	1.145	MS	3.780	11.394	2.225	6.706	0.810	2.442	0.407	MS	4.27	12.871	0.173	0.522	4.687	14.129	9.001	27.133		
GRAIN	CONTENT	0.127	0.384	0.022	0.066	0.024	0.071	0.013	0.038	0.014	0.043	0.007	0.020	2.083	6.279	15.504	46.737	1.588	4.787	1.584	4.775		
	UPTAKE	12.65	38.133	3.54	10.67	2.802	8.445	0.455	MS	0.915	MS	0.21	MS	7.989	24.082	75.632	227.985	7.458	22.483	10.268	30.952		

\* g/ha

were statistically significant as a result of differences in irrigation schedule. It is seen from the data (Table 4.5.6) that both in case of straw (except treatment T<sub>3</sub>) and in case of seed (except treatment T<sub>4</sub>) for almost all the treatments the concentration was the least. This is attributable to the dilution effect as a result of increased dry matter production. Similar effect of reduction in concentration as a result of increase in yield has been observed by Wright et al. (1988) for N. In case of uptake of nutrients in case of mustard stover (stalk) except Ca, greater uptake of the other major nutrients was observed in case of treatment giving the highest yield (i.e. T<sub>3</sub>). In case of Ca and the micronutrients the treatment giving the least yield (T<sub>5</sub>) gave the highest uptake (Table 4.5.6). This may be attributable to larger accumulation of these nutrients as compared to the differences, in yield. In case of seed however, no such consistency was observed. The differences may be attributable to the inconsistent accumulation of the nutrients in the seed as compared to the yield.

#### 4.5.7 Effect of Different Irrigation Schedules on the Nutrient Content in and Uptake by Wheat (cv. GW 496)

The data on the effect of different irrigation schedule on the content of nutrients in and their uptake by straw and grain portions of wheat (cv. GW 496) are presented

in the table 4.5.7. The data reveal that in case of content of nutrients in the straw and their uptake, treatments differed significantly for all the nutrients except Zn uptake by straw. In case of grain differences among the treatments for Ca and Na concentration were non significant, while the effect of treatments on the uptake for the major nutrients was at par. In case of the four micronutrients, however, the treatment differed significantly as far as the uptake of these nutrients was concerned. It is also observed from the data (Table 4.5.7) that both in the case of straw and grain, the concentration of the nutrients were the least in the treatment giving the highest dry matter yield. This is attributable to the dilution effect. Reddy and Bhardwaj (1983) also observed the contents of NPK to be higher in treatment of one irrigation to wheat as compared to irrigation at 0.6 atm tension. The yield at 0.6 atm tensions irrigation was higher than one irrigation to wheat. This indicates the dilution effect of increased dry matter production on nutrient concentrations. As far as uptake of nutrients by straw and grain are concerned, the data (Table 4.5.7) reveal that both in case of grain and straw, there is inconsistent pattern with respect to irrigation schedules. This may be attributed to the large variation in nutrient contents as compared to the yield. This has resulted in the effect of treatments being masked. Yadava (1991) while studying the effect of

Table 4.5.7 : Effect of different irrigation schedules on content and uptake of nutrients in wheat (cv.GH 496) grown at Anand (Coarse loamy, Fluventic Ustochrepts)

Treatment	Plant part	NUTRIENT CONTENT AND UPTAKE																					
		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	Mg	Na	Cu	Fe	Zn	Mn	%	kg/ha	ppm	g/ha								
T <sub>1</sub> 30 % DP	STRAW	1.16	99.02	0.20	17.11	2.67	228.04	0.68	58.04	0.21	18.39	0.31	26.28	28.60	243.16	328.00	2.80	33.50	286.99	26.00	222.18		
	GRAIN	2.02	79.99	0.99	39.16	1.13	44.76	0.20	7.88	0.27	10.72	0.09	3.56	26.50	104.92	119.50	472.79*	30.50	120.81	37.50	148.26		
T <sub>2</sub> 50 % DP	STRAW	1.21	97.96	0.21	16.81	2.81	237.55	0.93	75.64	0.22	18.25	0.32	26.11	41.00	332.28	377.00	3.05	41.50	337.26	26.26	213.27		
	GRAIN	1.98	80.99	0.91	37.40	1.07	43.75	0.18	7.36	0.26	10.41	0.09	3.57	21.00	86.89	58.50	239.10*	17.50	71.28	33.00	135.03		
T <sub>3</sub> 70 % DP	STRAW	1.35	90.32	0.26	17.39	3.29	220.12	0.97	65.24	0.24	16.39	0.35	23.25	43.00	289.24	392.50	2.63	60.50	337.86	50.00	334.63		
	GRAIN	2.04	79.57	1.01	39.49	1.14	44.69	0.22	8.57	0.28	10.92	0.09	3.56	28.50	111.21	168.00	665.22*	30.76	119.99	42.00	163.86		
T <sub>4</sub> IW/CPE	STRAW	1.39	90.44	0.29	18.87	3.00	195.19	1.00	65.07	0.33	21.48	0.38	24.64	51.25	333.42	566.50	3.69	63.00	344.73	64.00	412.21		
	GRAIN	2.11	80.68	1.07	41.07	1.35	51.23	0.24	9.16	0.31	11.88	0.10	3.83	45.50	173.79	306.00	1169.83*	35.76	136.22	41.50	158.58		
T <sub>5</sub> Critical stages	STRAW	1.26	89.50	0.23	16.34	2.85	202.46	0.95	67.49	0.23	16.70	0.33	23.27	42.50	301.89	380.50	2.70	49.76	363.51	47.75	339.24		
	GRAIN	2.08	80.59	1.02	39.53	1.18	45.72	0.23	8.91	0.29	11.39	0.10	3.83	34.00	131.73	251.00	972.52*	35.25	136.72	41.00	158.88		
T <sub>6</sub> Soil-Crop -Climate Model	STRAW	1.06	94.48	0.17	14.71	2.46	227.00	0.65	57.92	0.19	16.71	0.31	27.31	23.50	209.43	311.50	2.77	33.00	294.15	26.75	229.43		
	GRAIN	2.00	81.13	0.97	39.37	1.11	45.23	0.19	7.71	0.26	10.54	0.09	3.59	25.50	103.24	86.00	348.88*	22.00	89.39	36.25	147.07		
		S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.	S.E.m.±	C.D.
		at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%	at 5%
STRAW	CONTENT	0.017	0.052	0.01	0.03	0.027	0.081	0.023	0.068	0.012	0.037	0.008	0.025	1.595	4.807	10.801	32.558	3.143	9.473	2.001	6.032		
	UPTAKE	1.94	5.846	0.943	2.843	7.994	24.096	1.779	5.363	0.179	3.565	0.942	2.839	12.916	38.933	0.103	0.311	25.821	NS	17.205	51.862		
GRAIN	CONTENT	0.018	0.054	0.02	0.06	0.017	0.052	0.02	NS	0.014	0.041	0.006	NS	1.883	5.675	4.753	14.327	2.737	8.251	1.949	5.875		
	UPTAKE	2.261	NS	1.131	NS	1.394	4.201	0.736	NS	0.66	NS	0.235	NS	8.601	26.927	32.697	98.262	11.214	33.802	8.389	25.288		

\* g/ha

being masked. Yadava (1991) while studying the effect of irrigation schedule on uptake of N, P and K observed that only upto a certain frequency of irrigation corresponding to 0.6 IW/CPE, was the effect significant with respect to uptake, beyond which the effect was not observed to be significant. Singh and Singh (1995) also found irrigation at IW/CPE ratio 0.8 and 1.0 to be an par for NPK uptake by oat. Wahab and Singh (1983) found the effect of irrigation on uptake of K by barley to be inconsistent. Dubey and Sharma (1996) have also observed greater frequency of irrigation to have non significant effect on uptake of N, P and K by wheat straw. Singh *et al.* (1971) also observed greater frequency of irrigation to have non significant effect on uptake of N and P by wheat. Whether the effect of treatments of irrigation will have significant effect on nutrient uptake also depends on several factors like inherent soil fertility, the fertilizer schedule followed, the depth of root proliferation to name but a few. Thus, it is quite natural that the literature may have incidences of contrasting results. In the present study the extent of changes undergone in the nutrient concentration have not been matched by proportionate and corresponding changes in yield with the result that the results end up being inconsistent.

**SUMMARY  
AND  
CONCLUSION**

## CHAPTER V

### SUMMARY AND CONCLUSION

Irrigated agriculture is a process requiring taking of decisions on the appropriate time and the appropriate quantity of water to be applied. Applying water without due consideration to the correct time and quantity ultimately results in wastage of this precious resource in terms of production derived per unit of water used. In aggregate, we have to face the problems of water logging, rise in water table, secondary salinization and alkalinization. It is not surprising therefore, that the bulk of research effort has been on finding out an appropriate irrigation schedule. In spite of so much scientific effort on this aspect of irrigated agriculture, yet sooner or later the command areas under most of the irrigation schemes end up with the problems mentioned above.

Research on scheduling irrigation has been largely based on (1) per cent allowable depletion (2) climatological approach and (3) the critical stage approach. Each of these approaches has its merits and demerits. The demerits of the approach generally arise when it is applied to situations which are beyond its purview or when the inherent limitations of the approaches are overlooked while applying

it. Basically, every approach holds merit given the situations that are to be met for which it is created.

It is now an accepted fact that the need for water for any crop is a combined effect of the soil's capacity to supply water (stored water), the climatic demand for water (as evinced by the potential evapotranspiration) and the inherent requirement of the crop for water. Thus, xerophytic plants have the capacity to withstand long spells of water shortages, while mesophytes require water at comparatively shorter intervals while hydrophytes may not be able to survive even a very short spell of water shortage. In the present study therefore, an attempt is made to combine all these three factors for arriving at an irrigation schedule. It is believed that any irrigation schedule developed by combining these three factors, will have a regional application, rather than being restrictive as a result of inherent limitations. It will be pertinent to point out that this approach has been tried out both abroad and in our country and is therefore not new. However, application of this approach on a regional basis like for example the Narmada Command and to know its extent of applicability is probably a first attempt.

The basic steps in this approach consists of determining the crop water need through the crop evapotranspiration needs. For this the potential

evapotranspiration is first determined. In the present study the empirical approach advocated by Hargreaves and Samani (1982) has been used to determine PET which requires only data on minimum and maximum temperature. Sheikh (1989) has reported this method to be satisfactory for the state of Gujarat. For calculating the reference crop evapotranspiration (ETc), use of crop coefficients (Doorenbos and Pruitt, 1977) has been made. However, in the present study, considering the local climatic conditions, the value of crop coefficients (Kc values) have been slightly modified. The product of PET x Kc gives the ETc. These values are computed on standard-week basis for the three crop growing seasons viz., hot weather (January to May), *kharif* or monsoon season (June to October, extendable to March depending on length of growing period) and *rabi* or winter season (October to March or April, depending on date of planting). Weekly values of effective rainfall (assumed to vary between 70 to 80 per cent of actual rainfall received depending on intensity and quantity) were deducted from the ETc values. These net values are considered to be the net irrigation requirement for the standard-week in question. The actual time of irrigating the crop was arrived at by computing the net deficit corresponding to 50 per cent depletion of the available water capacity of the soil. When the summation of weekly ETc values reached this 50 per cent depletion value, irrigation was initiated. It is now agreed

by all that, in general, plants are not put to undue moisture stress till around 50 per cent of the soil available water capacity is depleted. The quantity of water required at this time is the quantity per irrigation and the product of this quantity and the number of irrigation events constitutes the net irrigation water applied. Gross irrigation water is computed taking into consideration of losses during field application. In the present study, field application efficiency is considered to be 90 per cent. Crop evapotranspiration values, net irrigation requirement values, quantity of net and gross irrigation water applied for the study site (Anand, Agronomy farm and WALMI farm) in question for the three seasons and seven crops widely grown in the state were computed and the validation carried out by actual field experimentation. The schedule was compared for the extent of its compatibility with the presently recommended irrigation schedules as well as different extent of depletion levels of AWC. It is observed from the validation exercise that in groundnut, pigeonpea, cotton, castor and wheat, this schedule has proved to be statistically at par with the other methods tried i.e. depletion of AWC at 30, 50 and 70 per cent, IW/CPE ratio (recommended) and critical stages approach, while in <sup>the</sup> case of pearl millet it has given statistically significant yield over 70 per cent depletion treatment. In <sup>the</sup> case of mustard, it has performed significantly better than the critical stages

approach. In all the crops, it has given a higher water use efficiency except of course the critical stages approach, wherein though the yields were the least, but the total water applied was also equally substantially less. In case of wheat however, this schedule has given a higher WUE than the critical stages approach. Based on these findings the crop evapotranspiration requirements, irrigation requirement net irrigation water to be applied for the 12 districts and the main soil types (based on AWC only) for these seven crops viz., pearl millet and groundnut (both summer and *kharif*), cotton, pigeonpea, castor, mustard and wheat have been computed. These values which were on standard-week basis were converted to first monthly basis. From these monthly values, daily values for irrigation water required were derived. The product of the daily values (mm) and the relative irrigated area (per cent CCA area converted to its relation to 1.0) resulted in the relative net irrigation requirement per day. These values were converted to litres per second per hectare, litres per hectare per day and then to million cubic meters per day and finally to million cubic meter per month. This value constitutes the net irrigation requirement. The net irrigation requirement month-wise was computed for each district of the command. Once this value was arrived at, seasonal evaluation for each district was carried out. The net scheme water requirement values in mm were converted to gross scheme water requirement values

taking the scheme irrigation efficiency as 50 per cent. The gross scheme water requirement values were converted to million cubic meter per month. This constituted the supply that is required per month during the respective seasons. Taking the value of flow in the minor distributory at the rate of 0.9 litres/second) hectare of the cultivable command area, (Anon., 1985) and also that this quantity of water is likely to flow for 24 hours through out the year the actual supply in million cubic meters per month for each of the crop growing seasons for each of the 12 districts, was computed. The ratio between the required supply to the actual supply gives the seasonal evaluation of the scheme. It is surprising to see that except for the months of high evaporative demand, when the values are around 50 per cent, in other months the values are quite low. It implies that during the months when the evaporative demand is low i.e. during monsoon season especially July and August the months of assured rainfall, and the cooler months of December and January, much of the water will be flowing when in reality its requirement is the least. Such results, emphasize the need to either adjust the cropping pattern which shall assure proper utility of the flowing water or to curtail the flow to a minimum and encourage use of under ground water for irrigation. This practice shall minimize the danger of the water table rising right upto the active root zone, as well as save wastage of this precious resource and also

facilitate its equitable distribution to the other sectors in competition for water (drinking water, industrial demand etc.).

The third objective of the present study was to find out alternative means of irrigation in areas subjected to rising water table in the present Mahi right bank canal area. Along the proximity of the canal, gradually, more and more areas are facing the problem of rising water table which is resulting in low crop yields or restricting the choice of crops to only paddy. Of late however, certain farmers have found a novel solution to this problem by growing summer groundnut without irrigation, taking advantage of the contribution of under ground water table. Noticing this practice, a field experiment was laid out in the farmer's field in which flood irrigation and sprinkler irrigation were compared with the practice of growing groundnut in summer (January to May) without irrigation. In the flood irrigation, the farmers practice of applying 50 mm water as pre-sowing, 55, 85 DAS and pre-harvest irrigation was practiced. Two light irrigations corresponding to 25 mm each at 55 and 85 DAS through sprinkler irrigation under two depths of water table 1.0 and 1.5 m. These were compared with no irrigation. It was observed that significantly high kernel yields were obtained from sprinkler irrigations over no irrigation and flood irrigation. The yields obtained without irrigation were significantly higher than the flood

irrigation, though less as compared to sprinkler irrigation. These results imply that under such situation of rising water table, irrigation can be altogether curtailed and crops like groundnut can be grown taking advantage of the contribution of the underground water table. Another alternative would be to make use of sprinkler irrigation to achieve substantially higher economic returns inspite of the higher water table conditions. The pumping of under ground water for sprinkler irrigation will also achieve the objective of keeping the under ground water table at safer depths.

The final objective of the study was to see the effect of the proposed irrigation schedule vis-a-vis the other irrigation schedules on the nutrient content and their uptake by the crops under study. The study revealed that as far as the concentration of nutrients in the straw and the grain portion of the crops is concerned, it is affected by the extent of dry matter production that a particular schedule causes. Invariably nutrient concentration was the least in those treatments which caused the highest dry matter production while it was the highest when the dry matter production was the least. Which crop will respond in what manner to the different irrigations schedule depends on the extent of crop's requirement for water. Crops which can do with relatively less water produced greater dry matter with less water, while the reverse was true of the crops

requiring more water. Also, the extent of root proliferation and the inherent nutrient supplying capacity of the soil are but a few of the factors that may lead to differences in nutrient accumulation. Though uptake of nutrient is the function of yield and in general greater dry matter means greater uptake, yet in the present study it was observed that differences in uptake were related to the correspondence between variation between nutrient concentration and yield as a result of treatment differences. When the correspondence between changes in nutrient concentration and yield, as a result of different treatments was lacking, inconsistent results in nutrient uptake vis-a-vis yield were observed.

## CONCLUSION

From the results of the present study following can be concluded :

1. Irrigation to crops is a process involving decisions on the correct time and the correct quantity of applying water.
2. When to irrigate ~~and~~ how much to irrigate depends on the crop to be grown, the evaporative demand of the area and the supplying capacity of the soil for water as modified by the physical and chemical properties of

soils. Clay alone or clay + silt have augmenting effect on the AWC, while  $\text{CaCO}_3$  content has an adverse effect.

3. Irrigation schedule based on data on soil-crop-climate can have a regional application.
4. The Net Irrigation Requirement depends on quantity and distribution of rainfall, length growing period of crop and differences in AWC of soils, as well as the season of crop growth.
5. Irrigation schedule based on soil-crop-climate data have given yields of the major crops studied which were statistically ~~at~~ par with the present recommended method and also gave higher water use efficiency than the other methods tried.
6. It is possible to schedule irrigation for a particular locality or over a entire region with the help of long term data on temperature (minimum and maximum), rainfall and determined values of available water capacity. This method requires minimum of instrumentation for making regional estimates of irrigation requirements with the use of minimum climate parameters (temperature and rainfall).

7. If continuous flow of Narmada canal water is allowed, it will result in much wastage of water. Greater utility of flowing water can be done by adjusting the cropping pattern or reducing the flow of water during months of low demand. During such times, use of underground water should be encouraged, which will also lessen the risk of rising water table. Perinneal crops like Banana and sugarcane should be included in soils with no root limitations or soil limitation.
8. In areas prone to water logging due to root limiting layer, areas with shallow soil depth, or heavy texture as well as low lying areas, alternative methods of irrigation like the use of sprinkler system or drip system can be practiced.
9. In most of the crops, the irrigation schedule based on soil-crop and climate has resulted in moderate uptake of nutrients due to moderate dry matter production. Such a schedule can prevent serious depletion of nutrient low in supply, thereby preventing situations of nutrient deficiency, and also promote greater nutrient use efficiency.
10. The irrigation schedule based on soil-crop-climate data needs to be tried in different crops and different soil types to ascertain its wide ranging applicability.

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# APPENDICES

APPENDIX 3.1

Extra-Terrestrial Radiation (Ra) expressed in equivalent  
evaporation in mm/day (Northern Hemisphere)

Lat.	J	F	M	A	M	J	J	A	S	O	N	D
50°	3.8	6.1	9.4	12.7	15.8	17.1	16.4	14.1	10.9	7.4	4.5	3.2
48	4.3	6.6	9.8	13.0	15.9	17.2	16.5	14.3	11.2	7.8	5.0	3.7
46	4.9	7.1	10.2	13.3	16.0	17.2	16.6	14.5	11.5	8.3	5.5	4.3
44	5.3	7.6	10.6	13.7	16.1	17.2	16.6	14.7	11.9	8.7	6.0	4.7
42	5.9	8.1	11.0	14.0	16.2	17.3	16.7	15.0	12.2	9.1	6.5	5.2
40	6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7.0	5.7
38	6.9	9.0	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10.0	7.5	6.1
36	7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8.0	6.6
34	7.9	9.8	12.4	14.8	16.5	17.1	16.8	15.5	13.4	10.8	8.5	7.2
32	8.3	10.2	12.8	15.0	16.5	17.0	16.8	15.6	13.6	11.2	9.0	7.8
30	8.8	10.7	13.1	15.2	16.5	17.0	16.8	15.7	13.9	11.6	9.5	8.3
28	9.3	11.1	13.4	15.3	16.5	16.8	16.7	15.7	14.1	12.0	9.9	8.8
26	9.8	11.5	13.7	15.3	16.4	16.7	16.6	15.7	14.3	12.3	10.3	9.3
24	10.2	11.9	13.9	15.4	16.4	16.6	16.5	15.8	14.5	12.6	10.7	9.7
22	10.7	12.3	14.2	15.5	16.3	16.4	16.4	15.8	14.6	13.0	11.1	10.2
20	11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7
18	11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1
16	12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6
14	12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0
12	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5
10	13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9
8	13.6	14.5	15.3	15.7	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3
6	13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7
4	14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1
2	14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4
0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.6

Source : Crop Water Requirements Publ. Water and Land Management Institute, Aurangabad p.71. Table 15, 1988.

## APPENDIX 3.2

### Method of Determining the date of Irrigation

Crop : Pearlmillet/Groundnut

1. Soil : Anand Sandy Loam  
(Deep Water Table beyond root zone)
2. Date of sowing : 14.2.1995
3. a) Available moisture holding capacity of the top 60 cm soil profile 97.0 mm
- b) Available moisture holding capacity of the date of sampling (17.2.1995) 118.4 mm
- c) Allowable soil moisture depletion until first irrigation (quantity in 3 (b) above minus 50 % of that in 3 (a) above) 69.9 mm
4. a) Available moisture in 0-100 cm soil profile after the first irrigation or adequate rainfall 155.0 mm
- b) Allowable soil moisture depletion (50 % of that shown in 4 (a)) 78.0 mm

Steps :

Date of computation	Aug.Etc of previous 3 days mm day <sup>-1</sup>	Current allowable soil moisture depletion, mm	Days to irrigation	
			From the date of previous computation	From the date of sowing
17.2.95	4.65	69.9	16	17(3.3.95)
25.2.95 (i.e. week above)	4.67	32.6	6	17(3.3.95)
28.2.95 (3 days before)	5.73	15.4	3	17(3.3.95)
	5.73	78.0	14	32(17.3.95) Next date of irrigation

APPENDIX 3.3

Mean Monthly Potential Evapotranspiration (B) and Rainfall (A) (mm) in some of the stations in the Narmada Command (Sheikh, 1989)

Station		J	F	M	A	M	J	J	A	S	O	N	D	Annual (mm)
Bharuch	A	0	1	0	0	6	113	242	296	152	36	12	2	860
	B	129	145	201	222	244	168	145	146	155	172	147	127	2002
Vadodara	A	1	1	1	1	0	134	286	277	128	15	14	9	867
	B	123	141	185	221	256	210	152	133	174	153	139	117	2003
Mehsana	A	1	1	1	0	12	68	173	201	143	5	5	1	610
	B	123	141	186	221	256	210	152	133	174	153	139	117	2003
Deesa	A	5	0	0	13	12	47	231	151	68	11	17	0	555
	B	112	137	184	212	244	217	174	153	170	158	123	101	1986
Anand	A	0	1	2	1	4	123	280	283	139	14	27	2	876
	B	135	135	164	252	234	193	168	118	141	188	123	104	1956
Ahmedabad	A	2	1	1	1	7	111	272	225	138	8	14	3	782
	B	123	142	118	223	256	212	153	133	175	156	141	117	2020
Arnej	A	0	0	1	1	5	81	123	152	54	24	15	1	457
	B	131	139	170	247	208	176	185	118	129	163	110	107	1882
Bhuj	A	0	0	0	0	0	51	113	113	39	17	6	0	340
	B	113	130	183	215	231	227	164	157	178	175	136	120	2031
Dhranga- dra	A	2	2	2	1	6	68	233	105	77	5	7	1	509
	B	123	142	188	223	256	212	153	133	175	156	141	117	2020
Rajkot	A	0	0	2	0	5	119	199	157	66	10	5	1	565
	B	112	136	184	211	237	193	148	131	159	171	130	122	1934
Virangam	A	2	1	1	1	9	76	233	170	103	9	7	2	614
	B	138	144	182	267	230	199	187	143	147	197	130	109	2073
Radhanpur	A	1	2	1	1	7	35	237	147	69	7	2	2	512
	B	123	141	185	221	256	210	152	133	174	153	139	117	2003
Lakhpat	A	2	6	0	0	0	28	111	86	12	1	1	3	250
	B	109	132	180	203	228	190	149	133	159	181	128	108	1901
Bhavnagar	A	1	2	3	0	6	128	161	152	119	5	13	2	590
	B	121	138	194	219	243	211	140	124	179	173	142	122	2006

APPENDIX 3.4

Present cropping pattern and projected cropping pattern in  
Narmada command area (% of C.C.A.)

Crop	Irrigated		Rainfed		Total	
	Present	Projected	Present	Projected	Present	Projected
Rice	0.6	10.9	2.5	-	3.1	10.9
Sorghum (K)	0.2	5.4	12.5	6.4	12.7	11.9
Sorghum (R)	-	0.7	-	0.1	-	0.8
Pearlmillet(K)*	0.6	7.6	15.4	5.6	16.0	13.2
Pearlmillet(S)	-	3.5	-	-	-	3.5
Wheat	3.2	22.3	4.8	1.5	8.0	23.8
Pigeonpea	0.1	1.6	3.0	0.8	3.1	2.4
Other pulses	-	3.6	3.7	3.3	3.7	6.9
Mustard	0.5	2.7	1.4	0.4	1.9	3.1
Castor	-	2.1	-	0.5	-	2.6
Groundnut(K)*	-	4.2	3.5	0.8	3.5	5.0
Groundnut(S)	-	3.2	-	-	-	3.2
Tobacco	0.7	2.4	1.0	-	1.7	2.4
Cotton (M.S)+	6.5	24.4	30.5	-	37.0	24.4
Cotton (S.S)	-	-	-	6.8	-	6.8
Sugarcane	-	0.5	-	-	-	0.5
Vegetables	-	4.0	-	-	-	4.0
Chillies	-	0.4	-	-	-	0.4
Fruits	-	2.3	-	-	-	2.3
Fodder	0.4	4.1	8.1	5.0	8.5	9.1
Other crops	0.2	-	5.6	-	5.8	-
All Crops	13.0	106.0	92.0	31.2	105.0	137.3

Source : Anon., (1985)

\* Includes both kharif (K), summer (S) and rabi (R) season crops

+ For present includes both medium staple (M.S. and short staple (S.S.) crop.

- Indicates that the crop is not grown as irrigated or rainfed.

APPENDIX 3.5

Location : Mahemdabad

Date Base : 1949-1984

Initial and conditional Probabilities (%) of Rainfall for selected amount

Std. week	> 10 mm			Mean (mm)
	W	W/W	W/D	
25	47	71	32	23.3
26	50	44	56	38.8
27	50	72	33	36.4
28	53	79	12	50.5
29	47	76	11	47.1
30	42	73	19	31.6
31	42	93	24	40.1
32	53	74	12	52.1
33	44	75	5	41.6
34	36	54	17	18.0
35	31	64	12	40.2
36	28	70	12	36.4
37	28	50	12	13.0
38	22	38	14	12.7
39	19	14	7	7.8
40	8	67	0	1.5

Source : Sheikh (1989)

Appendix 3.5 contd..

Initial and conditional Probabilities (%) of Rainfall for selected amount

Location : Anand  
Data Base : 1949-1987

Location : Vijapur  
Date Base: 1976-1987

Std. week	> 10 mm			Mean (mm)	> 10 mm			Mean (mm)
	W	W/W	W/D		W	W/W	W/D	
25	41	63	61	30.3	50	50	67	15.9
26	62	71	53	54.5	58	43	40	60.1
27	64	68	79	66.8	42	60	86	47.8
28	72	86	64	73.1	75	100	33	89.6
29	79	77	38	76.2	83	80	100	68.7
30	69	85	50	53.4	83	70	50	51.6
31	74	83	80	59.3	67	100	50	71.9
32	82	75	57	77.1	83	70	100	89.8
33	72	61	36	63.8	75	56	0	53.8
34	54	71	39	35.3	42	40	57	35.0
35	56	73	24	57.7	50	33	17	39.6
36	51	65	11	54.9	25	33	22	24.1
37	38	53	25	30.5	25	33	22	6.0
38	36	57	16	22.2	25	33	11	4.6
39	31	33	7	15.2	17	0	20	3.3
40	15	33	6	5.7	17	100	0	19.5

Appendix 3.5 contd..

Initial and conditional Probabilities (%) of Rainfall for selected amount

Location : Thasra  
Data Base : 1949-1984

Location : Deesa  
Data Base: 1901-1969

Std. week	> 10 mm			Mean (mm)	> 10 mm			Mean (mm)
	W	W/W	W/D		W	W/W	W/D	
25	49	82	61	25.9	26	44	37	9.9
26	71	80	50	62.9	39	74	50	24.4
27	71	84	40	58.9	59	73	46	45.2
28	71	84	50	74.4	62	72	54	40.1
29	74	77	22	55.9	65	73	29	42.5
30	63	77	69	53.7	58	70	45	70.7
31	74	88	78	53.3	59	63	50	62.2
32	86	67	40	63.9	58	63	24	34.0
33	63	68	62	45.6	46	63	41	40.9
34	66	83	42	38.5	51	74	29	45.4
35	69	71	27	64.2	52	50	33	47.3
36	57	55	20	56.1	42	59	20	31.1
37	40	57	29	29.7	36	20	20	25.8
38	40	36	24	21.0	20	36	15	8.7
39	29	30	12	15.3	19	31	2	7.4
40	17	50	3	6.1	7	40	5	2.3

Appendix 3.5 contd..

Initial and conditional Probabilities (%) of Rainfall for selected amount

Location : Arnej  
Data Base : 1951-1987

Location : Rajkot  
Data Base: 1976-1987

Std. week	> 10 mm			Mean (mm)	> 10 mm			Mean (mm)
	W	W/W	W/D		W	W/W	W/D	
25	54	73	38	22.2	50	67	33	40.6
26	57	56	42	28.6	50	50	50	48.7
27	50	64	43	25.9	50	50	67	22.5
28	54	67	62	30.4	58	57	40	40.2
29	64	67	30	32.7	50	67	50	49.0
30	54	87	46	25.5	58	57	40	33.5
31	68	74	56	45.1	50	67	67	30.3
32	68	53	33	43.4	67	63	75	112.4
33	46	54	20	31.8	67	25	0	19.2
34	36	60	28	10.6	17	0	50	3.1
35	39	82	18	33.2	42	40	14	40.7
36	43	67	25	18.1	25	67	44	9.1
37	43	17	25	14.3	50	50	17	43.8
38	21	33	18	6.6	33	25	13	14.8
39	21	17	18	8.9	17	0	10	5.1
40	18	60	9	7.6	8	0	0	1.1

Appendix 3.5 contd..

Initial and conditional Probabilities (%) of Rainfall for selected amount

Location : Gogha (Bhavnagar)  
Data Base : 1901-1966

Location : Bhuj  
Data Base: 1901-1966

Std. week	> 10 mm			Mean (mm)	> 10 mm			Mean (mm)
	W	W/W	W/D		W	W/W	W/D	
25	45	73	44	26.0	9	33	22	6.3
26	58	82	54	40.1	23	53	39	15.7
27	70	76	65	54.4	42	46	42	31.5
28	73	63	39	54.9	44	38	30	42.9
29	56	78	66	36.8	33	73	39	21.2
30	73	67	56	56.8	50	48	30	28.6
31	64	52	46	36.0	39	42	23	32.8
32	50	64	39	23.1	30	25	30	17.7
33	52	53	41	35.0	29	42	28	18.0
34	47	77	40	31.1	32	57	18	14.5
35	58	63	39	29.3	30	50	24	19.8
36	53	60	29	40.8	32	43	16	24.9
37	45	43	25	25.5	24	19	14	14.5
38	33	23	27	27.5	15	10	7	7.0
39	26	12	8	16.1	8	40	3	2.7
40	9	50	3	6.5	6	0	3	3.9

APPENDIX 3.6

*Handwritten notes:*  
 1500  
 2000  
 2500

Standard weekwise data of PET and Rainfall (mm) of climatic stations in the command area

CLIMATIC STATION ANAND AWC 155 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	30.48	0.00
2	08-14		30.48	0.00
3	15-21		30.48	0.00
4	22-28		30.48	0.00
5	29-04	Jan.-Feb.	32.10	0.11
6	05-11	Feb.	33.15	0.25
7	12-18		33.15	0.25
8	19-25		33.15	0.25
9	26-04	Feb.-March	35.37	0.35
10	05-11	March	37.03	0.45
11	12-18		37.03	0.45
12	19-25		37.03	0.45
13	26-01	March-April	40.14	0.34
14	02-08	April	58.80	0.23
15	09-15		58.80	0.23
16	16-22		58.80	0.23
17	23-29		58.80	0.23
18	30-06	April-May	53.69	0.57
19	07-13	May	52.84	0.90
20	14-20		52.84	0.90
21	21-27		52.84	0.90
22	28-03	May-June	49.49	14.60
23	04-10	June	45.03	28.70
24	11-17		45.03	28.70
25	18-24		45.03	28.70
26	25-01	June-July	44.02	46.25
27	02-08	July	37.94	63.23
28	09-15		37.94	63.23
29	16-22		37.94	63.23
30	23-29		37.94	63.23
31	30-05	July-Aug.	29.87	63.56

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET (mm)	R.F. (mm)
32	06-12	August	26.65	63.90
33	13-19		26.65	63.90
34	20-26		26.65	63.90
35	27-02	Aug.-Sept.	28.43	48.43
36	03-09	September	32.90	32.43
37	10-16		32.90	32.43
38	17-23		32.90	32.43
39	24-30		32.90	32.43
40	01-07	October	42.45	3.16
41	08-14		42.45	3.16
42	15-21		42.45	3.16
43	22-28		42.45	3.16
44	29-04	Oct.-Nov.	34.59	4.70
45	05-11	November	28.70	6.30
46	12-18		28.70	6.30
47	19-25		28.70	6.30
48	26-02	Nov.-Dec.	27.21	3.33
49	03-09	December	23.48	0.45
50	10-16		23.48	0.45
51	17-23		23.48	0.45
52	24-31		26.84	0.52

APPENDIX 3.6

CLIMATIC STATION AHMEDABAD AND GANDHINAGAR AWC 150 and 200 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	27.77	0.2
2	08-14		27.77	0.2
3	15-21		27.77	0.2
4	22-28		27.77	0.1
5	29-04	Jan.-Feb.	31.83	0.3
6	05-11	Feb.	34.88	0.2
7	12-18		34.88	0.1
8	19-25		34.88	0.3
9	26-04	Feb.-March	30.18	0.4
10	05-11	March	26.65	0.1
11	12-18		26.65	0.3
12	19-25		26.65	0.3
13	26-01	March-April	32.27	0.1
14	02-08	April	52.03	0.1
15	09-15		52.03	0.1
16	16-22		52.03	0.7
17	23-29		52.03	0.2
18	30-06	April-May	56.98	0.9
19	07-13	May	57.81	1.3
20	14-20		57.81	1.7
21	21-27		57.81	2.4
22	28-03	May-June	54.23	4.2
23	04-10	June	49.47	11.7
24	11-17		49.47	15.8
25	18-24		49.47	19.9
26	25-01	June-July	47.50	35.5
27	02-08	July	34.55	47.0
28	09-15		34.55	52.7
29	16-22		34.55	43.7
30	23-29		34.55	72.3
31	30-05	July-Aug.	32.04	44.5

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET (mm)	R.F. (mm)
32	06-12	August	30.03	37.2
33	13-19		30.03	35.1
34	20-26		30.03	32.8
35	27-02	Aug.-Sept.	33.12	37.3
36	03-09	September	40.43	33.6
37	10-16		40.83	24.0
38	17-23		40.83	19.6
39	24-30		40.83	13.4
40	01-07	October	35.23	5.5
41	08-14		35.23	4.3
42	15-21		35.23	1.3
43	22-28		35.23	1.2
44	29-04	Oct.-Nov.	33.90	1.0
45	05-11	November	32.90	1.5
46	12-18		32.90	1.4
47	19-25		32.90	1.8
48	26-02	Nov.-Dec.	31.05	0.8
49	03-09	December	26.42	0.2
50	10-16		26.42	0.4
51	17-23		26.42	0.5
52	24-31		30.19	0.0

APPENDIX 3.6

CLIMATIC STATION VADODARA AWC 150 and 200 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F. (mm)
1	01-07	January	27.77	0.0
2	08-14		27.77	0.3
3	15-21		27.77	0.1
4	22-28		27.77	0.2
5	29-04	Jan.-Feb.	31.69	0.2
6	05-11	Feb.	34.63	0.1
7	12-18		34.63	0.2
8	19-25		34.63	0.4
9	26-04	Feb.-March	38.71	1.1
10	05-11	March	41.77	0.1
11	12-18		41.77	0.1
12	19-25		41.77	0.3
13	26-01	March-April	43.18	0.0
14	02-08	April	51.57	0.0
15	09-15		51.57	0.0
16	16-22		51.57	0.8
17	23-29		51.57	0.0
18	30-06	April-May	56.92	0.3
19	07-13	May	57.81	0.7
20	14-20		57.81	1.2
21	21-27		57.81	2.3
22	28-03	May-June	54.03	7.3
23	04-10	June	49.00	15.4
24	11-17		49.00	27.0
25	18-24		49.00	32.6
26	25-01	June-July	46.90	55.9
27	02-08	July	34.32	73.5
28	09-15		34.32	78.7
29	16-22		34.32	77.9
30	23-29		34.32	92.0
31	30-05	July-Aug.	31.25	76.8

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET (mm)	R. F. (mm)
32	06-12	August	30.03	68.8
33	13-19		30.03	59.4
34	20-26		30.03	54.2
35	27-02	Aug.-Sept.	33.05	64.7
36	03-09	September	40.60	52.1
37	10-16		40.60	40.3
38	17-23		40.60	34.9
39	24-30		40.60	24.5
40	01-07	October	34.55	10.7
41	08-14		34.55	7.4
42	15-21		34.55	3.9
43	22-28		34.55	1.4
44	29-04	Oct.-Nov.	33.34	2.1
45	05-11	November	32.43	3.4
46	12-18		32.43	1.6
47	19-25		32.43	3.6
48	26-02	Nov.-Dec.	30.72	1.7
49	03-09	December	26.42	0.2
50	10-16		26.42	0.5
51	17-23		26.42	0.4
52	24-31		30.19	0.0

APPENDIX 3.6

CLIMATIC STATION BHARUCH AWC 200 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	29.13	0.0
2	08-14		29.13	0.0
3	15-21		29.13	0.0
4	22-28		29.13	0.0
5	29-04	Jan.-Feb.	32.83	0.0
6	05-11	Feb.	35.61	0.0
7	12-18		35.61	0.0
8	19-25		35.61	0.0
9	26-04	Feb.-March	41.20	0.0
10	05-11	March	45.39	0.0
11	12-18		45.39	0.0
12	19-25		45.39	0.0
13	26-01	March-April	46.30	0.0
14	02-08	April	51.80	0.0
15	09-15		51.80	0.0
16	16-22		51.80	0.0
17	23-29		51.80	0.0
18	30-06	April-May	54.63	1.1
19	07-13	May	55.10	1.4
20	14-20		55.10	1.4
21	21-27		55.10	1.4
22	28-03	May-June	48.28	12.1
23	04-10	June	39.20	26.4
24	11-17		39.20	26.4
25	18-24		39.20	26.4
26	25-01	June-July	38.28	30.4
27	02-08	July	32.74	54.65
28	09-15		32.74	54.65
29	16-22		32.74	54.65
30	23-29		32.74	54.65
31	30-05	July-Aug.	32.90	63.30

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET (mm)	R.F. (mm)
32	06-12	August	32.97	66.84
33	13-19		32.97	66.84
34	20-26		32.97	66.84
35	27-02	Aug.-Sept.	33.88	57.88
36	03-09	September	36.17	35.50
37	10-16		36.17	35.50
38	17-23		36.17	35.50
39	24-30		36.17	35.50
40	01-07	October	38.84	8.13
41	08-14		38.84	8.13
42	15-21		38.84	8.13
43	22-28		38.84	8.13
44	29-04	Oct.-Nov.	36.25	16.30
45	05-11	November	34.30	2.80
46	12-18		34.30	2.80
47	19-25		34.30	2.80
48	26-02	Nov.-Dec.	32.69	2.10
49	03-09	December	28.68	0.45
50	10-16		28.68	0.45
51	17-23		28.68	0.45
52	24-31		32.77	0.52

APPENDIX 3.6

CLIMATIC STATION GODHRA AWC 150 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	27.77	0.0
2	08-14		27.77	0.0
3	15-21		27.77	0.0
4	22-28		27.77	0.0
5	29-04	Jan.-Feb.	31.69	0.0
6	05-11	Feb.	34.63	0.0
7	12-18		34.63	0.0
8	19-25		34.63	0.0
9	26-04	Feb.-March	41.19	0.0
10	05-11	March	41.77	0.0
11	12-18		41.77	0.0
12	19-25		41.77	0.0
13	26-01	March-April	43.18	0.03
14	02-08	April	51.57	0.23
15	09-15		51.57	0.23
16	16-22		51.57	0.23
17	23-29		51.57	0.23
18	30-06	April-May	57.92	1.00
19	07-13	May	57.81	1.10
20	14-20		57.81	1.10
21	21-27		57.81	1.10
22	28-03	May-June	54.03	13.70
23	04-10	June	49.00	30.6
24	11-17		49.00	30.6
25	18-24		49.00	30.6
26	25-01	June-July	46.90	35.1
27	02-08	July	34.32	62.3
28	09-15		34.32	62.3
29	16-22		34.32	62.3
30	23-29		34.32	62.3
31	30-05	July-Aug.	31.26	69.9

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
32	06-12	August	30.03	72.9
33	13-19		30.03	72.9
34	20-26		30.03	72.9
35	27-02	Aug.-Sept.	33.05	62.8
36	03-09	September	40.60	37.3
37	10-16		40.60	37.3
38	17-23		40.60	37.3
39	24-30		40.60	37.3
40	01-07	October	34.55	3.6
41	08-14		34.55	3.6
42	15-21		34.55	3.6
43	22-28		34.55	3.6
44	29-04	Oct.-Nov.	33.34	3.6
45	05-11	November	32.43	3.7
46	12-18		32.43	3.7
47	19-25		32.43	3.7
48	26-02	Nov.-Dec.	30.72	2.8
49	03-09	December	26.42	0.4
50	10-16		26.42	0.4
51	17-23		26.42	0.4
52	24-31		30.19	0.5

APPENDIX 3.6

CLIMATIC STATION MEHSANA AWC 150 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	27.77	0.4
2	08-14		27.77	0.1
3	15-21		27.77	0.3
4	22-28		27.77	0.4
5	29-04	Jan.-Feb.	31.69	0.3
6	05-11	Feb.	34.63	0.0
7	12-18		34.63	0.2
8	19-25		34.63	0.5
9	26-04	Feb.-March	38.84	0.2
10	05-11	March	42.00	0.3
11	12-18		42.00	0.0
12	19-25		42.00	0.4
13	26-01	March-April	43.37	0.3
14	02-08	April	51.57	0.1
15	09-15		51.57	0.1
16	16-22		51.57	0.4
17	23-29		51.57	0.1
18	30-06	April-May	56.92	0.7
19	07-13	May	57.81	0.4
20	14-20		57.81	1.6
21	21-27		57.81	0.9
22	28-03	May-June	54.03	1.7
23	04-10	June	49.00	5.1
24	11-17		49.00	11.2
25	18-24		49.00	16.6
26	25-01	June-July	46.90	34.8
27	02-08	July	34.32	53.7
28	09-15		34.32	51.0
29	16-22		34.32	49.4
30	23-29		34.32	62.3
31	30-05	July-Aug.	31.26	43.3

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
32	06-12	August	30.03	46.0
33	13-19		30.03	38.6
34	20-26		30.03	37.4
35	27-02	Aug.-Sept.	33.77	38.9
36	03-09	September	40.60	36.1
37	10-16		40.60	26.7
38	17-23		40.60	16.0
39	24-30		40.60	10.3
40	01-07	October	34.55	2.7
41	08-14		34.55	3.0
42	15-21		34.55	0.6
43	22-28		34.55	0.9
44	29-04	Oct.-Nov.	33.34	1.4
45	05-11	November	32.43	1.2
46	12-18		32.43	1.1
47	19-25		32.43	1.9
48	26-02	Nov.-Dec.	30.72	0.4
49	03-09	December	26.42	0.2
50	10-16		26.42	0.3
51	17-23		26.42	0.5
52	24-31		30.19	0.0

49573

APPENDIX 3.6

CLIMATIC STATION DEESA AWC 75 mm/m

STD. WK.	DATE	MONTH	PET (mm)	R. F. (mm)
1	01-07	January	25.29	0.4
2	08-14		25.29	0.5
3	15-21		25.29	0.2
4	22-28		25.29	0.6
5	29-04	Jan.-Feb.	30.06	0.4
6	05-11	Feb.	33.65	0.3
7	12-18		33.65	0.6
8	19-25		33.65	0.6
9	26-04	Feb.-March	38.16	0.7
10	05-11	March	41.55	0.3
11	12-18		41.55	0.1
12	19-25		41.55	0.9
13	26-01	March-April	42.68	0.2
14	02-08	April	49.47	0.1
15	09-15		49.47	0.3
16	16-22		49.47	0.1
17	23-29		49.47	0.2
18	30-06	April-May	54.30	0.4
19	07-13	May	55.10	1.2
20	14-20		55.10	1.8
21	21-27		55.10	1.2
22	28-03	May-June	53.18	3.0
23	04-10	June	50.63	4.3
24	11-17		50.63	9.1
25	18-24		50.63	10.5
26	25-01	June-July	49.01	28.1
27	02-08	July	39.29	44.6
28	09-15		39.29	43.9
29	16-22		39.29	44.7
30	23-29		39.29	75.6
31	30-05	July-Aug.	35.91	51.4

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
32	06-12	August	34.55	38.8
33	13-19		34.55	40.4
34	20-26		34.55	44.4
35	27-02	Aug.-Sept.	36.01	42.8
36	03-09	September	39.67	28.5
37	10-16		39.67	23.2
38	17-23		39.67	9.3
39	24-30		39.67	7.6
40	01-07	October	35.68	3.0
41	08-14		35.68	2.7
42	15-21		35.68	0.3
43	22-28		35.68	2.8
44	29-04	Oct.-Nov.	31.69	1.6
45	05-11	November	28.70	0.7
46	12-18		28.70	1.1
47	19-25		28.70	1.3
48	26-02	Nov.-Dec.	27.02	0.6
49	03-09	December	22.81	0.2
50	10-16		22.81	0.1
51	17-23		22.81	0.9
52	24-31		26.06	0.0

APPENDIX 3.6

CLIMATIC STATION BHAVNAGAR AWC 150 and 200 mm/m

STD. WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	27.32	0.9
2	08-14		27.32	0.1
3	15-21		27.32	0.2
4	22-28		27.32	0.1
5	29-04	Jan.-Feb.	31.08	0.3
6	05-11	Feb.	33.89	0.1
7	12-18		33.89	0.1
8	19-25		33.89	0.4
9	26-04	Feb.-March	39.56	0.5
10	05-11	March	43.81	0.0
11	12-18		43.81	0.2
12	19-25		43.81	0.3
13	26-01	March-April	44.85	0.2
14	02-08	April	51.10	0.2
15	09-15		51.10	0.2
16	16-22		51.10	3.5
17	23-29		51.10	0.1
18	30-06	April-May	54.33	0.7
19	07-13	May	54.87	0.6
20	14-20		54.87	2.1
21	21-27		54.87	1.4
22	28-03	May-June	52.45	4.8
23	04-10	June	49.23	12.6
24	11-17		49.23	23.6
25	18-24		49.23	29.1
26	25-01	June-July	46.72	41.9
27	02-08	July	31.61	48.8
28	09-15		31.61	49.6
29	16-22		31.61	41.5
30	23-29		31.61	46.6
31	30-05	July-Aug.	29.03	32.6

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F. (mm)
32	06-12	August	28.00	25.6
33	13-19		28.00	30.9
34	20-26		28.00	26.5
35	27-02	Aug.-Sept.	31.93	30.3
36	03-09	September	41.77	30.6
37	10-16		41.77	20.1
38	17-23		41.77	27.8
39	24-30		41.77	19.5
40	01-07	October	39.06	9.1
41	08-14		39.06	10.3
42	15-21		39.06	3.1
43	22-28		39.06	2.0
44	29-04	Oct.-Nov.	35.67	2.4
45	05-11	November	33.13	3.2
46	12-18		33.13	3.2
47	19-25		33.13	1.6
48	26-02	Nov.-Dec.	31.54	0.8
49	03-09	December	27.55	0.0
50	10-16		27.55	0.2
51	17-23		27.55	0.5
52	24-31		31.48	0.0

APPENDIX 3.6

CLIMATIC STATION BHUJ AWC 150 mm/m

STD. WK.	DATE	MONTH	PET (mm)	R. F. (mm)
1	01-07	January	25.52	0.3
2	08-14		25.52	0.2
3	15-21		25.52	0.2
4	22-28		25.52	0.4
5	29-04	Jan.-Feb.	29.19	0.5
6	05-11	Feb.	31.92	0.3
7	12-18		31.92	0.8
8	19-25		31.92	0.7
9	26-04	Feb.-March	37.29	0.2
10	05-11	March	41.32	0.1
11	12-18		41.32	0.1
12	19-25		41.32	0.4
13	26-01	March-April	42.59	0.0
14	02-08	April	50.17	0.0
15	09-15		50.17	0.3
16	16-22		50.17	0.0
17	23-29		50.17	0.0
18	30-06	April-May	51.88	0.2
19	07-13	May	52.16	0.3
20	14-20		52.16	1.8
21	21-27		52.16	0.4
22	28-03	May-June	52.51	1.2
23	04-10	June	52.97	3.7
24	11-17		52.97	6.7
25	18-24		52.97	12.0
26	25-01	June-July	50.69	22.0
27	02-08	July	37.03	30.2
28	09-15		37.03	42.1
29	16-22		37.03	33.8
30	23-29		37.03	38.6
31	30-05	July-Aug.	35.90	30.7

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
32	06-12	August	35.45	27.3
33	13-19		35.45	21.3
34	20-26		35.45	15.2
35	27-02	Aug.-Sept.	37.19	22.2
36	03-09	September	41.53	22.7
37	10-16		41.53	15.9
38	17-23		41.53	4.8
39	24-30		41.53	4.6
40	01-07	October	39.51	2.7
41	08-14		39.51	1.1
42	15-21		39.51	1.4
43	22-28		39.51	2.9
44	29-04	Oct.-Nov.	35.07	1.5
45	05-11	November	31.73	0.5
46	12-18		31.73	0.8
47	19-25		31.73	0.8
48	26-02	Nov.-Dec.	30.41	0.2
49	03-09	December	27.10	0.0
50	10-16		27.10	0.2
51	17-23		27.10	0.6
52	24-31		30.97	0.1

## APPENDIX 3.6

## CLIMATIC STATION RAJKOT AWC 200 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	25.29	0.0
2	08-14		25.29	0.0
3	15-21		25.29	0.0
4	22-28		25.29	0.0
5	29-04	Jan.-Feb.	29.93	0.0
6	05-11	Feb.	33.40	0.0
7	12-18		33.40	0.0
8	19-25		33.40	0.0
9	26-04	Feb.-March	40.44	0.3
10	05-11	March	41.55	0.4
11	12-18		41.55	0.4
12	19-25		41.55	0.4
13	26-01	March-April	42.64	0.4
14	02-08	April	49.23	0.0
15	09-15		49.23	0.0
16	16-22		49.23	0.0
17	23-29		49.23	0.0
18	30-06	April-May	52.90	1.0
19	07-13	May	53.52	1.1
20	14-20		53.52	1.1
21	21-27		53.52	1.1
22	28-03	May-June	49.88	12.5
23	04-10	June	45.03	27.8
24	11-17		45.03	27.8
25	18-24		45.03	27.8
26	25-01	June-July	43.37	30.2
27	02-08	July	33.42	44.9
28	09-15		33.42	44.9
29	16-22		33.42	44.9
30	23-29		33.42	44.9
31	30-05	July-Aug.	30.68	38.1

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET (mm)	R.F. (mm)
32	06-12	August	29.58	35.4
33	13-19		29.58	35.4
34	20-26		29.58	35.4
35	27-02	Aug.-Sept.	31.73	29.7
36	03-09	September	37.10	15.4
37	10-16		37.10	15.4
38	17-23		37.10	15.4
39	24-30		37.10	15.4
40	01-07	October	38.61	2.2
41	08-14		38.61	2.2
42	15-21		38.61	2.2
43	22-28		38.61	2.2
44	29-04	Oct.-Nov.	33.88	1.6
45	05-11	November	30.33	1.2
46	12-18		30.33	1.2
47	19-25		30.33	1.2
48	26-02	Nov.-Dec.	29.54	0.9
49	03-09	December	27.55	0.2
50	10-16		27.55	0.2
51	17-23		27.55	0.2
52	24-31		31.48	0.2

APPENDIX 3.6

CLIMATIC STATION DHRANGADRA AWC 175 mm/m

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
1	01-07	January	27.77	0.2
2	08-14		27.77	0.3
3	15-21		27.77	0.2
4	22-28		27.77	0.4
5	29-04	Jan.-Feb.	31.83	0.2
6	05-11	Feb.	34.88	0.1
7	12-18		34.88	0.2
8	19-25		34.88	0.3
9	26-04	Feb.-March	39.21	0.3
10	05-11	March	42.45	0.2
11	12-18		42.45	0.3
12	19-25		42.45	0.2
13	26-01	March-April	43.82	0.1
14	02-08	April	52.03	0.0
15	09-15		52.03	0.2
16	16-22		52.03	0.6
17	23-29		52.03	0.1
18	30-06	April-May	56.98	0.4
19	07-13	May	57.81	0.8
20	14-20		57.81	1.8
21	21-27		57.81	1.5
22	28-03	May-June	54.23	2.8
23	04-10	June	49.47	9.2
24	11-17		49.47	14.6
25	18-24		49.47	18.1
26	25-01	June-July	47.34	30.5
27	02-08	July	34.55	40.9
28	09-15		34.55	42.5
29	16-22		34.55	37.6
30	23-29		34.55	60.8
31	30-05	July-Aug.	31.32	33.9

Appendix 3.6 contd..

STD.WK.	DATE	MONTH	PET(mm)	R.F.(mm)
32	06-12	August	30.03	27.9
33	13-19		30.03	27.3
34	20-26		30.03	24.0
35	27-02	Aug.-Sept.	33.12	30.0
36	03-09	September	40.83	26.4
37	10-16		40.83	16.6
38	17-23		40.83	17.2
39	24-30		40.83	11.2
40	01-07	October	35.23	4.9
41	08-14		35.23	2.5
42	15-21		35.23	0.6
43	22-28		35.23	1.7
44	29-04	Oct.-Nov.	33.90	0.4
45	05-11	November	32.90	1.6
46	12-18		32.90	1.4
47	19-25		32.90	2.3
48	26-02	Nov.-Dec.	31.05	0.6
49	03-09	December	26.42	0.1
50	10-16		26.42	0.3
51	17-23		26.42	0.4
52	24-31		30.19	0.0

APPENDIX 3.7 —

The districtwise area (lakh hectares)  
under the Narmada Command

Sr. No.	District	Area (CCA)
1.	Ahmedabad	3.30
2.	Banaskantha	3.13
3.	Baroda	3.40
4.	Bhavnagar	0.48
5.	Broach	0.98
6.	Gandhinagar	0.10
7.	Kaira	1.16
8.	Mehsana	1.50
9.	Panchmahals	0.10
10.	Kutch	0.37
11.	Rajkot	0.34
12.	Surendranagar	3.04

Source : Anonymous (1991)

**APPENDIX 4.1.**

**CROP EVAPOTRANSPIRATION AND IRRIGATION REQUIREMENTS**

NO.	DISTRICT	CLIMATIC STATION	AWC (mm/m)
1.	KHEDA	ANAND	155/116
2.	AHMEDABAD AND GANDHINAGAR	AHMEDABAD	150 and 200
3.	BARODA	BARODA	150 and 200
4.	BHARUCH	BHARUCH	200
5.	PANCHMAHALS	GODHRA	150
6.	MEHSANA	MEHSANA	150
7.	BANASKANTHA	DEESA	75
8.	BHAVNAGAR	BHAVNAGAR	150 and 200
9.	KUTCH	BHUJ	150
10.	RAJKOT	RAJKOT	200
11.	SURENDRANAGAR	DHRANGADRA	175

**DETAILS OF CROPS (FOR DISTRICTS EXCEPT KHEDA)**

CROP	SEASON	PLANTING DATE	HARVESTING DATE	LGP
Pearl millet	Summer	25 Feb.	5 June	100
Groundnut	Summer	21 Jan.	11 May	110
Pearl millet	Kharif	21 June	9 Oct.	110
Groundnut	Kharif	21 June	19 Oct.	120
Mustard	Rabi	15 Oct.	13 Feb.	120
Wheat	Rabi	5 Nov.	5 March	120
Pigeonpea	Kharif	14 July	9 Feb.	210
Cotton	Kharif	21 June	18 Jan.	210
Castor	Kharif	2 Aug.	28 March	240

**FOR KHEDA DISTRICT (FIELD EXPT. AT ANAND)**

Pearl millet	Summer	21 Feb.	31 May	100
Groundnut	Summer	14 Feb.	24 May	100
Mustard	Rabi	19 Oct.	15 Feb.	120
Wheat	Rabi	13 Nov.	11 March	120
Cotton	Kharif	26 June	20 Jan.	210
Pigeonpea	Kharif	14 July	9 Feb.	210
Castor	Kharif	2 Aug.	28 March	240

**STAGES OF CROP GROWTH**

A = Initial stage

B = Development Stage

C = Mid Season Stage

D = Harvest or Maturity Stage

APPENDIX 4.1.1

Pearlmillet (Summer)

AWC : 155 mm/m

LGP : 100 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <—mm/std.wk—>	Irri. Req.
5 Feb.	8A	4.67	3.74	18.70	0.20	18.50
12 Feb-March	9A	5.73	4.58	32.06	0.27	31.79
19 March	10A/B	6.04	4.83	33.82	0.36	33.46*
26	11B	6.16	4.93	34.51	0.36	34.15
33	12B	6.07	4.86	34.02	0.36	33.66
40 March-April	13B	6.24	4.99	34.93	0.27	34.66*
47 April	14C	6.89	7.23	50.61	0.18	50.43*
54	15C	7.13	7.49	52.43	0.18	52.25
61	16C	7.16	7.52	52.64	0.18	52.46*
68	17C	7.23	7.59	53.13	0.18	52.95*
75 April-May	18C	7.45	7.82	54.74	0.46	54.28
			7.72x5	38.60		
82 May	19C/D	7.35	6.61x2	13.22	0.72	51.10*
89	20D	7.24	6.52	45.64	0.72	44.92
96	21D	7.00	6.30	44.10	0.72	43.38*
103 May-June	22D	6.78	6.10x4	24.40	6.67	12.72
				617.55	11.83	605.72

Net Irri. Req. = 605.72 + 60 = 665.72 mm

Gross Irri. Req. = 673.02 + 67 = 740.02 mm

No. of Irrigation = 7 on 18, 35, 47, 57, 67, 78, 92 DAS

Net water applied 78 x 7 = 546 mm + 60 = 606 mm

Gross water applied 87 x 7 = 609 mm + 67 = 676 mm

APPENDIX 4.1.1

Groundnut (Summer)

AWC : 155 mm/m

LGP : 100 Days

Days/Month	Std. Week	ET <sub>o</sub>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain	Irri. Req.
		<—mm/d—>			<—mm/std.wk—>	
5 February	7A	4.65	3.72	18.60	0.20	18.40
12	8A	4.67	3.74	26.18	0.20	25.98
19 Feb.-March	9A	5.73	4.58	32.06	0.28	31.78*
			4.83x1	4.83		
26	10A/B	6.04	4.83x6	28.98	0.36	33.45
33	11B	6.16	4.93	34.51	0.36	34.15
40	12B	6.07	4.86	34.02	0.36	33.66*
			4.99x5	24.95		
47 March-April	13B/C	6.24	6.55x2	13.10	0.27	37.78
54 April	14C	6.89	7.23	50.61	0.18	50.43*
61	15C	7.13	7.49	52.43	0.18	52.25*
68	16C	7.16	7.52	52.64	0.18	52.46
75	17C	7.23	7.59	53.13	0.18	52.95*
			7.82x5	39.10		
82 April-May	18C/D	7.45	4.47x2	8.94	0.46	47.58*
89 May	19D	7.35	4.41	30.87	0.72	30.15
96	20D	7.24	4.34	30.38	0.72	29.66
103	21D	7.00	4.20x4	16.80	0.41	16.08*
				552.13	5.06	547.07

Net Irri. Req. = 547.07 + 60 = 607.07 mm

Gross Irri. Req. = 607.86 + 67 = 674.86 mm

\* No. of Irrigation = 7 on 19, 35, 49, 60, 70, 81, 99 DAS

Net water applied = 78 x 7 = 546 + 60 mm = 606 mm

Gross water applied = 87 x 7 = 609 mm + 67 = 676 mm

APPENDIX 4.1.1  
Mustard (Rabi)

AWC : 155 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.rain <—mm/std.wk—>	Irri.Req.
3 Oct.	42A	5.34	3.20	9.60	2.53	7.07
10	43A	5.38	3.23	22.61	2.53	20.08
17 Oct.-Nov.	44A	4.51	2.71	18.97	3.76	15.21
			2.64x3	7.92		
24 November	45A/B	4.40	3.52x4	14.08	5.04	16.96
31	46B	4.31	3.45	24.15	5.04	19.11*
38	47B	4.13	3.30	23.10	5.04	18.06
45 Nov.-Dec.	48B	3.99	3.19	22.33	2.66	19.67
			2.94x5	14.70		
52 December	49B/C	3.68	3.86x2	7.72	0.36	22.06
59	50C	3.63	3.81	26.67	0.36	26.31*
66	51C	3.64	3.82	26.74	0.36	26.38
74	52C	3.49	3.66	29.28	0.42	28.86
81 January	1C	3.76	3.95	27.65	0.0	27.65*
88	2C	3.73	3.92	27.44	0.0	27.44
95	3C	3.78	3.97	27.79	0.0	27.79
102	4D	3.91	3.32	24.64	0.0	24.64*
109 Jan.-Feb.	5D	4.41	3.97	27.79	0.09	27.70*
116 February	6D	4.53	4.08	28.56	0.20	28.36
123	7D	4.68	4.21x4	16.84	0.11	16.64
				428.58	28.50	400.08

Net Irri.Req. = 400.08 + 60 = 468.08 mm

Gross Irri.Req. = 444.53 + 67 = 511.53 mm

\* No.of Irrigation = 5 on 31, 57, 77, 97, 107 DAS

Net water applied 78 x 5 = 390 mm + 60 = 450 mm

Gross water applied 87 x 5 = 435 mm + 67 = 502 mm

APPENDIX 4.1.1  
Wheat (Rabi)

AWC : 116 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <—mm/std.wk—>	Irri. Req.
6 November	46A	4.31	2.59	15.54	5.04	10.50
13	47A	4.13	2.48	17.36	5.04	12.32
			2.39x2	4.78		
20 Nov.-Dec.	48A/B	3.99	3.19x5	15.95	2.66	18.07
27 December	49B	3.68	2.94	20.58	0.36	20.22*
34	50B	3.63	2.90	20.30	0.36	19.94
			3.28x6	19.68		
41	51B/C	4.10	4.51x1	4.51	0.36	23.83*
49	52C	3.49	3.84	30.72	0.42	30.30
56 January	1C	3.76	4.14	28.98	0.0	28.58*
63	2C	3.73	4.10	28.70	0.0	28.70
70	3C	3.76	4.16	29.12	0.0	29.12*
77	4C	3.91	4.30	30.10	0.0	30.10
84 Jan.-Feb.	5C	4.41	4.85	33.95	0.09	33.86*
			4.98x6	29.88		
91 February	6C/D	4.53	3.62x1	3.62	0.20	33.30
98	7D	4.65	3.72	26.04	0.20	25.84*
105	8D	4.67	3.74	26.18	0.20	25.98
112 Feb.-March	9D	5.73	4.58	32.06	0.27	31.79*
119 March	10D	6.04	4.83	33.81	0.36	33.45
126	11D	6.16	4.93x1	4.93	0.05	4.88
				456.79	15.61	441.18

Net Irri. Req. = 441.18 + 60 = 501.18 mm

Gross Irri. Req. = 490.20 + 67 = 557.20 mm

\* No. of Irrigation = 7 on 26, 40, 55, 69, 82, 95, 109 DAS

Net water applied 58 x 7 = 406 mm + 60 = 466 mm

Gross water applied 64 x 7 = 448 mm + 67 = 515 mm

APPENDIX 4.1.1  
Pigenopea (Kharif)

AWC : 155 mm/m

LGP : 210 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.rain <—mm/std.wk—>	Irri.Req.
2 July	28A	4.72	2.36x2	4.72	63.2	-58.48
9	29A	4.50	2.25	15.75	169.30	-153.55
16	30A	5.06	2.53	17.71	77.90	-60.19
23 July-Aug.	31A	4.10	2.05	14.35	21.40	-7.05
30 August	32A	3.97	1.98	13.86	16.80	-2.94
37	33B	4.05	3.08	21.56	3.70	17.86
44	34B	4.12	3.13	21.91	12.50	9.41
51 Aug.-Sept.	35B	4.29	3.26	22.82	96.20	-73.38
58 September	36B	4.13	3.14	21.98	63.80	-41.81
65	37B	4.32	3.28	22.96	2.2	20.76
72	38B	4.78	3.63	25.41	0.0	25.41
79	39B	4.89	3.72	26.04	0.0	26.04
			3.71x1	3.71		
86 October	40B/C	4.88	5.86x6	35.16	0.0	38.87*
93	41C	5.10	6.12	42.84	3.6	39.24
100	42C	5.34	6.41	44.87	6.0	38.87*
107	43C	5.38	6.46	45.22	0.0	45.22*
113 Oct.-Nov.	44C	4.51	5.41	37.87	0.0	37.87
120 November	45C	4.40	5.28	36.96	0.0	36.96
127	46C	4.31	5.17	36.19	0.0	36.19*
134	47C	4.13	4.96	34.72	0.0	34.72
			4.79x6	28.74		
141 Nov.-Dec.	48C/D	3.99	2.79x1	2.79	0.0	31.53*
147 December	49D	3.68	2.58	18.06	0.0	18.06
155	50D	3.63	2.54	17.78	0.0	17.78
162 December	51D	3.64	2.55	17.85	0.0	17.85*
170	52D	4.06	2.84	22.72	0.0	22.72
177 January	1D	3.76	2.63	18.41	0.0	18.41
184	2D	3.73	2.61	18.27	0.0	18.27
191	3D	3.78	2.65	18.55	0.0	18.55*
197	4D	3.91	2.74	19.18	0.0	19.18
205 Jan.-Feb.	5D	4.41	3.09	21.63	0.0	21.63
211 February	6D	4.53	3.17x5	15.85	0.0	15.85
				766.44	139.19	627.25

Net Irri.Req. = 627.25 + 60 = 687.25 mm

Gross Irri.Req. = 696.94 + 67 = 763.94 mm

\* No.of Irrigation = 7 on 80, 94,107,121,135,159,187 DAS

Net water applied 78 x 7 = 546 mm + 60 = 606 mm

Gross water applied 87 x 7 = 609 mm + 67 = 676 mm

APPENDIX 4.1.1  
Cotton (Kharif)

AWC : 155 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <—mm/std.wk—>	Irri. Req.	
6	June-July	26A	5.32	2.66x6	15.96	0.0	15.96
12	July	27A	4.94	2.47	17.29	0.0	17.29
19		28A	4.74	2.36	16.52	63.20	-46.68
26		29A	4.50	2.25	15.75	169.30	-153.55
				2.53x4	10.12		
33		30A/B	5.06	3.04x3	9.12	77.90	-58.66
40	July-Aug.	31B	4.10	2.46	17.22	21.40	-4.18
47	August	32B	3.97	2.38	16.66	16.80	-0.14
54		33B	4.05	2.43	17.01	3.70	13.31
61		34B	4.12	2.47	17.29	12.50	4.79
68	Aug.Sept.	35B	4.29	2.57	17.99	96.20	-76.21
75	Sept.	36B	4.13	2.48	17.36	63.83	-46.44
				2.59x5	12.95		
82		37B/C	4.32	5.18x2	10.36	2.2	21.11
89		38C	4.78	5.74	40.18	0.0	40.18
96		39C	4.89	5.87	41.09	0.0	41.09*
103	October	40C	4.88	5.86	41.02	0.0	41.02
110		41C	5.10	6.12	42.84	0.0	42.84*
117		42C	5.34	6.41	44.87	0.0	44.87*
123		43C	5.38	6.46	45.22	0.0	45.22
130	Oct.-Nov.	44C	4.51	5.41	37.87	0.0	37.87*
137	November	45C	4.40	5.28	36.96	0.0	36.96
143		46C	4.31	5.17	36.19	0.0	36.19
150		47C	4.13	4.96	34.72	0.0	34.72*
157	Nov.-Dec.	48D	3.99	2.59	18.13	0.0	18.13
164	December	49D	3.68	2.39	16.73	0.0	16.73
171		50D	3.63	2.36	16.52	0.0	16.52*
178		51D	3.64	2.37	16.59	0.0	16.59
186		52D	3.49	2.27	18.16	0.0	18.16
193		1D	3.76	2.44	17.08	0.0	17.08
200		2D	3.72	2.42	16.49	0.0	16.94*
207		3D	3.78	2.46	17.22	0.0	17.22
214		4D	3.91	2.54x3	7.62	0.0	7.62
					757.10	138.69	618.41

Net Irri. Req. = 618.41 + 60 = 678.41 mm

Gross Irri. Req. = 687.12 + 67 = 754.12 mm

\* No. of Irrigation = 7 on 92, 105, 117, 130, 144, 166, 198 DAS

Net water applied 78 x 7 = 546 mm + 60 = 606 mm

Gross water applied 87 x 7 = 609 mm + 67 = 676 mm

APPENDIX 4.1.1  
Castor (Kharif)

AWC : 155 mm/m

LGP : 240 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff.rain <—mm/std.wk—>	Irri.Req.
4 August	31A	4.10	2.87x4	11.48	1.2	10.28
11	32A	3.97	2.78	19.46	16.80	2.66
18	33A	4.05	2.84	19.88	3.70	16.18
25	34A	4.12	2.88	20.16	12.50	7.66
			3.00x5	15.00		
32 Aug.-Sept.	35A/B	4.29	3.43x2	6.86	96.20	-74.34
39 September	36B	4.13	3.30	23.10	63.80	-40.70
46	37B	4.32	3.46	24.22	2.20	22.02
53	38B	4.78	3.82	26.74	0.0	26.74
60	39B	4.89	3.91	27.37	0.0	27.37*
67 October	40B	4.88	3.90	27.30	0.0	27.30
74	41B	5.10	4.08	28.56	3.6	24.96
81	42B	5.34	4.27	29.89	6.0	23.89*
88	43B	5.38	4.30	30.10	0.0	30.10
			3.61x2	7.22		
95 Oct.-Nov.	44B/C	4.51	5.19x5	25.95	0.0	33.17
102 November	45C	4.40	5.06	35.42	0.0	35.42*
109	46C	4.31	4.96	34.72	0.0	34.72
116	47C	4.13	4.75	33.25	0.0	33.25*
123 Nov.-Dec.	48C	3.99	4.59	32.13	0.0	32.13
130 December	49C	3.68	4.23	29.61	0.0	29.61*
137	50C	3.63	4.17	29.19	0.0	29.19
144	51C	3.64	4.19	29.33	0.0	29.33
152	52C	3.49	4.01	32.08	0.0	32.08*
159 January	1C	3.76	4.32	30.24	0.0	30.24
166	2C	3.73	4.29	30.03	0.0	30.03*
173	3C	3.78	4.35	30.45	0.0	30.45
180	4C	3.91	4.50	31.50	0.0	31.50*
187 Jan.-Feb.	5D	4.41	3.09	21.63	0.0	21.63
195	6D	4.53	3.17	22.19	0.0	22.19
202	7D	4.65	3.26	22.82	0.0	22.82*
209	8D	4.67	3.27	22.89	0.0	22.89
216 Feb.-March	9D	5.73	4.01	28.07	0.0	28.07
223	10D	6.04	4.23	29.61	0.0	29.61*
230	11D	6.16	4.31	30.17	0.0	30.17
237	12D	6.07	4.25	29.75	0.0	29.75
244 March-April	13D	6.24	4.37x3	13.10	0.0	13.10
				941.47	90.96	850.51

Net Irri.Req. = 850.51 + 60 = 910.51 mm

Gross Irri.Req. = 945.01 + 67 = 1012.01mm

\* No.of Irrigation = 11, 60, 81,98,112,127,145,161,178,202,222 DAS

Net water applied 78 x 11= 858 mm + 60 = 918 mm

Gross water applied 87 x 11=957 mm + 67 = 1024 mm;

APPENDIX 4.1.2  
Pearl millet (Summer)

AWC : 150 mm/m and 200 mm/m

LGP : 100 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <— mm/std.wk —>	Irri. Req.
1 Feb.	8A	4.98	3.98	3.98 @80%	0.03	3.95
8 Feb-March	9A	4.31	3.45	24.15	0.19	23.96
15 March	10A	3.81	3.05	21.35	0.18	21.17
22	11B	3.81	3.05	21.35	0.18	21.17
29	12B	3.81	3.05	21.35	0.18	21.17*
36 March-April	13B	4.61	3.69	25.83	0.18	+25.65
			5.94x4	23.76		
43 April	14B/C	7.43	7.80x3	23.40	0.19	46.97*
50	15C	7.43	7.80	54.60	0.19	+54.41
57	16C	7.43	7.80	54.60	0.19	54.41*
64	17C	7.43	7.80	54.60	0.19	+54.41*
71 April-May	18C	8.14	8.55	59.85	0.73	59.12*
78	19C	8.26	8.87	60.69	1.26	+59.43*
			8.67x2	17.34		
85	20C/D	8.26	7.43x5	37.15	1.26	53.23
92	21D	8.26	7.43	52.01	1.26	+50.75*
99 May-June	22D	7.75	6.97	48.79 @ 75%	10.16	38.63
106 June	23D	7.07	6.36x1	6.36	2.78	3.58*
				611.16	19.15	592.01

For AWC 150 mm/m

Net Irri. Req. = 592.01 + 60 = 652.01 mm

Gross Irri. Req. = 657.79 + 67 = 724.79 mm

\* No. of Irrigation = 8 on 23, 41, 51, 60, 70, 78, 87 and 100 DAS

Net water applied 75 x 8 = 600 mm + 60 = 660 mm

Gross water applied 83 x 8 = 664 mm + 67 = 731 mm

For AWC 200 mm/m

+ No. of Irrigation = 5 on 31, 48, 60, 73, 87 DAS

Net water applied : 100 x 5 = 500 + 60 = 560 mm

Gross water applied : 111 x 5 = 555 + 67 = 622 mm

APPENDIX 4.1.2

Groundnut (Summer)

AWC : 150 mm/m and 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 %	
					Eff.Rain <—mm/std.wk—>	Irri.Req.
1 January	3A	3.97	3.17	3.17	0.05	3.12
8	4A	3.97	3.17	22.19	0.36	21.83
15 Jan.-Feb.	5A	4.55	3.64	25.48	0.28	25.20
22 February	6A/B	4.98	3.98	27.86	0.20	27.66*
29	7B	4.98	3.98	27.86	0.20	+27.66
36	8B	4.98	3.98	27.86	0.20	27.66
43 Feb.-March	9B	4.31	3.45	24.15	0.19	23.96*
			3.05x2	6.10		
50 March	10B/C	3.81	4.00x5	20.00	0.18	25.92
57	11C	3.81	4.00	28.00	0.18	+27.22
64	12C	3.81	4.00	28.00	0.18	27.22*
71 March-April	13C	4.61	4.84	33.88	0.18	33.70
78 April	14C	7.43	7.80	54.60	0.19	+54.41*
85	15C	7.43	7.80	54.60	0.19	54.41*
			7.80x1	7.80		
92	16C/D	7.43	4.46x6	26.76	0.19	+34.37
99	17D	7.43	4.46	31.22	0.19	31.03*
106 April-May	18D	8.14	4.88	34.16	0.73	33.43
113 May	19D	8.26	4.96x4	19.84	1.26	18.58
				503.53	4.95	498.58

For AWC 150 mm/m

Net Irri.Req. = 498.58 + 60 = 558.58 mm  
 Gross Irri.Req. = 553.98 + 67 = 620.98 mm  
 \* No.of Irrigation = 6 on 21, 41, 61, 74, 84, 99 DAS  
 Net water applied 75 x 6 = 450 mm + 60 = 510 mm  
 Gross water applied 83 x 6 = 498 mm + 67 = 565 mm

For AWC 200 mm/m

+ No.of Irrigation = 4 on 28, 54, 74, 89 DAS  
 Net water applied 100 x 4 = 400 + 60 = 460 mm  
 Gross water applied 111 x 4 = 444 + 67 = 511 mm

APPENDIX 4.1.2  
Mustard (Rabi)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain <— mm/std.wk —>	Irri. Req.
7 Oct.	42A	5.03	3.02	21.14	1.45	19.69	
14	43A	5.03	3.02	21.14	1.45	19.69	
			2.90x1	2.90			
21 Oct.-Nov.	44A/B	4.84	3.87x6	23.22	2.02	24.10	
28 November	45B	4.70	3.76	26.32	2.61	23.71*	
35	46B	4.70	3.76	26.32	2.61	+23.71	
42	47B	4.70	3.76	26.32	2.61	23.71	
49 Nov.-Dec.	48B	4.44	3.55	24.85	1.56	23.29*	
			3.02x1	3.02			
56 December	49B/C	3.77	3.96x6	23.76	0.54	26.24	
63	50C	3.77	3.96	27.72	0.54	+27.18	
70	51C	3.77	3.96	27.72	0.54	27.18*	
77	52C	3.77	3.96	31.68	0.62	31.06	
85 June	1C	3.97	4.17	29.19	0.36	+28.83*	
92	2C	3.97	4.17	29.19	0.36	28.83	
			4.17x3	12.51			
99	3C/D	3.97	3.57x4	14.28	0.36	26.43	
106	4D	3.97	3.57	24.99	0.36	24.63*	
113 Jan.-Feb.	5D	4.55	4.10	28.70	0.28	+28.42	
120 February	6D	4.98	4.48	31.36	0.03	31.33	
				456.33	18.30	438.03	

For AWC 150 mm/m

Net Irri. Req. = 438.03 + 60 = 498.03 mm

Gross Irri. Req. = 486.67 + 67 = 553.67 mm

\* No. of Irrigation = 5 on 24, 46, 65, 83, 101 DAS

Net water applied 75 x 5 = 375 mm + 60 = 435 mm

Gross water applied 83 x 5 = 415 mm + 67 = 482 mm

For AWC 200 mm/m

+ No. of Irrigation = 4 on 32, 60, 84, 110 DAS

Net water applied : 100 x 4 = 400 + 60 = 460 mm

Gross water applied : 111 x 4 = 444 + 67 = 511 mm

APPENDIX 4.1.2  
Wheat (Rabi)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <— mm/std.wk —>	Irri. Req.
7 Nov.	45A	4.70	2.82	19.74	2.61	17.13
14	46A	4.70	2.82	19.74	2.61	17.13
			2.82x1	2.82		
21	47A/B	4.70	3.76x6	22.56	2.61	22.77
28 Nov. Dec.	48B	4.44	3.55	24.85	1.56	23.29*
35 December	49B	3.77	3.02	21.14	0.54	+20.60
			3.02x5	15.10		
42	50B/C	3.77	4.15x2	8.30	0.54	22.86
49	51C	3.77	4.15	29.05	0.54	28.51*
57	52C	3.77	4.15	33.20	0.62	32.58
64 January	1C	3.97	4.37	30.59	0.36	+30.23
71	2C	3.97	4.37	30.59	0.36	30.23*
78	3C	3.97	4.37	30.59	0.36	30.23
85	4C	3.97	4.37	30.59	0.36	+30.23*
			5.01x5	25.05		
92 Jan.-Feb.	5C/D	4.55	3.64x2	7.28	0.28	32.05
99 February	6D	4.98	3.98	27.86	0.20	27.66
106	7D	4.98	3.98	27.86	0.20	27.66*
113	8D	4.98	3.98	27.86	0.20	+27.66
120 Feb.-March	9D	4.31	3.45	24.15	0.19	23.96
				458.92	14.14	444.78

For AWC 150 mm/m

Net Irri. Req. = 444.78 + 60 = 504.78 mm  
 Gross Irri. Req. = 494.20 + 67 = 561.20 mm  
 \* No. of Irrigation = 5 on 26, 48, 65, 83, 100 DAS  
 Net water applied : 75 x 5 = 375 mm + 60 = 435 mm  
 Gross water applied : 83 x 5 = 415 mm + 67 = 482 mm

For AWC 200 mm/m

+ No. of Irrigation = 4 on 35, 59, 83, 107 DAS  
 Net water applied : 100 x 4 = 400 + 60 = 460 mm  
 Gross water applied : 111 x 4 = 444 + 67 = 511 mm

APPENDIX 4.1.2  
Pearl millet (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.rain <— mm/std.wk—>	Irri.Req.
4 June	25A	7.07	5.66	22.64	11.10	11.54
11 June-July	26A	6.79	5.43	38.01	30.77	7.24
18 July	27A/B	4.94	3.95	27.65	42.99	-15.34
25	28B	4.94	3.95	27.65	42.99	-15.34
32	29B	4.94	3.95	27.65	42.99	-15.34
39	30B	4.94	3.95	27.65	42.99	-15.34
			3.66x1	3.66		
46 July-Aug.	31B/C	4.58	4.81x6	28.86	39.28	-6.76
53 August	32C	4.29	4.50	31.50	35.56	-4.06
60	33C	4.29	4.50	31.50	35.56	-4.06
67	34	4.29	4.50	31.50	35.56	-4.06
74 Aug.-Sept.	35	4.73	4.97	34.79	29.16	5.63
			6.12x6	36.72		
81 Sept.	36C/D	5.83	5.25x1	5.25	24.15	17.82
88	37D	5.83	5.25	36.75	24.15	12.60
95	38	5.83	5.25	36.75	24.15	12.60
102	39	5.83	5.25	36.75	24.15	12.60
109 Oct.	40	5.03	4.53	31.71	1.45	30.26*
116	41	5.03	4.53x1	4.53	0.21	4.32
				521.52	106.91	114.61

For AWC 150 mm/m

Net Irri.Req. = 114.61 + 60 = 174.61 mm

Gross Irri.Req. = 127.34 + 67 = 194.34 mm

\* No. of Irrigation = 1 on 105 DAS

Net water applied : 75 x 1 = 75 mm

Gross water applied : 83 x 1 = 83 mm

For AWC 200 mm/m

No Irrigation required.

APPENDIX 4.1.2  
Groundnut (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <—mm/std.wk—>	Irri. Req.
4 June	25A	7.07	5.66	22.64 @ 75%	11.10	11.54
11 June-July	26A	6.79	5.43	38.01 @ 70%	30.77	7.24
18 July	27A	4.94	3.95	27.65	42.99	-15.34
25	28A/B	4.94	3.95	27.65	42.99	-15.34
32	29B	4.94	3.95	27.65	42.99	-15.34
39	30B	4.94	3.95	27.65	42.99	-15.34
			3.66x6	21.96		
46 July-Aug.	31B/C	4.57	4.80x1	4.80	39.28	-12.52
53 August	32C	4.29	4.50	31.50	35.56	-4.06
60	33C	4.29	4.50	31.50	35.56	-4.06
67	34C	4.29	4.50	31.50	35.56	-4.06
74 Aug.Sept.	35C	4.73	4.97	34.79	29.16	5.63
			6.12x6	36.72		
81 September	36C/D	5.83	3.50x1	3.50 @ 75%	24.15	16.07
88	37D	5.83	3.50	24.50	25.15	0.35
95	38D	5.83	3.50	24.50	25.15	0.35
102	39D	5.83	3.50	24.50	25.15	0.35
109 October	40D	5.03	3.02	21.14 @ 80%	1.45	19.69
116	41D	5.03	3.02	21.14	1.45	19.69
123	42D	5.03	3.02x4	12.08	0.83	11.25
				495.38	403.22	93.16

No irrigation required.

APPENDIX 4.1.2  
Cotton (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. rain <—mm/std.wk—>	Irri. Req.
4 June	25A	7.07	3.18	12.72	@75% 11.10	1.62
11 June-July	26A	6.79	3.06	21.42	@70% 30.77	-9.35
18 July	27A	4.94	2.22	15.54	42.99	-27.45
25	28A	4.94	2.22	15.54	42.99	-27.45
			2.22x5	11.10		
32	29A/B	4.94	2.77x2	5.54	42.99	-26.35
39	30B	4.94	2.77	19.39	42.99	-23.60
46 July-Aug.	31B	4.56	2.55	17.85	39.28	-21.43
53 August	32B	4.29	2.40	16.80	35.56	-18.26
60	33B	4.29	2.40	16.80	35.56	-18.26
67	34B	4.29	2.40	16.80	35.56	-18.26
74 Aug.-Sept.	35B	4.73	2.65	18.55	29.16	-10.61
			3.26x6	19.56		
81 September	36B/C	5.83	7.00x1	7.00	@75% 24.15	2.41
88	37C	5.83	7.00	49.00	24.15	24.85
95	38C	5.83	7.00	49.00	24.15	24.85
102	39C	5.83	7.00	49.00	24.15	24.85*
109 Oct.	40C	5.03	6.04	42.28	@80% 1.45	+40.83
116	41C	5.03	6.04	42.28	1.45	40.83*
123	42C	5.03	6.04	42.28	1.45	+40.83
130	43C	5.03	6.04	42.28	1.45	40.83*
137 Oct.-Nov.	44C	4.84	5.81	40.67	2.02	38.65
144 November	45C	4.70	5.64	39.48	2.61	+36.87*
			5.64x6	33.84		
151	46C/D	4.70	3.05x1	3.05	2.61	34.28
158	47D	4.70	3.05	21.35	2.16	18.74
165 Nov.-Dec.	48D	4.43	2.88	20.16	1.56	18.60
172 December	49D	3.77	2.45	17.15	0.54	+16.61*
179	50D	3.77	2.45	17.15	0.54	16.61
186	51D	3.77	2.45	17.15	0.54	16.61
194	52D	4.31	2.80	22.40	0.62	21.78
201	1D	3.97	2.58	18.06	0.36	17.70*
208	2D	3.97	2.58	18.06	0.36	17.70
210	3D	3.97	2.58x2	5.16	0.10	+ 5.06
				804.41	303.30	501.11

For AWC 150 mm/m : Net Irri. Req. = 501.11 + 60 = 561.11 mm

Gross Irri. Req. = 556.79 + 67 = 623.79 mm

\* No. of Irrigation = 6 on 102, 114, 128, 142, 170, 198 DAS

Net water applied : 75 x 6 = 450 mm + 60 = 510 mm

Gross water applied: 83 x 6 = 498mm + 67 = 565 mm;

For AWC 200 mm/m : + No. of Irrigation = 5 on 106, 123, 141, 170, 209 DAS

Net water applied : 100 x 5 = 500+60 = 560 mm

Gross water applied : 111 x 5 = 535+67 = 622mm;

APPENDIX 4.1.3  
Pearlmillet (Summer)

AWC : 150 mm/m and 200 mm/m

LGP : 100 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	ETc	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
1 Feb.	8A	4.95	3.96x1	3.96		0.03	3.93
8 Feb.-March	9A	5.53	4.42	30.94		0.19	30.75
15 March	10A	5.97	4.78	33.46		0.18	33.28
22	11B	5.97	4.78	33.46		0.18	+33.28
29	12B	5.97	4.78	33.46		0.18	33.28
36 March-April	13B	6.17	4.94	34.58		0.18	34.40*
			5.90x4	23.60			
43 April	14B/C	7.37	7.74x3	23.22		0.19	+46.63
50	15C	7.37	7.74	54.18		0.19	53.99*
57	16C	7.37	7.74	54.18		0.19	+53.99*
64	17C	7.37	7.74	54.18		0.19	53.99
71 April-May	18C	8.13	8.54	59.78		0.09	+59.69*
78 May	19C	8.26	8.67	60.69		0.0	+60.69*
			8.67x2	17.34			
85	20C	8.26	7.43x5	37.15		0.0	54.49*
92	21C	8.26	7.43	52.01		0.0	+52.01
99 May-June	22C	7.72	6.95	48.65	@ 75%	11.53	37.12*
106 June	23C	7.00	6.30x1	6.30		3.35	2.95
				661.14		16.67	644.47

For AWC 150 mm/m :

Net Irri. Req. = 644.47 + 60 = 704.47mm

Gross Irri. Req. = 716.08 + 67 = 783.08mm

\* No. of Irri. = 8 (17, 33, 45, 56, 65, 75, 84, 96 DAS)

Net Irri. water applied = 75 x 8 = 600mm + 60 = 660mm

Gross Irri. water applied = 83 x 8 = 664mm + 67 = 731mm

For AWC 200 mm/m :

+ No. of Irri. = 6 (22, 41, 54, 67, 78 and 91 DAS)

Net Irri. water applied = 100 x 6 = 600mm + 60 = 660mm

Gross Irri. water applied = 111 x 6 = 666mm + 67 = 733mm

APPENDIX 4.1.3  
Groundnut (Summer)

AWC : 150 mm/m and 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain ←mm/Std.wk→	Net Irri. Req.
1 January	3A	3.97	3.18	3.18	0.03	3.15
8	4A	3.97	3.18	22.26	0.18	22.08
15 Jan.-Feb.	5A	4.53	3.62	25.34	0.19	25.15
22 Feb.	6A/B	4.53	3.62	25.34	0.20	25.14*
29	7B	4.53	3.62	25.34	0.20	+25.14
36	8B	4.53	3.62	25.34	0.20	25.14
43 Feb.-March	9B	5.53	4.42	30.94	0.19	30.75*
			4.78x2	9.56		
50 March	10B/C	5.97	6.27x5	31.35	0.18	+40.73
57	11C	5.97	6.27	43.89	0.18	43.71*
64	12C	5.97	6.27	43.89	0.18	43.71
71 March-April	13C	6.17	6.48	45.36	0.18	+45.18*
78 April	14C	7.37	7.74	54.18	0.19	53.99*
85	15C	7.37	7.74	54.18	0.19	+53.99
			7.74x1	7.74		
92	16C/D	7.37	4.42x6	26.52	0.19	34.07*
99	17D	7.37	4.42	30.94	0.19	+30.75
106 April-May	18D	8.13	4.88	34.16	0.09	34.07*
113 May	19D	8.26	4.96x4	19.84	0.0	19.84
				559.35	2.76	556.59

For AWC 150 mm/m :

Net Irri. Req. = 556.59 + 60 = 616.59mm

Gross Irri. Req. = 618.43 + 67 = 685.43mm

\* No. of Irri. = 7 (22, 42, 54, 66, 72, 87 and 104 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

For AWC 200 mm/m :

+ No. of Irri. = 5 (29, 50, 66, 79 and 97 DAS)

Net Irri. water applied = 100 x 5 = 500mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.3  
Mustard (Rabi)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain ←mm/Std. wk→	Net Irri. Req.
7 October	42A	4.94	2.96	20.72	2.71	18.01
15	43A	4.94	2.96	20.72	2.71	18.01
			2.86x6	17.16		
21 Oct.-Nov.	44A/B	4.76	3.81x1	3.81	2.66	18.31
28 November	45B	4.63	3.70	25.90	2.61	23.29*
35	46B	4.63	3.70	25.90	2.61	+23.29
42	47B	4.63	3.70	25.90	2.61	23.29
49 Nov.-Dec.	48B	4.39	3.51	24.57	2.11	22.46
			3.02x1	3.02		
56 Dec.	49B/C	3.77	3.96x6	23.73	1.63	25.15*
63	50C	3.77	3.96	27.72	1.63	+26.09
70	51C	3.77	3.96	27.72	1.63	26.09*
78	52C	3.77	3.96	31.68	1.86	29.82
85 January	1C	3.97	4.17	29.19	0.18	29.01
92	2C	3.97	4.17	29.19	0.18	+29.01*
			4.17x3	12.51		
99	3C	3.97	3.57x4	14.28	0.18	26.61
106	4C	3.97	3.57	24.99	0.18	24.81
113 Jan.-Feb.	5C	4.53	4.08	28.56	0.19	28.37*
120 Feb.	6C	4.95	4.46	31.22	0.20	+31.02
				448.52	25.88	422.64

For AWC 150 mm/m :

Net Irri. Req. = 422.64 + 60 = 482.64mm

Gross Irri. Req. = 496.60 + 67 = 536.60mm

\* No. of Irri. = 5 (27, 50, 70, 89 and 108 DAS)

Net Irri. water applied = 75 x 5 = 375mm + 60 = 435mm

Gross Irri. water applied = 83 x 5 = 415mm + 67 = 482mm

For AWC 200 mm/m:

+ No. of Irri. = 4 (35, 63, 88 and 114 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.3  
Wheat (Rabi)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 Nov.	45A	4.63	2.78	19.46	2.61	16.85
14	46A	4.63	2.78	19.46	2.61	16.85
			2.78x1	2.78		
21	47A/B	4.63	3.70x6	22.20	2.61	22.37
28 Nov.-Dec.	48B	4.39	3.51	24.57	2.11	22.46*
35 Dec.	49B	3.77	3.02	21.14	1.63	+19.51
			3.02x5	15.10		
42	50B/C	3.77	4.15x2	8.30	1.63	21.77
49	51C	3.77	4.15	29.05	1.63	27.42*
57	52C	3.77	4.15	33.20	1.86	31.34
63 January	1C	3.97	4.37	30.59	0.18	+30.41
70 January	2C	3.97	4.37	30.59	0.18	30.41*
77	3C	3.97	4.37	30.59	0.18	30.41
84	4C	3.97	4.37	30.59	0.18	+30.41*
			4.98x6	29.88		
91 Jan.-March	5C	4.53	3.62x1	3.62	0.19	33.31
98 Feb.	6C	4.95	3.96	27.72	0.20	27.52
105	7C	4.95	3.96	27.72	0.20	27.52*
112	8C	4.95	3.96	27.72	0.20	+27.52
119 Feb.-March	9C	5.53	4.42	30.94	0.19	30.75*
126 March	10C	5.97	4.78x1	4.78	0.03	4.75
				470.00	18.42	451.58

For AWC 150 mm/m :

Net Irri. Req. = 451.58 + 60 = 511.58mm

Gross Irri. Req. = 501.76 + 67 = 568.76mm

\* No. of Irri. = 6 (27, 49, 65, 83, 100 and 118 DAS)

Net Irri. water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

For AWC 200 mm/m:

+ No. of Irri. = 4 (35, 61, 83 and 107 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.3  
Groundnut (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.00	5.60	22.40	@ 75% 13.40	9.00
11 June-July	26A	6.70	5.36	37.52	@ 70% 33.74	3.78
18 July	27A	4.90	3.92	27.44	45.21	-17.77
25	28A/B	4.90	3.92	27.44	45.21	-17.77
32	29B	4.90	3.92	27.44	45.21	-17.77
39	30B	4.90	3.92	27.44	45.21	-17.77
			3.57x6	21.42		
46 July-Aug	31B/C	4.46	4.68x1	24.68	44.50	-18.40
53 Aug.	32C	4.29	4.50	31.50	43.78	-12.28
60	33C	4.29	4.50	31.50	43.78	-12.28
67	34C	4.29	4.50	31.50	43.78	-12.28
74 Aug.-Sept.	35C	4.72	4.96	34.72	32.53	2.19
81 Sept.	36C	5.80	6.09	42.63	@ 75% 22.40	20.23
			6.09x5	30.45		
88	37C/D	5.80	4.06x2	8.12	22.40	16.17
95	38D	5.80	4.06	28.42	22.40	6.02
102	39D	5.80	4.06	28.42	22.40	6.02
109 October	40D	4.94	3.46	24.22	@ 80% 2.71	21.51
116	41D	4.94	3.46	24.22	2.71	21.51*
123	42D	4.94	2.46x4	13.84	1.55	+12.29
				525.32	406.60	118.72

For AWC 150 mm/m :

Net Irri. Req. = 118.72 + 60 = 178.72mm

Gross Irri. Req. = 131.91 + 67 = 198.91mm

\* No. of Irri. = 1 (110 DAS)

Net Irri. water applied = 75 + 60 = 135mm

Gross Irri. water applied = 83 x 67 = 150mm

For AWC 200 mm/m:

+ No. of Irri. = 1 (118 DAS)

Net Irri. water applied = 100 + 60 = 160mm

Gross Irri. water applied = 111 + 67 = 178mm

APPENDIX 4.1.3  
Cotton (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.00	3.15	12.60 @ 75%	13.40	-0.80
11 June-July	26A	6.70	3.02	21.14 @ 70%	33.74	-12.60
18 July	27A	4.90	2.21	15.47	45.21	-29.74
25	28A	4.90	2.21	15.47	45.21	-29.74
			2.21x5	11.05		
32	29A/B	4.90	2.74x2	5.48	45.21	-29.74
39	30B	4.90	2.74	19.18	45.21	-26.03
46 July-Aug	31B	4.46	2.50	17.50	44.50	-27.00
53 Aug.	32B	4.29	2.40	16.80	43.78	-26.98
60	33B	4.29	2.40	16.80	43.78	-26.98
67	34B	4.29	2.40	16.80	43.78	-26.98
74 Aug.-Sept.	35B	4.72	2.64	18.48	32.53	-14.05
			3.25x6	19.50		
81 Sept.	36B/C	5.80	6.96x1	6.96 @ 75%	22.40	4.06
88	37C	5.80	6.96	48.72	22.40	26.32
95	38C	5.80	6.96	48.72	22.40	26.32
102	39C	5.80	6.96	48.72	22.40	26.32*
109 October	40C	4.94	5.92	41.44 @ 80%	2.71	+38.73
116	41C	4.94	5.92	41.44	2.71	38.73*
123	42C	4.94	5.92	41.44	2.71	+38.73
130	43C	4.94	5.92	41.44	2.71	38.73*
137 Oct.-Nov.	44C	4.76	5.72	40.04	2.66	37.38
144 Nov.	45C	4.63	5.56	38.92	2.61	+33.76*
			5.56x6	33.36		
151	46C/D	4.63	3.01x1	3.01	2.61	33.76
158	47D	4.63	3.01	21.07	2.61	18.46
165	48D	4.39	2.85	19.95	2.11	17.84
172	49D	3.77	2.45	17.15	1.63	+15.52*
179	50D	3.77	2.45	17.15	1.63	15.52
186	51D	3.77	2.45	17.15	1.63	15.52
194	52D	3.77	2.45	19.60	1.86	17.74
201	1C	3.97	2.58	18.06	0.18	17.88*
208	2C	3.97	2.58	18.06	0.18	17.88
215	3C	3.97	2.58x2	5.16	0.05	5.11
				793.83	306.97	486.86

For AWC 150 mm/m : Net Irri. Req. = 486.86 + 60 = 546.86mm

Gross Irri. Req. = 540.96 + 67 = 607.96mm

\* No. of Irri. = 6 (100, 114, 128, 142, 169 and 196 DAS)

Net Irri. water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

For AWC 200 mm/m: +No. of Irri. = 4 (105, 123, 141, and 172 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.4  
Wheat(Rabi)

AWC : 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc <—mm/d—>	ETc	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 Nov.	45A	4.90	2.94	20.58	2.24	18.34
14	46A	4.90	2.94	20.58	2.24	18.34
			2.94x1	2.94		
21	47A/B	4.90	3.92x6	23.52	2.24	24.22
28 Nov.-Dec.	48B	4.67	3.74	26.18	1.29	24.89
35 Dec.	49B	4.10	3.28	22.96	0.36	22.60*
			3.28x5	16.40		
42	50B/C	4.10	4.51x2	9.02	0.36	25.06
49	51C	4.10	4.51	31.57	0.36	31.21
57	52C	4.10	4.51	36.08	0.41	35.67*
64 January	1C	4.16	4.58	32.06	0.0	32.06
71 January	2C	4.16	4.58	32.06	0.0	32.06
78	3C	4.16	4.58	32.06	0.0	32.06*
85	4C	4.16	4.58	32.06	0.0	32.06
			5.16x5	25.80		
92 Jan.-Feb.	5C/D	4.69	3.75x2	7.50	0.09	33.21
99 Feb.	6D	5.09	4.07	28.49	0.20	28.29
106	7D	5.09	4.07	28.49	0.20	28.29*
113	8D	5.09	4.07	28.49	0.20	28.29
120 Feb.-March	9D	5.89	4.71	32.97	0.09	32.88
				489.81	10.28	479.53

For AWC 200 mm/m :

Net Irri. Req. = 479.53 + 60 = 539.53mm

Gross Irri. Req. = 532.81 + 67 = 599.81mm

\* No. of Irri. = 4 (32, 56, 78, 100 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.4  
Pearl millet (Kharif)

AWC : 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	5.60	4.48	17.92 @ 75%	11.30	6.62
11 June-July	26A	5.47	4.37	30.59 @ 70%	28.52	2.07
			3.74x4	14.96		
18 July	27A/B	4.68	3.74x3	11.22	38.25	-12.07
25	28B	4.68	3.74	26.18	38.25	-12.07
32	29B	4.68	3.74	26.18	38.25	-12.07
39	30B	4.68	3.74	26.18	38.25	-12.07
			3.76x1	3.76		
46 July-Aug	31B/C	4.70	4.94x6	29.64	42.52	-9.12
53 Aug.	32C	4.71	4.95	34.65	46.79	-12.14
60	33C	4.71	4.95	34.65	46.79	-12.14
67	34C	4.71	4.95	34.65	46.79	-12.14
44 Aug.-Sept.	35C	4.84	5.08	35.56	35.99	-0.43
			5.42x6	32.52		
81 Sept.	36C/D	5.17	4.65x1	4.65 @ 75%	26.60	10.57
88	37D	5.17	4.65	32.55	26.60	5.95
95	38D	5.17	4.65	32.55	26.60	5.95
102	39D	5.17	4.65	32.55	26.60	5.95
109 October	40D	5.55	4.99	34.93 @ 80%	6.50	28.43
116	41D	5.55	4.99x1	4.99	0.93	4.06
				500.88	431.28	69.60

For AWC 150 mm/m :

Net Irri. Req. = 69.60 + 60 = 129.60mm

Gross Irri. Req. = 77.33 + 67 = 144.33mm

No irrigation required

APPENDIX 4.1.4  
Cotton (Kharif)

AWC : 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
4 June	25A	5.60	2.52	10.08 @ 75%	11.30	-1.22
11 June-July	26A	5.47	2.46	17.22 @ 70%	28.52	-11.30
18 July	27A	4.68	2.10	14.70	38.25	-23.55
25	28A	4.68	2.10	14.70	38.25	-23.55
			2.10x5	10.50		
32	29A/B	4.68	2.62x2	5.24	38.25	-22.51
39	30B	4.68	2.62	18.34	38.25	-19.91
46 July-Aug	31B	4.70	2.63	18.42	42.52	-24.10
53 Aug.	32B	4.71	2.64	18.46	46.79	-28.33
60	33B	4.71	2.64	18.46	46.79	-28.33
67	34B	4.71	2.64	18.46	46.79	-28.33
74 Aug.-Sept.	35B	4.84	2.71	18.97	35.99	-17.02
			2.89x6	17.34		
81 Sept.	36B/C	5.17	6.20x1	6.20 @75%	26.60	-3.06
88	37C	5.17	6.20	43.40	26.60	16.80
95	38C	5.17	6.20	43.40	26.60	16.80
102	39C	5.17	6.20	43.40	26.60	16.80
109 October	40C	5.55	6.66	46.61 @80%	6.50	40.11
116	41C	5.55	6.66	46.61	6.50	40.11*
123	42C	5.55	6.66	46.61	6.50	40.11
130	43C	5.55	6.66	46.61	6.50	40.11
137 Oct.-Nov.	44C	5.18	6.21	43.47	4.41	39.06*
144 Nov.	45C	4.90	5.88	41.16	2.24	38.92
			5.88x6	35.28		
151	46C/D	4.90	3.19x1	3.19	2.24	36.23
158	47D	4.90	3.19	22.33	2.24	20.09*
165 Nov.-Dec.	48D	4.67	3.04	21.28	1.29	19.99
172 Dec.	49D	4.10	2.66	18.62	0.36	18.26
179	50D	4.10	2.66	18.62	0.36	18.26
186	51D	4.10	2.66	18.62	0.36	18.26*
193	52D	4.10	2.66	21.28	0.41	20.87
200 Jan.	1D	4.16	2.70	18.90	0.0	18.90
207	2D	4.16	2.70	18.90	0.0	18.90
214	3D	4.16	2.70x3	8.10	0.0	8.10
				813.48	326.80	486.68

For AWC 150 mm/m :

Net Irri. Req. = 486.68 + 60 = 526.68mm

Gross Irri. Req. = 540.76 + 67 = 607.76mm

\* No. of Irri. = 4 (111, 135, 153, 185 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.4  
Pigeonpea (Kharif)

AWC : 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.
2 July	28A	4.68	2.34	4.68 @70%	10.93	-6.25
9	29A	4.68	2.34	16.38	38.25	-21.87
16	30A	4.68	2.34	16.38	38.25	-21.87
23 July-Aug.	31A	4.70	2.35	16.45	42.52	-26.07
30 August	32A	4.71	2.36	16.52	46.79	-30.27
37	33B	4.71	3.58	25.06	46.79	-21.73
44	34B	4.71	3.58	25.06	46.79	-21.71
51 Aug.-Sep.	35B	4.84	3.68	25.76	35.99	-10.23
58 September	36B	5.17	3.93	27.51 @75%	26.60	0.91
65	37B	5.17	3.93	27.51	26.60	0.91
72 Aug.-Sept.	38B	5.17	3.93	27.51	26.60	0.91
79	39B	5.17	3.93	27.51	26.60	0.91
			4.22x1	4.22		
86 Oct.	40B/C	5.55	6.66x1	39.96 @80%	6.50	37.68
93	41C	5.55	6.66	46.62	6.50	40.12
100	42C	5.55	6.66	46.62	6.50	40.12*
107	43C	5.55	6.66	46.62	6.50	40.12
114 Oct.-Nov.	44C	5.18	6.22	43.54	4.41	39.13*
121 November	45C	4.90	5.88	41.16	2.24	38.92
128	46C	4.90	5.88	41.16	2.24	38.92
135	47C	4.90	5.88	41.16	2.24	38.92*
			5.60x5	28.00		
142 Nov.-Dec.	48C/D	4.67	3.27x2	6.54	1.29	33.25
149 December	49D	4.10	2.87	20.08	0.36	19.72
156	50D	4.10	2.87	20.08	0.36	19.72
163	51D	4.10	2.87	20.08	0.36	19.72*
171	52D	4.10	2.87	22.94	0.41	22.53
178 January	1D	4.16	2.91	20.39	0.0	20.39
185	2D	4.16	2.91	20.39	0.0	20.39
192	3D	4.16	2.91	20.39	0.0	20.39
199	4D	4.16	2.91	20.39	0.0	20.39*
206 Jan.-Feb.	5D	4.69	3.28	22.98	0.09	22.89
213 Feb.	6D	5.09	3.56x4	14.24	0.11	14.13
				843.89	292.87	551.09

For AWC 150 mm/m :

Net Irri. Req. = 551.09 + 60 = 611.09mm

Gross Irri.Req.= 612.32 + 67 = 679.32mm

\* No.of Irri. = 5 (96, 114, 132, 159, 193 DAS)

Net Irri.water applied = 100 x 5 = 500mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.5  
Pearl millet (Summer)

AWC : 150 mm/m

LGP : 100 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain ←mm/Std.wk→	Net Irri. Req.
1 Feb.	8A	4.95	3.96	3.96	0.0	3.96
8 Feb.-March	9A	5.88	4.71	32.97	0.0	32.97
15 March	10A	5.97	4.77	33.39	0.0	33.39
22	11B	5.97	4.77	33.39	0.0	33.39*
29	12B	5.97	4.77	33.39	0.0	33.39
36 March-April	13B	6.17	4.94	34.58	0.09	34.49*
			5.89x4	23.56		
43 April	14B/C	7.37	7.74x3	23.12	0.19	46.59
50	15C	7.37	7.74	54.18	0.19	53.99*
57	16C	7.37	7.74	54.18	0.19	53.99*
64	17C	7.37	7.74	54.18	0.19	53.99*
71 April-May	18C	8.27	8.69	60.83	0.55	60.28
78 May	19C	8.26	8.67	60.69	0.90	59.79*
			8.67x2	17.34		
85	20C/D	8.26	7.43x5	37.15	0.90	53.59*
92	21D	8.26	7.43	52.01	0.90	51.11*
99 May-June	22D	7.72	6.95	48.65	12.48	36.17
106 June	23D	7.00	6.3x1	6.30	3.49	2.81
				663.97	20.07	643.90

For AWC 150 mm/m :

Net Irri. Req. = 643.90 + 60 = 703.90mm

Gross Irri. Req. = 715.44 + 67 = 782.44mm

\* No. of Irri. = 8 (16, 32, 44, 54, 63, 72, 81, 91 DAS)

Net Irri. water applied = 75 x 8 = 600mm + 60 = 660mm

Gross Irri. water applied = 83 x 8 = 664mm + 67 = 731mm

APPENDIX 4.1.5  
Groundnut (Summer)

AWC : 150 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain ←mm/Std.wk→	Net Irri. Req.
1 January	3A	3.97	3.18x1	3.18	0.0	3.18
8	4A	3.97	3.18	22.26	0.0	22.26
15 Jan.-Feb.	5A	4.53	3.62	25.34	0.0	25.34
			3.96x5	19.80		
22 Feb.	6A/B	4.95	3.96x2	7.92	0.0	27.72*
29	7B	4.95	3.96	27.72	0.0	27.72
36	8B	4.95	3.96	27.72	0.0	27.72
43 Feb.-March	9B	5.88	4.71	32.97	0.0	32.97*
			4.77x2	9.54		
50 March	10B/C	5.97	6.27x5	31.35	0.0	40.89
57	11C	5.97	6.27	43.89	0.0	43.89*
64	12C	5.97	6.27	43.89	0.0	43.89*
71 March-April	13C	6.17	6.48	45.36	0.09	45.27
78 April	14C	7.37	7.74	54.18	0.19	53.99*
85	15C	7.37	7.74	54.18	0.19	53.99*
			7.74x1	7.74		
92	16C/D	7.37	4.42x6	26.52	0.19	34.07
99	17D	7.37	4.42	30.94	0.19	30.75
106 April-May	18D	8.27	4.96	34.72	0.55	34.17*
113 May	19D	8.26	4.96x4	19.84	0.52	19.32
				569.06	1.92	567.14

For AWC 150 mm/m :

Net Irri. Req. = 567.14 + 60 = 627.14mm

Gross Irri. Req. = 630.16 + 67 = 697.16mm

\* No. of Irri. = 7 (22, 39, 53, 64, 75, 85, and 101 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

APPENDIX 4.1.5  
Wheat (Rabi)

AWC :150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
7 Nov.	45A	4.63	2.78	19.46	2.99	16.47
14	46A	4.63	2.78	19.46	2.99	16.47
			2.78x1	2.78		
21	47A/B	4.63	3.70x6	22.22	2.99	22.01
28 Nov.-Dec.	48B	4.39	3.51	24.57	1.65	22.92*
35 Dec.	49B	3.77	3.02	21.14	0.36	20.78
			3.02x5	15.10		
42	50B/C	3.77	4.15x2	8.30	0.36	23.04
49	51C	3.77	4.15	29.05	0.36	28.69*
57	52C	3.77	4.15	33.20	0.36	32.84
64 January	1C	3.97	4.36	30.52	0.0	30.52*
71	2C	3.97	4.36	30.52	0.0	30.52
78	3C	3.97	4.36	30.52	0.0	30.52
85	4C	3.97	4.36	30.52	0.0	30.52*
			4.98x5	24.90		
92 Jan.-Feb.	5C/D	4.53	3.62x2	7.24	0.0	32.14
99 February	6D	4.95	3.96	27.72	0.0	27.72*
106	7D	4.95	3.96	27.72	0.0	27.72
113	8D	4.95	3.96	27.72	0.0	27.72
120 Feb.March	9D	5.88	4.71	32.97	0.0	32.97*
				465.63	12.06	453.57

For AWC 150 mm/m :

Net Irri. Req. = 453.57 + 60 = 513.57mm

Gross Irri.Req.= 503.97 + 67 = 570.97mm

\* No.of Irri. = 6 (22, 44, 61, 79, 96, 114 DAS)

Net Irri.water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.5  
Pearl millet (Kharif)

AWC : 150 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.00	5.6	22.40	@75% 13.10	9.30
11 June-July	26A	6.70	5.36	37.52	@70% 32.69	4.83
			3.92x4	15.68		
18 July	27A/B	4.90	3.92x3	11.76	43.63	-16.19
25	28B	4.90	3.92	27.44	43.63	-16.19
32	29B	4.90	3.92	27.44	43.63	-16.19
39	30B	4.90	3.92	27.44	43.63	-16.19
			3.57x1	3.57		
46 July-Aug	31B/C	4.47	4.69x6	28.14	47.34	-15.63
53 Aug.	32C	4.29	4.50	31.50	51.05	-19.55
60	33C	4.29	4.50	31.50	51.05	-19.55
67	34C	4.29	4.50	31.50	51.05	-19.55
74 Aug.-Sept.	35C	4.72	4.96	34.72	38.80	-4.08
			6.09x6	36.54		
81 Sept.	36C/D	5.80	5.22x1	5.22	@75% 28.00	13.76
88	37D	5.80	5.22	36.54	28.00	8.54
95	38D	5.80	5.22	36.54	28.00	8.54
102	39D	5.80	5.22	36.54	28.00	8.54
109 October	40D	4.94	4.44	31.08	@80% 2.89	28.19
116	41D	4.94	4.44x1	4.44	0.41	4.03
				517.51	431.78	85.73

Net Irri. Req. = 85.73 + 60 = 145.73mm

Gross Irri. Req. = 95.26 + 67 = 162.26mm

No. of Irri. = Nil

APPENDIX 4.1.5  
Groundnut (Kharif)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.00	5.6	22.40	@75% 13.10	9.30
11 June-July	26A	6.70	5.36	37.52	@70% 32.69	4.83
18 July	27A	4.90	3.92	27.44	43.63	-16.19
			3.92x2	7.84		
25	28A/B	4.90	3.92x5	16.60	43.63	-16.19
32	29B	4.90	3.92	27.44	43.63	-16.19
39	30B	4.90	3.92	27.44	43.63	-16.19
			3.57x6	21.42		
46 July-Aug	31B/C	4.47	4.69x1	4.69	47.34	-21.23
53 Aug.	32C	4.29	4.50	31.50	51.05	-19.55
60	33C	4.29	4.50	31.50	51.05	-19.55
67	34C	4.29	4.50	31.50	51.05	-19.55
74 Aug.-Sept.	35C	4.72	4.96	34.72	38.80	-4.08
81 Sept.	36C	5.80	6.09	42.63	@75% 28.00	14.63
			6.09x5	30.45		
88	37C/D	5.80	3.48x2	6.96	28.00	9.41
95	38D	5.80	3.48	24.36	28.00	-3.64
102	39D	5.80	3.48	24.36	28.00	-3.64
109 October	40D	4.94	2.96	20.72	@80% 2.89	17.83
116	41D	4.94	2.96	20.72	2.89	17.83
123	42D	4.94	2.96	11.84	1.65	10.19
				507.05	423.03	84.02

Net Irri. Req. = 84.02 + 60 = 144.02mm

Gross Irri. Req. = 93.36 + 67 = 160.36mm

No. of Irri. = Nil

APPENDIX 4.1.5  
Cotton (Kharif)

AWC : 150 mm/m

LGP : 210 Days

Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.
4 June	25A	7.00	3.15	12.60	@75% 13.10	-0.50
11 June-July	26A	6.70	3.02	21.14	@70% 32.69	-11.55
18 July	27A	4.90	2.21	15.47	@70% 43.63	-28.16
25	28A	4.90	2.21	15.47	43.63	-28.16
			2.21x5	11.05		
32	29A/B	4.90	2.74x2	05.48	43.63	-27.10
39	30B	4.90	2.74	19.18	43.63	-24.45
46 July-Aug	31B	4.47	2.50	17.50	47.34	-29.84
53 Aug.	32B	4.29	2.40	16.80	51.05	-34.25
60	33B	4.29	2.40	16.80	51.05	-34.25
67	34B	4.29	2.40	16.80	51.05	-34.25
74 Aug.-Sept.	35B	4.72	2.64	18.48	38.80	-20.32
			3.25x6	19.50		
81 Sept.	36B/C	5.80	6.96x1	6.96	@75% 28.00	-1.54
88	37C	5.80	6.96	48.72	28.00	20.72
95	38C	5.80	6.96	48.72	28.00	20.72
102	39C	5.80	6.96	48.72	28.00	20.72
109 October	40C	4.94	5.92	41.44	@80% 2.89	38.55*
116	41C	4.94	5.92	41.44	2.89	38.55
123	42C	4.94	5.92	41.44	2.89	38.55*
130	43C	4.94	5.92	41.44	2.89	38.55
137 Oct.-Nov.	44C	4.76	5.72	40.04	2.94	37.10*
144 Nov.	45C	4.63	5.56	38.92	2.99	35.93
			5.56x6	33.36		
151	46C/D	4.63	3.01x1	3.01	2.99	33.38*
158	47D	4.63	3.01	21.07	2.99	18.08
165 Nov.-Dec.	48D	4.39	2.85	19.95	1.65	18.30
172 Dec.	49D	3.77	2.45	17.15	0.36	16.79*
179	50D	3.77	2.45	17.15	0.36	16.79
186	51D	3.77	2.45	17.15	0.36	16.79
194	52D	3.77	2.45	19.60	0.36	19.24
201 Jan.	1D	3.97	2.58	18.06	0.00	18.06
208	2D	3.97	2.58	18.06	0.00	18.06*
215	3D	3.97	2.58x2	5.16	0.00	5.16
				793.83	323.79	470.04

Net Irri. Req. = 470.04 + 60 = 530.04mm

Gross Irri.Req.= 522.27 + 67 = 589.27mm

\* No.of Irri. = 6 (104, 118, 132, 146, 172, 202 DAS)

Net Irri.water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.6  
Pearl millet(Summer)

AWC : 150 mm/m

LGP : 100 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
1 Feb.	8A	4.95	3.96	3.96	0.03	3.93
8 Feb.-March	9A	5.55	4.44	31.08	0.19	30.89
15 March	10A	6.00	4.80	33.60	0.18	33.42*
22	11B	6.00	4.80	33.60	0.18	33.42
29	12B	6.00	4.80	33.60	0.18	33.42
36 March-April	13B	6.20	4.96	34.72	0.09	34.63*
			5.89x4	23.56		
43 April	14B/C	7.37	7.74x3	23.22	0.0	46.78
50	15C	7.37	7.74	54.18	0.0	54.18*
57	16C	7.37	7.74	54.18	0.0	54.18*
64	17C	7.37	7.74	54.18	0.0	54.18*
71 April-May	18C	8.13	8.54	59.78	1.10	58.68
78 May	19C	8.26	8.67	60.69	2.17	58.52*
			8.67x2	17.34		
85	20C/D	8.26	7.43x5	37.15	2.17	52.32*
92	21D	8.26	7.43	52.01	2.17	49.84*
99 May-June	22D	7.72	6.95	48.65	7.34	41.31
106 June	23D	7.00	6.30x1	6.30	1.81	4.49
				661.80	17.61	644.19

For AWC 150 mm/m :

Net Irri. Req. = 644.19 + 60 = 704.19mm

Gross Irri.Req.= 715.77 + 67 = 782.77mm

\* No.of Irri. = 8 (16, 32, 44, 54, 64, 72, 81, 92 DAS)

Net Irri.water applied = 75 x 8 = 600mm + 60 = 660mm

Gross Irri. water applied = 83 x 8 = 664mm + 67 = 731mm

APPENDIX 4.1.6  
Mustard (Rabi)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff. Rain <—mm/Std. wk—>	Net Irri. Req.
7 October	42A	4.94	2.96	20.72	0.90	19.82
14	43A	4.94	2.96	20.72	0.90	19.82
			2.86x6	17.16		
21 Oct.-Nov.	44A/B	4.76	3.81x1	3.81	0.92	20.05
28 November	45B	4.63	3.71	25.97	0.93	25.04*
35	46B	4.63	3.71	25.97	0.93	25.04
42	47B	4.63	3.71	25.97	0.93	25.04
49 Nov.-Dec.	48B	4.39	3.51	24.57	0.55	24.02*
			3.02x1	3.02		
56 Dec.	49B/C	3.77	3.96x6	23.76	0.18	26.60
63	50C	3.77	3.96	27.72	0.18	27.54
70	51C	3.77	3.96	27.72	0.18	27.54*
78	52C	3.77	3.96	31.68	0.21	31.47
85 January	1C	3.97	4.17	29.19	0.18	29.01*
92	2C	3.57	4.17	29.19	0.18	29.01
			4.17x3	12.51		
99	3C/D	3.97	3.57x4	14.28	0.18	26.61
106	4D	3.97	3.57	24.99	0.18	24.81*
113 Jan.-Feb.	5D	4.53	4.07	28.49	0.19	28.30
120 Feb.	6D	4.95	4.45	31.15	0.20	30.95*
				448.59	7.92	440.67

For AWC 150 mm/m :

Net Irri. Req. = 440.67 + 60 = 500.67mm

Gross Irri. Req. = 489.63 + 67 = 556.63mm

\* No. of Irri. = 6 (25, 46, 66, 84, 103, 115 DAS)

Net Irri. water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.6  
Wheat (Rabi)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
7 Nov.	45A	4.63	2.78	19.46	0.93	18.53
14	46A	4.63	2.78	19.46	0.93	18.53
			2.78x1	2.78		
21	47A/B	4.63	3.70x6	22.20	0.93	24.05
28 Nov.-Dec.	48B	4.39	3.51	24.57	0.55	24.02*
35 Dec.	49B	3.77	3.02	21.14	0.18	20.96
			3.02x5	15.10		
42	50B/C	3.77	4.15x2	8.30	0.18	23.22
49	51C	3.77	4.15	29.05	0.18	28.87*
57	52C	3.77	4.15	33.20	0.21	32.99
64 January	1C	3.97	4.37	30.59	0.18	30.41*
71	2C	3.97	4.37	30.59	0.18	30.41
78	3C	3.97	4.37	30.59	0.18	30.41
85	4C	3.97	4.37	30.59	0.18	30.41*
			4.98x5	24.90		
92 Jan.-Feb.	5C/D	4.53	3.62x2	7.24	0.19	31.95
99 February	6D	4.95	3.96	27.72	0.20	27.52*
106	7D	4.95	3.96	27.72	0.20	27.52
113	8D	4.95	3.96	27.72	0.20	27.52
120 Feb.March	9D	5.55	4.44	31.08	0.38	30.70*
				464.00	5.98	458.02

Net Irri. Req. = 458.02 + 60 = 518.02mm

Gross Irri.Req. = 508.91 + 67 = 575.91mm

\* No.of Irri. = 6 (25, 47, 64, 81, 98, 117, DAS)

Net Irri.water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.6  
Pearlmillet (Kharif)

AWC : 150 mm/m

LGP : 110 Days

Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.	
4 June	25A	7.00	5.6	22.40	@80%	7.25	15.15
11 June-July	26A	6.70	5.36	37.52	@70%	19.36	18.16
			3.92x4	15.68			
18 July	27A/B	4.90	3.92x3	11.76		27.35	0.09
25	28/B	4.90	3.92	27.44		27.35	0.09
32	29B	4.90	3.92	27.44		27.35	0.09
39	30B	4.90	3.92	27.44		27.35	0.09*
			3.57x1	3.57			
46 July-Aug	31B/C	4.47	4.69x6	28.14		29.56	2.15
53 Aug.	32C	4.29	4.50	31.50		31.77	-0.27
60	33C	4.29	4.50	31.50		31.77	-0.27
67	34C	4.29	4.50	31.50		31.77	-0.27
74 Aug.-Sept.	35C	4.82	5.06	35.42		27.63	7.79
			6.09x6	36.54			
81 Sept.	36C/D	5.80	5.22x1	5.22	@75%	25.03	16.73
88	37D	5.80	5.22	36.54		25.03	11.51
95	38D	5.80	5.22	36.54		25.03	11.51
102	39D	5.80	5.22	36.54		25.03	11.51
109 October	40D	4.94	4.44	31.08	@80%	0.90	30.18
116	41D	4.94	4.44x1	4.44		0.13	4.31
				518.21		388.85	129.36

Net Irri. Req. = 129.36 + 60 = 189.36mm

Gross Irri.Req.= 143.73 + 67 = 210.73mm

\* No.of Irri. = 1 (39 DAS)

Net Irri. water applied = 75 + 60 = 135mm

Gross Irri. water applied = 83 + 67 = 150mm

APPENDIX 4.1.6  
Cotton (Kharif)

AWC : 150 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.	
4 June	25A	7.00	3.15	12.60	@80%	7.25	5.35
11 June-July	26A	6.70	3.02	21.14	@70%	19.36	1.76
18 July	27A	4.90	2.21	15.47	@70%	27.35	-11.88
25	28A	4.90	2.21	15.47		27.35	-11.88
			2.21x5	11.05			
32	29A/B	4.90	2.74x2	5.48		27.35	-10.82
39	30B	4.90	2.74	19.18		27.35	-8.17
46 July-Aug	31B	4.47	2.50	17.50		29.56	-12.06
53 August	32B	4.29	2.40	16.80		31.77	-14.97
60	33B	4.29	2.40	16.80		31.77	-14.97
67	34B	4.29	2.40	16.80		31.77	-14.97
74 Aug.-Sept.	35B	4.82	2.70	18.90		27.63	-8.73
80 September	36B	5.80	3.25	22.75	@75%	25.03	-2.28
87	37C	5.80	6.96	48.72		25.03	23.69
94	38C	5.80	6.96	48.72		25.03	23.69
101	39C	5.80	6.96	48.72		25.03	23.69*
108 October	40C	4.94	5.92	41.44	@80%	0.90	40.54
115	41C	4.94	5.92	41.44		0.90	40.54*
122	42C	4.94	5.92	41.44		0.90	40.54
129	43C	4.94	5.92	41.44		0.90	40.54*
136 Oct.-Nov.	44C	4.76	5.72	40.04		0.92	39.12
143 November	45C	4.63	5.56	38.92		0.93	37.99*
150	46C	4.63	5.56	38.92		0.93	37.99
157	47D	4.63	3.01	21.07		0.93	20.14*
164 Nov.-Dec.	48D	4.39	2.85	19.95		0.55	19.40
171 December	49D	3.77	2.45	17.15		0.18	16.97
178	50D	3.77	2.45	17.15		0.18	16.97
185	51D	3.77	2.45	17.15		0.18	16.97
193	52D	3.77	2.45	19.60		0.21	19.39*
200	1D	3.97	2.58	18.06		0.18	17.88
207	2D	3.97	2.58	18.06		0.18	17.88
214	3D	3.97	2.58x3	7.74		0.08	7.66
				795.67		286.95	508.72

Net Irri. Req. = 508.72 + 60 = 568.72mm  
Gross Irri. Req. = 565.24 + 67 = 632.24mm  
\* No. of Irri. = 6 (101, 113, 126, 140, 157, 186 DAS)  
Net Irri. water applied = 75 x 6 = 450mm + 60 = 510mm  
Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.6  
Castor (Kharif)

AWC : 150 mm/m

LGP : 240 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.	
5 August	31A	4.47	3.13	15.63	@70%	31.77	-16.14
12	32A	4.29	3.00	21.02		31.77	-10.75
19	33A	4.29	3.00	21.02		31.77	-10.75
26	34A	4.29	3.00	21.02		31.77	-10.75
			3.38x4	13.52			
33 Aug.-Sept.	35A/B	4.82	3.86x3	11.58	@70%	27.63	-2.53
40 September	36B	5.80	4.64	32.48	@75%	25.02	7.46
47	37B	5.80	4.64	32.48		25.02	7.46
54	38B	5.80	4.64	32.48		25.02	7.46
61	39B	5.80	4.64	32.48		25.02	7.46
68 October	40B	4.94	3.95	27.64	@80%	0.90	26.74
75	41B	4.94	3.95	27.64		0.90	26.74
82	42B	4.94	3.95	27.64		0.90	26.74*
89	43B	4.94	3.95	27.64		0.90	26.74
			3.81x1	3.81			
96 Oct.-Nov.	44B/C	4.76	5.47x6	32.82		0.92	35.71
103 November	45C	4.63	5.33	37.31		0.93	36.38*
110	46C	4.63	5.33	37.31		0.93	36.38
117	47C	4.63	5.33	37.31		0.93	36.38*
124 Nov.-Dec.	48C	4.39	5.05	35.35		0.55	34.80
131 December	49C	3.17	4.34	30.38		0.18	30.20*
138	50C	3.17	4.34	30.38		0.18	30.20
145	51C	3.17	4.34	30.38		0.18	30.20*
153	52C	3.77	4.34	34.72		0.21	34.51
160 January	1C	3.97	4.56	31.92		0.18	31.74
167	2C	3.97	4.56	31.92		0.18	31.74*
174	3C	3.97	4.56	31.92		0.18	31.74
			4.56x6	27.36			
181	4C/D	3.97	2.78x1	2.78		0.18	29.96*
188 Jan.-Feb.	5D	4.53	3.17	22.19		0.19	22.00
195 February	6D	4.95	3.46	24.22		0.20	24.02
202	7D	4.95	3.46	24.22		0.20	24.02*
209	8D	4.95	3.46	24.22		0.20	24.02
216 Feb.-March	9D	5.55	3.88	27.16		0.19	26.97
223 March	10D	6.00	4.20	29.40		0.18	29.22*
230	11D	6.00	4.20	29.40		0.18	29.22
237	12D	6.00	4.20	29.40		0.18	29.22*
244 March-April	13D	6.20	4.34x3	13.02		0.04	12.98
					1003.17	214.76	788.41

Net Irri. Req. = 788.41 + 60 = 848.41mm

Gross Irri. Req. = 876.01 + 67 = 943.01mm

\* No. of Irri. = 10 (80, 98, 113, 128, 145, 161, 177, 197, 219, 237 DAS)

Net Irri. water applied = 75 x 10 = 750mm + 60 = 810mm

Gross Irri. water applied = 83 x 10 = 830mm + 67 = 897mm

APPENDIX 4.1.7  
Pearl millet (Summer)

AWC : 75 mm/m

LGP : 100 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
1 Feb.	8A	4.81	3.85	3.85	0.0	3.85
8 Feb.-March	9A	5.45	4.36	30.52	0.0	30.52*
15 March	10A	5.94	4.75	33.25	0.0	33.25*
22	11B	5.94	4.75	33.25	0.0	33.25*
29	12B	5.94	4.75	33.25	0.0	33.25*
36 March-April	13B	6.10	4.88	34.16	1.19	32.97*
			5.65x4	22.60		
43 April	14B/C	7.07	7.42x3	22.26	2.43	42.43*
50	15C	7.07	7.42	51.94	2.43	49.51*
57	16C	7.07	7.42	51.94	2.43	49.51**
64	17C	7.07	7.42	51.94	2.43	49.51**
71 April-May	18C	7.76	8.15	57.05	2.30	54.75*
78 May	19C	7.87	8.27	57.89	2.17	55.72**
			8.27x2	16.54		
85	20C/D	7.87	7.08x5	35.40	2.17	49.77*
92	21D	7.87	7.08	49.56	2.17	47.39*
99 May-June	22D	7.60	6.84	47.88	5.42	42.46*
106 June	23D	7.23	6.51	6.51x1	1.25	5.26
				639.79	26.39	613.40

Net Irri. Req. = 613.40 + 60 = 673.40mm

Gross Irri.Req.= 681.56 + 67 = 748.56mm

\*No.of Irri. = 15 (8,22,29,36,42,47,53,58,62,68,73,76,83,90 and 96DAS)

Net Irri.water applied = 15 x 37.5 = 562.5 + 60 = 622.5 mm

Gross Irri. water applied = 15 x 42 = 630mm + 67 = 707mm

APPENDIX 4.1.7  
Mustard (Rabi)

AWC : 75 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 October	42A	5.10	3.06	21.42	1.99	19.43
14	43A	5.10	3.06	21.42	1.99	19.43*
			2.72x6	16.32		
21 Oct.-Nov.	44A/B	4.53	3.62x1	3.62	2.57	17.37
28 November	45B	4.10	3.28	22.96	3.17	19.79*
35	46B	4.10	3.28	22.96	3.17	19.79
42	47B	4.10	3.28	22.96	3.17	19.79*
49 Nov.-Dec.	48B	3.86	3.09	21.63	1.56	20.07
			2.61x1	2.61		
56 December	49B/C	3.26	3.42x6	20.52	0.0	23.13*
63	50C	3.26	3.42	23.94	0.0	23.94
70	51C	3.26	3.42	23.94	0.0	23.94*
78	52C	3.26	3.42	27.36	0.0	27.36*
85 January	1C	3.61	3.79	26.53	0.90	25.63
92	2C	3.61	3.79	26.53	0.90	25.63
			3.79x3	11.37		
99	3C/D	3.61	3.25x4	13.00	0.90	23.47*
106	4D	3.61	3.25	22.75	0.90	21.85
113 Jan.-Feb.	5D	4.29	3.86	27.02	0.47	26.55*
120 Feb.	6D	4.81	4.33	30.31	0.0	30.31*
				409.17	21.69	387.48

Net Irri. Req. = 387.48 + 60 = 447.48mm

Gross Irri. Req. = 430.53 + 67 = 497.53mm

\* No. of Irri. = 10 (14, 28, 41, 53, 64, 75, 86, 96, 108 and 117 DAS)

Net Irri. water applied = 37.5 x 10 = 375.00 + 60 = 435mm

Gross Irri. water applied = 42.0 x 10 = 420.00 + 67 = 487mm

APPENDIX 4.1.7  
Wheat (Rabi)

AWC : 75 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain ←mm/Std.wk→	Net Irri. Req.
7 Nov.	45A	4.10	2.46	17.22	3.17	14.05
14	46A	4.10	2.46	17.22	3.17	14.05
			2.46x1	2.46		
21	47A/B	4.10	3.28x6	19.68	3.17	18.97*
28 Nov.-Dec.	48B	3.86	3.09	21.63	1.56	20.07
35 December	49B	3.26	2.61	18.27	0.0	18.27*
			2.61x5	13.05		
42	50B/C	3.26	3.59x2	7.02	0.0	20.07
49	51C	3.26	3.59	25.13	0.0	25.13*
57	52C	3.26	3.59	28.72	0.0	28.72*
64 January	1C	3.61	4.33	30.31	0.90	29.41*
71 January	2C	3.61	4.33	30.31	0.290	29.41*
78	3C	3.61	4.33	30.31	0.90	29.41
85	4C	3.61	4.33	30.31	0.90	29.41*
			5.15x5	25.73		
92 Jan.-March	5C/D	4.29	3.43x2	6.86	0.47	32.12*
99 Feb.	6D	4.81	3.85	26.95	0.0	26.95*
106	7D	4.81	3.85	26.95	0.0	26.95*
113	8D	4.81	3.85	26.95	0.0	26.95
120 Feb.-March	9D	5.45	4.36	30.52	0.0	30.52*
				435.60	15.14	420.46

Net Irri. Req. = 420.46 + 60 = 480.46mm

Gross Irri. Req. = 467.18 + 67 = 534.18mm

\* No. of Irri. = 11 (17,31,44,54,61,70,79,88,94,104 and 114 DAS)

Net Irri. water applied = 37.5 x 11 = 412.60 + 60 = 472.50mm

Gross Irri. water applied = 42.0 x 11 = 462.00 + 67 = 529.00mm

APPENDIX 4.1.7  
Pearlmillet (Kharif)

AWC : 75 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.
4 June	25A	7.23	5.79	23.16	@80% 5.01	18.15
11 June-July	26A	7.00	5.60	39.20	@70% 22.33	16.87*
			4.49x4	17.96		
18 July	27A/B	5.61	4.49x3	13.47	36.51	-5.08
25	28B	5.61	4.49	31.43	36.51	-5.08
32	29B	5.61	4.49	31.43	36.51	-5.08
39	30B	5.61	4.49	31.43	36.51	-5.08
			4.10x1	4.10		
46 July-Aug.	31B/C	5.13	5.39x6	32.34	30.19	6.25
53 August	32C	4.94	5.18	36.26	@75% 25.57	10.69
60	33C	4.94	5.18	36.26	25.57	10.69
67	34C	4.94	5.18	36.26	25.57	10.69*
74 Aug.-Sept.	35C	5.14	5.40	37.80	18.85	18.85
			5.95x6	35.70		
81 September	36C/D	5.67	5.10x1	5.10	@80% 12.69	28.11*
88	37D	5.67	5.10	35.70	12.69	23.01
95	38D	5.67	5.10	35.70	12.69	23.01*
102	39D	5.67	5.10	35.70	12.69	23.01*
109 October	40D	5.10	4.59	32.13	1.99	30.14
116	41D	5.10	4.59x1	4.59	0.28	4.31
				555.72	331.84	223.88

Net Irri. Req. = 223.88 + 60 = 283.88mm

Gross Irri.Req.= 248.76 + 67 = 315.76mm

\* No.of Irri. = 5 (11, 66, 78, 89 and 101 DAS)

Net Irri.water applied = 37.5 x 5 = 187.50 + 60 = 247.50 mm

Gross Irri. water applied = 42.0 x 5 = 210.00 + 67 = 277.00 mm

APPENDIX 4.1.7  
Cotton (Kharif)

AWC : 75 mm/m

LGP : 210 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc <—mm/d—>	ETc <—mm/d—>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 June	26A	7.00	3.15	22.05	@70% 22.33	-0.28
14 July	27A	5.61	2.52	17.64	36.51	-18.87
21	28A	5.61	2.52	17.64	36.51	-18.87
28	29A	5.61	2.52	17.64	36.51	-18.87
			2.52x2	5.04		
35	30A/B	5.61	3.14x5	15.70	36.51	-15.77
42 July-Aug.	31B	5.13	2.87	20.09	30.19	-10.10
49 August	32B	4.94	2.77	19.39	@75% 25.57	-6.18
56	33B	4.94	2.77	19.39	25.57	-6.18
63	34B	4.94	2.77	19.39	25.57	-6.18
70 Aug.-Sept.	35B	5.14	2.88	20.16	@75% 18.85	1.31
77 September	36B	5.67	3.18	22.26	@80% 12.69	9.57
			3.18x3	9.54		
84	37B/C	5.67	6.80x4	27.20	12.69	24.05*
91	38C	5.67	6.80	47.60	12.69	34.91*
98	39C	5.67	6.80	47.60	12.69	34.91
105 October	40C	5.10	6.12	42.84	1.99	40.85*
112	41C	5.10	6.12	42.84	1.99	40.85*
119	42C	5.10	6.12	42.84	1.99	40.85*
126	43C	5.10	6.12	42.84	1.99	40.85*
133 Oct.-Nov.	44C	4.53	5.44	38.08	2.57	35.51*
140 November	45C	4.10	4.92	34.44	3.17	31.27*
147	46C	4.10	4.92	34.44	3.17	31.27*
			4.92x5	24.60		
152	47C/D	4.10	2.67x2	5.34	3.17	26.77
159 Nov.-Dec.	48D	3.86	2.51	17.57	1.56	16.01*
166 December	49D	3.26	2.12	14.84	0.0	14.84
173	50D	3.26	2.12	14.84	0.0	14.84*
180	51D	3.26	2.12	14.84	0.0	14.84
188	52D	3.26	2.12	16.96	0.0	14.84
195 January	1D	3.61	2.35	16.45	0.90	15.55*
202	2D	3.61	2.35	16.45	0.90	15.55
209	3D	3.61	2.35	16.45	0.90	15.55*
216	4D	3.61	2.35x1	2.35	0.13	2.22
				787.34	270.13	517.21

Net Irri. Req. = 517.21 + 60 = 577.21mm

Gross Irri. Req. = 574.68 + 67 = 641.68mm

\* No. of Irri. = 14 (84, 91, 104, 110, 117, 123, 130, 138, 147, 156, 173, 191 and 208 DAS)

Net Irri. water applied = 37.5 x 14 = 525.00 + 60 = 585mm

Gross Irri. water applied = 14.0 x 42 = 588.00 + 67 = 655mm

APPENDIX 4.1.7  
Castor (Kharif)

AWC : 75 mm/m

LGP : 240 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
5 August	31A	5.13	3.59	17.95 @75%	18.27	-0.32
12	32A	4.94	3.46	24.22	25.57	-1.35
19	33A	4.94	3.46	24.22	25.57	-1.35
26	34A	4.94	3.46	24.22	25.57	-1.35
			3.60x4	14.44		
33 Aug.-Sept.	35A/B	5.14	4.11x3	12.33	18.85	7.92
40 September	36B	5.67	4.54	31.78 @80%	12.69	19.09
47	37B	5.67	4.54	31.78	12.69	19.09*
54	38B	5.67	4.54	31.78	12.69	19.09
61	39B	5.67	4.54	31.78	12.69	19.09*
68 October	40B	5.10	4.08	28.56	1.99	26.57*
75	41B	5.10	4.08	28.56	1.99	26.57
82	42B	5.10	4.08	28.56	1.99	26.57*
89	43B	5.10	4.08	28.56	1.99	26.57*
			3.62x1	3.62		
96 Oct.-Nov.	44B/C	4.53	5.21x6	31.26	2.57	32.31*
103 November	45C	4.10	4.72	33.04	3.17	29.87*
110	46C	4.10	4.72	33.04	3.17	29.87*
117	47C	4.10	4.72	33.04	3.17	29.87*
124 Nov.-Dec.	48C	3.86	4.44	31.08	1.56	29.52
131	49C	3.26	3.75	26.25	0.0	26.25*
138	50C	3.26	3.75	26.25	0.0	26.25*
145	51C	3.26	3.75	26.25	0.0	26.25
153	52C	3.26	3.75	30.00	0.0	30.00*
160 January	1C	3.61	4.15	29.05	0.90	28.15*
167	2C	3.61	4.15	29.05	0.90	28.15*
174	3C	3.61	4.15	29.05	0.90	28.15*
			4.15x6	24.90		
181	4C/D	3.61	2.35x1	2.35	0.90	26.35
188 Jan.-Feb.	5D	4.29	2.79	19.53	0.47	19.06*
195 February	6D	4.81	3.13	21.91	0.0	21.91
202	7D	4.81	3.13	21.91	0.0	21.91*
209	8D	4.81	3.13	21.91	0.0	21.91*
216 Feb.-March	9D	5.45	3.54	24.78	0.0	24.78*
223 March	10D	5.94	3.86	27.02	0.0	27.02
230	11D	5.94	3.86	27.02	0.0	27.02*
237	12D	5.94	3.86	27.02	0.0	27.02*
244 March-April	13D	6.10	3.97x3	11.91	0.51	11.40
				949.78	186.40	763.58

Net Irri. Req. = 763.58 + 60 = 823.58mm

Gross Irri. Req. = 848.42 + 67 = 915.42mm;

\*No. of Irri. = 21(44, 58, 68, 77, 85, 91, 100, 109, 117, 126, 136, 146, 156, 165, 174, 185, 197, 206, 216, 225, 235 DAS)

Net Irri. water applied = 37.5 x 21 = 787.5 + 60 = 847.5mm

Gross Irri. water applied = 42 x 21 = 882.0 + 67 = 949mm

APPENDIX 4.1.8  
Groundnut (Summer)

AWC : 150 and 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.
1 January	3A	3.90	3.12x1	3.12	0.03	3.09
8	4A	3.90	3.12	21.84	0.18	21.66
15 Jan.-Feb.	5A	4.44	3.55	24.85	0.28	24.57
			3.87x5	19.35		
22 Feb.	6A/B	4.84	3.87x2	7.74	0.39	26.70*
29	7B	4.84	3.87	27.09	0.39	+26.70
36	8B	4.84	3.87	27.09	0.39	26.70
43 Feb.-March	9B	5.65	4.52	31.64	0.47	31.17*
			5.01x2	10.02		
50 March	10B/C	6.26	6.57x5	32.85	0.54	+42.33
57	11C	6.26	6.57	45.99	0.54	45.45*
64	12C	6.26	6.57	45.99	0.54	45.45*
71 March-April	13C	6.41	6.73	47.11	0.28	+46.83
78 April	14C	7.30	7.67	53.69	0.0	53.69*
85	15C	7.30	7.67	53.69	0.0	+53.69*
			7.67x1	7.67		
92	16C/D	7.30	4.38x6	26.28	0.0	33.95
99	17D	7.30	4.38	30.66	0.0	+30.66*
106 April-May	18D	7.76	4.66	32.62	0.0	32.62
113 May	19D	7.84	4.70x4	18.80	0.0	18.80
				568.09	4.03	564.06

For AWC 150 mm : Net Irri. Req. = 564.06 + 60 = 624.06mm

Gross Irri.Req. = 626.73 + 67 = 693.73mm

\* No. of Irri. = 7 (22, 41, 52, 63, 73, 83 and 98 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

For AWC 200 mm/m :

+ No. of Irri. = 5 (29, 50, 66, 79 and 97 DAS)

Net Irri. water applied = 100 x 5 = 500mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.8  
Mustard (Rabi)

AWC : 150 and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 October	42A	5.58	3.35	23.45	0.90	22.55
14	43A	5.58	3.35	23.45	0.90	22.55
			3.06x6	18.36		
21 Oct.-Nov.	44A/B	5.10	4.08x1	4.08	1.65	20.75
28 November	45B	4.73	3.79	26.53	2.43	24.10*
35	46B	4.73	3.79	26.53	2.43	+24.10
42	47B	4.73	3.79	26.53	2.43	24.10
49 Nov.-Dec.	48B	4.51	3.60	25.20	1.38	23.82*
			3.15x1	3.15		
56 Dec.	49B/C	3.94	4.14x6	24.84	0.36	+27.63
63	50C	3.94	4.14	28.98	0.36	28.62
70	51C	3.94	4.14	28.98	0.36	28.62*
78	52C	3.94	4.14	33.12	0.36	+32.76
85 January	1C	3.90	4.10	28.70	0.18	28.52*
92	2C	3.90	4.10	28.70	0.18	28.52
			4.10x3	12.30		
99	3C/D	3.90	3.51x4	14.04	0.18	26.16
106	4D	3.90	3.51	24.57	0.18	+24.39*
113 Jan.-Feb.	5D	4.44	4.00	28.00	0.28	27.72
120 Feb.	6D	4.84	4.36	30.52	0.39	30.13
				460.03	14.95	445.08

For AWC 150 mm/m :

Net Irri. Req. = 445.08 + 60 = 505.08mm

Gross Irri. Req. = 494.53 + 67 = 561.53mm

\* No. of Irri. = 5 (24, 45, 64, 82, 101 DAS)

Net Irri. water applied = 75 x 5 = 375mm + 60 = 435mm

Gross Irri. water applied = 83 x 5 = 415mm + 67 = 482mm

For AWC 200 mm/m:

+ No. of Irri. = 4 (31, 52, 76, 103 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.8  
Wheat (Rabi)

8WC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
7 Nov.	45A	4.73	2.84	19.88	2.43	17.45
14	46A	4.73	2.84	19.88	2.43	17.45
			2.84x1	2.84		
21	47A/B	4.73	3.78x6	22.68	2.43	23.09
28 Nov.-Dec.	48B	4.50	3.60	25.20	1.38	23.82*
35 Dec.	49B	3.94	3.15	22.05	0.36	+21.69
			3.15x5	15.75		
42	50B/C	3.94	4.33x2	8.66	0.36	24.05
49	51C	3.94	4.33	30.31	0.36	29.95*
57	52C	3.94	4.33	34.64	0.36	34.28
64 January	1C	3.90	4.29	30.03	0.18	+29.85*
71 January	2C	3.90	4.29	30.03	0.18	29.85
78	3C	3.90	4.29	30.03	0.18	29.85
85	4C	3.90	4.29	30.03	0.18	+29.85*
			4.66x5	23.30		
92 Jan.-March	5C/D	4.44	3.55x2	7.10	0.28	30.12
99 Feb.	6D	4.84	3.87	27.09	0.39	26.70
106	7D	4.84	3.87	27.09	0.39	+26.70*
113	8D	4.84	3.87	27.09	0.39	26.70
120 Feb.-March	9D	5.65	4.52	31.64	0.47	31.17*
				465.32	12.75	452.57

For AWC 150 mm/m :

Net Irri. Req. = 452.57 + 60 = 512.57mm

Gross Irri.Req.= 502.86 + 67 = 569.86mm

\* No.of Irri. = 6 (26, 47, 64, 81, 100, 118 DAS)

Net Irri.water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

For AWC 200 mm/m:

+ No.of Irri. = 4 (34, 58, 81, 106 DAS)

Net Irri.water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.8  
Pearl millet (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
4 June	25A	7.03	5.63	39.41	@75% 12.80	26.61
11 June-July	26A	6.67	5.34	37.38	@70% 23.21	14.17
			3.62x4	14.48		
18 July	27A/B	4.52	3.62x3	10.86	25.45	-0.11
25	28B	4.52	3.62	25.34	25.45	-0.11
32	29B	4.52	3.62	25.34	25.45	-0.11
39	30B	4.52	3.62	25.34	25.45	-0.11
			3.32x1	3.32		
46 July-Aug	31B/C	4.15	4.36x6	26.16	24.74	4.74
53 Aug.	32C	4.00	4.20	29.40	24.03	5.37
60	33C	4.00	4.20	29.40	24.03	5.37
67	34C	4.00	4.20	29.40	24.03	5.37
74 Aug.-Sept.	35C	4.56	4.79	33.53	21.77	11.76
			6.27x6	37.62		
81 September	36C/D	5.97	5.37x1	5.37	@75% 20.83	22.16
88	37D	5.97	5.37	37.59	20.83	16.76
95	38D	5.97	5.37	37.59	20.83	16.76*
102	39D	5.97	5.37	37.59	20.83	+16.76
109 October	40D	5.58	5.02	35.14	@80% 0.90	34.24
116	41D	5.58	5.02x1	5.02	0.13	4.89
				525.28	340.32	184.96

For AWC 150 mm/m :

Net Irri. Req. = 184.96 + 60 = 244.96mm  
 Gross Irri. Req. = 205.51 + 67 = 272.51mm  
 \* No. of Irri. = 1 (89 DAS)  
 Net Irri. water applied = 75 + 60 = 135mm  
 Gross Irri. water applied = 83 + 67 = 648mm

For AWC 200 mm/m:

+ No. of Irri. = 1 (100 DAS)  
 Net Irri. water applied = 100 + 60 = 160mm  
 Gross Irri. water applied = 111 + 67 = 178mm

APPENDIX 4.1.8  
Groundnut (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 120 Days

Days/month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std. wk—>	Net Irri. Req.
4 June	25A	7.03	5.63	22.52	@75% 12.80	9.72
11 June-July	26A	6.67	3.34	37.38	@70% 23.21	14.17
18 July	27A	4.52	3.61	25.27	25.45	-0.18
			3.61x2	7.22		
25	28A/B	4.52	3.61x5	18.05	25.45	-0.18
32	29B	4.52	3.61	25.27	25.45	-0.18
39	30B	4.52	3.61	25.27	25.45	-0.18
			3.32x6	19.92		
46 July-Aug	31B/C	4.15	4.36x1	4.36	24.74	-0.46
53 Aug.	32C	4.00	4.20	29.40	24.03	5.37
60	33C	4.00	4.20	29.40	24.03	5.37
67	34C	4.00	4.20	29.40	24.03	5.37
74 Aug.-Sept.	35C	4.56	4.79	33.53	21.77	11.76
81 Sept.	36C	5.97	6.27	43.89	@75% 20.83	23.06
			6.27x5	31.35		
88	37C/D	5.97	3.58x2	7.16	20.83	17.68
95	38D	5.97	3.58	25.06	20.83	4.23
102	39D	5.97	3.58	25.06	20.83	4.23*
109 October	40D	5.58	3.35	23.45	@80% 0.90	+22.55
116	41D	5.58	3.35	23.45	0.90	22.55
123	42D	5.58	3.35x4	13.40	0.52	12.88
				499.81	340.87	157.76

For AWC 150 mm/m :

Net Irri. Req. = 157.76 + 60 = 217.76mm

Gross Irri. Req. = 175.29 + 67 = 242.29mm

\* No. of Irri. = 1 (98 DAS)

Net Irri. water applied = 75 x 1 = 75mm + 60 = 135mm

Gross Irri. water applied = 83 x 1 = 83mm + 67 = 150mm

For AWC 200 mm/m:

+ No. of Irri. = 1 (109 DAS)

Net Irri. water applied = 100 x 1 = 100mm + 60 = 160mm

Gross Irri. water applied = 111 x 1 = 111mm + 67 = 178mm

APPENDIX 4.1.8  
Cotton (Kharif)

AWC : 150 mm/m and 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
4 June	25A	7.03	3.16	12.64	@75% 12.80	-0.16
11 June-July	26A	6.67	3.00	21.00	@70% 23.21	-2.21
18 July	27A	4.52	2.03	14.21	25.45	-11.24
25	28A	4.52	2.03	14.21	25.45	-11.24
			2.03x5	10.15		
32	29A/B	4.52	2.53x2	5.06	25.45	-10.24
39	30B	5.52	2.53	17.71	25.45	-7.74
46 July-Aug	31B	4.15	2.32	16.24	24.74	-8.50
53 Aug.	32B	4.00	2.24	15.68	24.03	-8.35
60	33B	4.00	2.24	15.68	24.03	-8.35
67	34B	4.00	2.24	15.68	24.03	-8.35
74 Aug.-Sept.	35B	4.56	2.55	17.85	21.77	-3.92
			3.34x6	20.04		
81 Sept.	36B/C	5.97	7.16x1	7.16	@75% 20.83	6.37
88	37C	5.97	7.16	50.12	20.83	29.29
95	38C	5.97	7.16	50.12	20.83	29.29
102	39C	5.97	7.16	50.12	20.83	29.29*
109 October	40C	5.58	6.70	46.90	@80% 0.90	+46.00
116	41C	5.58	6.70	46.90	0.90	46.00*
123	42C	5.58	6.70	46.90	0.90	+46.00*
130	43C	5.58	6.70	46.90	0.90	46.00
137 Oct.-Nov.	44C	5.10	6.11	42.77	1.65	+41.12*
144 Nov.	45C	4.73	5.68	39.79	2.43	37.33
			5.68x6	34.08		
151	46C/D	4.73	3.07x1	3.07	2.43	34.72*
158	47D	4.73	3.07x7	21.49	2.43	+19.06
165	48D	4.51	2.93	20.51	1.38	19.13
172	49D	3.94	2.56	17.92	0.36	17.56*
179	50D	3.94	2.56	17.92	0.36	17.56
186	51D	3.94	2.56	17.92	0.36	17.56
194	52D	3.94	2.56	20.48	0.36	+17.56
201	1D	3.90	2.54	17.78	0.18	17.60*
208	2D	3.90	2.54	17.78	0.18	17.60
215	3D	3.90	2.54x2	5.08	0.05	5.03
				815.27	275.20	459.77

For AWC 150 mm/m : Net Irri. Req. = 459.77 + 60 = 519.77mm

Gross Irri. Req. = 510.86 + 67 = 577.86mm

\* No. of Irri. = 7 (97, 110, 122, 134, 148, 166, 196 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

For AWC 200 mm/m: + No. of Irri. = 5 (103, 118, 134, 154, 193 DAS)

Net Irri. water applied = 100 x 5 = 500mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.8  
Castor (Kharif)

AWC : 150 and 200 mm/m

LGP : 240 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
5 August	31A	4.15	2.90	14.50	@70% 17.16	-2.66
12	32A	4.00	2.80	19.60	24.02	-4.42
19	33A	4.00	2.80	19.60	24.02	-4.42
26	34A	4.00	2.80	19.60	24.02	-4.42
			3.19x4	12.76		
33 Aug.-Sept.	35A/B	4.56	3.65x3	10.95	23.38	0.33
40 September	36B	5.97	4.77	33.39	@75% 20.83	12.56
47	37B	5.97	4.77	33.39	20.83	12.56
53	38B	5.97	4.77	33.39	20.83	12.56
60	39B	5.97	4.77	33.39	20.83	12.56
67 October	40B	5.58	4.46	31.22	@80% 0.90	30.32*
74	41B	5.58	4.46	31.22	0.90	+30.32
81	42B	5.58	4.46	31.22	0.90	30.32
88	43B	5.58	4.46	31.22	0.90	30.32*
			4.08x2	8.16		
95 Oct.-Nov.	44B/C	5.10	5.87x5	29.35	1.65	+35.86
102 November	45C	4.73	5.44	38.08	2.43	35.65*
109	46C	4.73	5.44	38.08	2.43	35.65
116	47C	4.73	5.44	38.08	2.43	+35.65*
123 Nov.-Dec.	48C	4.51	5.18	36.26	1.38	34.88
130	49C	3.94	4.53	31.71	0.36	31.35*
137	50C	3.94	4.53	31.71	0.36	+31.35
144	51C	3.94	4.53	31.71	0.36	31.35
152	52C	3.94	4.53	36.24	0.36	35.88
159 January	1C	3.90	4.49	31.43	0.18	31.25*
166	2C	3.90	4.49	31.43	0.18	+31.25
173	3C	3.90	4.49	31.43	0.18	31.25*
180	4C	3.90	4.49	31.43	0.18	+31.25*
187 Jan.-Feb.	5D	4.44	3.11	21.77	0.28	21.49
194 February	6D	4.84	3.39	23.73	0.39	23.34
201	7D	4.84	3.39	23.73	0.39	23.34*
208	8D	4.84	3.39	23.73	0.39	+23.34
215 Feb.-March	9D	5.65	3.96	27.72	0.47	27.25
222 March	10D	6.26	4.38	30.66	0.54	30.12*
230	11D	6.26	4.38	30.66	0.54	+30.12
237	12D	6.26	4.38	30.66	0.54	30.12*
245 March-April	13D	6.41	4.49x3	13.47	0.12	13.35
				1026.68	199.74	811.02

For 150 AWC : Net Irri. Req. = 811.02 + 60 = 871.02mm

Gross Irri. Req. = 901.13 + 67 = 968.13mm

\* No. of Irri. = 11(67,84,99,114,129,146,162,179,201,218,235 DAS)

Net Irri. water applied = 75 x 11 = 825 + 60 = 885mm

Gross Irri. water applied = 83 x 42 = 913 + 67 = 980mm

For 200 AWC : + No. of Irri. Req. 8 (72,91,111,132,154,176,206,230 DAS)

Net Irrigation water applied : 100 x 8 = 800 + 60 = 860 mm

Gross Irrigation water applied : 111 x 8 = 111 + 67 = 955 mm

APPENDIX 4.1.9  
Groundnut (Summer)

AWC : 150 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
1 January	3A	3.65	2.92	2.92	0.0	2.92
8	4A	3.65	2.92	20.44	0.0	20.44
15 Jan.-Feb.	5A	4.17	3.34	23.38	0.0	23.38
			3.65x5	18.25		
22 Feb.	6A/B	4.56	3.65x2	7.30	0.0	25.55*
29	7B	4.56	3.65	25.55	0.0	25.55
36	8B	4.56	3.65	25.55	0.0	25.55
43 Feb.-March	9B	5.33	4.26	29.82	0.0	29.62*
			4.72x2	9.44		
50 March	10B/C	5.90	6.20x5	31.00	0.0	40.44
57	11C	5.90	6.20	43.40	0.0	43.40*
64	12C	5.90	6.20	43.40	0.0	43.40
71 March-April	13C	6.08	6.39	44.73	0.0	44.73*
78 April	14C	7.17	7.53	52.71	0.0	52.71*
85	15C	7.17	7.53	52.71	0.0	52.71
			7.53x1	7.53		
92	16C/D	7.17	4.30x6	25.80	0.0	33.33*
99	17D	7.17	4.30	30.10	0.0	30.10*
106 April-May	18D	7.41	4.45	31.15	0.0	31.15
113 May	19D	7.45	4.47x4	17.88	0.0	17.88
				543.06	0.0	543.06

For AWC 150 mm :

Net Irri. Req. = 543.06 + 60 = 603.06mm

Gross Irri. Req. = 603.67 + 67 = 670.40mm

\* No. of Irri. = 7 (20, 40, 53, 65, 76, 86 and 99 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

APPENDIX 4.1.9  
Mustard (Rabi)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 October	42A	5.64	3.39	23.73	3.07	20.66
14	43A	5.64	3.39	23.73	3.07	20.66
			3.01x3	9.03		
21 Oct.-Nov.	44A/B	5.01	4.01x4	16.04	2.11	22.96
28 November	45B	4.53	3.63	25.41	1.12	24.29*
35	46B	4.53	3.63	25.41	1.12	24.29
42	47B	4.53	3.63	25.41	1.12	24.29
49 Nov.-Dec.	48B	4.34	3.48	24.36	0.55	23.81*
			3.10x10	3.10		
56 Dec.	49B/C	3.87	4.06x6	24.36	0.0	27.46
63	50C	3.87	4.06	28.42	0.0	28.42
70	51C	3.87	4.06	28.42	0.0	28.42*
78	52C	3.87	4.06	32.48	0.0	32.48
85 January	1C	3.65	3.83	26.81	0.0	26.81*
92	2C	3.65	3.83	26.81	0.0	26.81
			3.83x3	11.49		
99	3C/D	3.65	3.29x4	13.16	0.0	24.65
106	4D	3.65	3.29	23.03	0.0	23.03*
113 Jan.-Feb.	5D	4.17	3.75	26.25	0.0	26.25
120 Feb.	6D	4.56	4.10	28.70	0.0	28.70
				446.15	12.16	433.99

For AWC 150 mm/m :

Net Irri. Req. = 433.99 + 60 = 493.99mm

Gross Irri. Req. = 482.21 + 67 = 549.21mm

\* No. of Irri. = 5 (24, 45, 64, 82, 101 DAS)

Net Irri. water applied = 75 x 5 = 375mm + 60 = 435mm

Gross Irri. water applied = 83 x 5 = 415mm + 67 = 482mm

APPENDIX 4.1.9  
Wheat (Rabi)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
7 Nov.	45A	4.53	2.72	19.04	1.12	17.92
14	46A	4.53	2.72	19.04	1.12	17.92
			2.72x1	2.72		
21	47A/B	4.53	3.62x6	21.72	1.12	23.32
28 Nov.-Dec.	48B	4.34	3.48	24.36	0.55	23.81*
35 Dec.	49B	3.87	3.10	21.70	0.0	21.70
			3.10x5	15.50		
42	50B/C	3.87	4.26x2	8.52	0.0	24.02
49	51C	3.87	4.26	29.82	0.0	29.82*
57	52C	3.87	4.26	34.08	0.0	34.08
64 January	1C	3.65	4.01	28.07	0.0	28.07*
71	2C	3.65	4.01	28.07	0.0	28.07
78	3C	3.65	4.01	28.07	0.0	28.07
85	4C	3.65	4.01	28.07	0.0	28.07*
			4.59x5	22.95		
92 Jan.-March	5C/D	4.17	3.34x2	6.68	0.0	29.63
99 Feb.	6D	4.56	3.65	25.55	0.0	25.55*
106	7D	4.56	3.65	25.55	0.0	25.55
113	8D	4.56	3.65	25.55	0.0	25.55
120 Feb.-March	9D	5.33	4.26	29.82	0.0	29.82*
				444.88	3.91	440.97

For AWC 150 mm/m :

Net Irri. Req. = 440.97 + 60 = 500.97mm

Gross Irri.Req.= 489.97 + 67 = 556.97mm

\* No.of Irri. = 6 (23, 45, 61, 80, 99, 118 DAS)

Net Irri.water applied = 75 x 6 = 450mm + 60 = 510mm

Gross Irri. water applied = 83 x 6 = 498mm + 67 = 565mm

APPENDIX 4.1.9  
Pearl millet (Kharif)

AWC : 150 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
4 June	25A	7.57	6.05	24.20	@80% 5.44	18.76
11 June-July	26A	7.24	5.79	40.53	@75% 14.11	26.42
			4.23x4	16.92		
18 July	27A/B	5.29	4.23x3	12.69	19.13	10.48
25	28B	5.29	4.23	29.61	19.13	10.48
32	29B	5.29	4.23	29.61	19.13	10.48*
39	30B	5.29	4.23	29.61	19.13	10.48
			4.10x1	4.10		
46 July-Aug	31B/C	5.13	5.39x6	32.34	19.13	17.31
53 Aug.	32C	5.06	5.32	37.24	19.13	18.11
60	33C	5.06	5.32	37.24	19.13	18.11
67	34C	5.06	5.32	37.24	19.13	18.11*
74 Aug.-Sept.	35C	5.31	5.58	39.06	@80% 13.95	25.11
			6.23x6	37.38		
81 September	36C/D	5.93	5.34x1	5.34	7.28	35.44
88	37D	5.93	5.34	37.38	7.28	30.10*
95	38D	5.93	5.34	37.38	7.28	30.10
102	39D	5.93	5.34	37.38	7.28	30.10*
109 October	40D	5.64	5.08	35.56	3.07	32.49
116	41D	5.64	5.08x1	5.08	0.44	4.64
				565.89	219.17	346.72

For AWC 150 mm/m :

Net Irri. Req. = 346.72 + 60 = 406.72mm

Gross Irri.Req.= 385.24 + 67 = 452.24mm

\* No.of Irri. = 4 (32, 64, 82, 99 DAS)

Net Irri.water applied = 75 x 4 = 300 + 60 = 360mm

Gross Irri. water applied = 83 x 4 = 332 + 67 = 399mm

APPENDIX 4.1.9  
Groundnut (Kharif)

AWC : 150 mm/m

LGP : 120 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.57	6.05	24.20	@80% 5.44	18.76
11 June-July	26A	7.24	5.79	40.53	@75% 14.11	26.42
18 July	27A	5.29	4.23	29.61	19.13	10.48
			4.23x2	8.46		
25	28A/B	5.29	4.23x5	21.15	19.13	10.48
32	29B	5.29	4.23	29.61	19.13	10.48
39	30B	5.29	4.23	29.61	19.13	10.48*
			4.10x6	24.60		
46 July-Aug	31B/C	5.13	5.39x1	5.39	19.13	10.86
53 Aug.	32C	5.06	5.32	37.24	19.13	18.11
60	33C	5.06	5.32	37.24	19.13	18.11
67	34C	5.06	5.32	37.24	19.13	18.11
74 Aug.-Sept.	35C	5.31	5.58	39.06	@80% 13.95	25.11*
81 Sept.	36C	5.93	6.23	43.61	7.28	36.33
			6.23x5	31.15		
88	37C/D	5.93	3.56x2	7.12	7.28	30.99*
95	38D	5.93	3.56	24.92	7.28	17.64
102	39D	5.93	3.56	24.92	7.28	17.64
109 October	40D	5.64	3.39	23.73	3.07	20.66
116	41D	5.64	3.39	23.73	3.07	20.66*
123	42D	5.64	3.39x4	13.56	1.75	11.81
				556.68	223.55	333.13

For AWC 150 mm/m :

Net Irri. Req. = 333.13 + 60 = 393.13mm

Gross Irri. Req. = 370.14 + 67 = 437.14mm

\* No. of Irri. = 4 (34, 69, 86, 112 DAS)

Net Irri. water applied = 75 x 4 = 300 + 60 = 360mm

Gross Irri. water applied = 83 x 4 = 332 + 67 = 399mm

APPENDIX 4.1.9  
Cotton (Kharif)

AWC : 150 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
4 June	25A	7.57	3.41	13.64 @80%	5.44	8.20
11 June-July	26A	7.24	3.26	22.82 @75%	14.11	8.71
18 July	27A	5.29	2.38	16.66	19.13	-2.47
25	28A	5.29	2.38	16.66	19.13	-2.47
			2.38x5	11.90		
32	29A/B	5.29	2.96x2	5.92	19.13	-1.31
39	30B	5.29	2.96	20.72	19.13	1.59
46 July-Aug	31B	5.13	2.87	20.09	19.13	0.96
53 Aug.	32B	5.06	2.84	19.88	19.13	0.75
60	33B	5.06	2.84	19.88	19.13	0.75
67	34B	5.06	2.84	19.88	19.13	0.75
74 Aug.-Sept.	35B	5.31	2.98	20.86@80%	13.95	6.91
			3.32x6	19.92		
81 Sept.	36B/C	5.93	7.12x1	7.12	7.28	19.76
88	37C	5.93	7.12	49.84	7.28	42.56*
95	38C	5.93	7.12	49.84	7.28	42.56
102	39C	5.93	7.12	49.84	7.28	42.56*
109 October	40C	5.64	6.77	47.39	3.07	44.32
116	41C	5.64	6.77	47.39	3.07	44.32*
123	42C	5.64	6.77	47.39	3.07	44.32
130	43C	5.64	6.77	47.39	3.07	44.32*
137 Oct.-Nov.	44C	5.01	6.01	42.07	2.11	39.96
144 Nov.	45C	4.53	5.44	38.08	1.12	36.96*
			5.44x6	32.64		
151	46C/D	4.53	2.94x1	2.94	1.12	34.46
158	47D	4.53	2.94	20.58	1.12	19.46
165 Nov.-Dec.	48D	4.34	2.82	19.64	0.55	19.19*
172 December	49D	3.87	2.52	17.64	0.0	17.64
179	50D	3.87	2.52	17.64	0.0	17.64
186	51D	3.87	2.52	17.64	0.0	17.64
194	52D	3.87	2.52	20.16	0.0	20.16*
201	1D	3.64	2.37	16.59	0.0	16.59
208	2D	3.64	2.37	16.59	0.0	16.59
215	3D	3.64	2.37x2	4.74	0.0	4.74
				842.08	277.71	564.37

For AWC 150 mm/m :

Net Irri. Req. = 564.37 + 60 = 624.37mm

Gross Irri. Req. = 627.08 + 67 = 694.08mm

\* No. of Irri. = 7 (88, 100, 112, 124, 138, 160, 189 DAS)

Net Irri. water applied = 75 x 7 = 525mm + 60 = 585mm

Gross Irri. water applied = 83 x 7 = 581mm + 67 = 648mm

APPENDIX 4.1.9  
Castor (Kharif)

AWC :150 mm/m

LGP : 240 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
5 August	31A	5.13	3.59	17.95@75%	13.67	4.28
12	32A	5.06	3.55	24.85	19.13	5.72
19	33A	5.06	3.55	24.85	19.13	5.72
26	34A	5.06	3.55	24.85	19.13	5.72
			3.72x4	14.88		
33 Aug.-Sept.	35A/B	5.31	4.25x3	12.75@80%	13.95	13.68
40 September	36B	5.93	4.75	33.25	7.28	25.97
47	37B	5.93	4.75	33.25	7.28	25.97*
54	38B	5.93	4.75	33.25	7.28	25.97
61	39B	5.93	4.75	33.25	7.28	25.97
68 October	40B	5.64	4.52	31.64	3.07	28.57*
75	41B	5.64	4.52	31.64	3.07	28.57
82	42B	5.64	4.52	31.64	3.07	28.57*
89	43B	5.64	4.52	31.64	3.07	28.57
			4.01x3	12.03		
96 Oct.-Nov.	44B/C	5.01	5.76x4	23.04	5.14	29.93
103 November	45C	4.53	5.21	36.47	1.12	35.35*
110	46C	4.53	5.21	36.47	1.12	35.35
117	47C	4.53	5.21	36.47	1.12	35.35*
124 Nov.-Dec.	48C	4.34	4.95	34.65	0.55	34.10
131 December	49C	3.87	4.45	31.15	0.0	31.15*
138	50C	3.87	4.45	31.15	0.0	31.15
145	51C	3.87	4.45	31.15	0.0	31.15
153	52C	3.87	4.45	35.60	0.0	35.60*
160 January	1C	3.65	4.19	29.33	0.0	29.33
167	2C	3.65	4.19	29.33	0.0	29.33*
174	3C	3.65	4.19	29.33	0.0	29.33
181	4C	3.65	4.19	29.33	0.0	29.33*
			4.79x1	4.79		
188 Jan.-Feb.	5C/D	4.17	2.92x6	17.52	0.0	22.31
195 February	6D	4.56	3.19	22.33	0.0	22.33
202	7D	4.56	3.19	22.33	0.0	22.33
209	8D	4.56	3.19	22.33	0.0	22.33*
216 Feb.-March	9D	5.33	3.73	26.11	0.0	26.11
223 March	10D	5.90	4.13	28.91	0.0	28.91
230	11D	5.90	4.13	28.91	0.0	28.91*
237	12D	5.90	4.13	28.91	0.0	28.91
244 March-April	13D	6.08	4.26x3	12.78	0.0	12.78
1020.11					135.46	884.65

Net Irri. Req. = 884.65 + 60 = 944.65mm

Gross Irri.Req.= 982.94 + 67 = 1049.94mm

\* No.of Irri. = 11(44,64,82,99,114,130,146,163,181,205,224 DAS)

Net Irri.water applied = 75 x 11 = 825 + 60 = 885mm

Gross Irri. water applied = 83 x 11 = 913 + 67 = 980mm

APPENDIX 4.1.10  
Pearlmillet (Summer)

AWC : 200 mm/m

LGP : 100 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	@ 80 % Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
1 Feb.	8A	4.77	3.82	3.82	0.0	3.82
8 Feb.-March	9A	5.78	4.62	32.34	0.19	32.15
15 March	10A	5.94	4.75	33.25	0.36	32.89
22	11B	5.94	4.75	33.25	0.36	32.89*
29	12B	5.94	4.75	33.25	0.36	32.89
36 March-April	13B	6.09	4.87	34.09	0.18	33.91
			5.63x4	22.52		
43 April	14B/C	7.03	7.38x3	22.14	0.0	44.66*
50	15C	7.03	7.38	51.66	0.0	51.66
57	16C	7.03	7.38	51.66	0.0	51.66*
64	17C	7.03	7.38	51.66	0.0	51.66
71 April-May	18C	7.56	7.94	55.58	0.46	55.12*
78 May	19C	7.65	8.03	56.21	0.90	55.31
			8.03x2	16.04		
85	20C/D	7.65	6.89x5	34.45	0.90	49.61*
92	21D	7.65	6.89	48.23	0.90	47.33
99 May-June	22D	7.13	6.41	44.87	11.38	33.49*
106 June	23D	6.43	5.79x1	5.79	3.17	2.62
				630.83	19.16	611.67

Net Irri. Req. = 611.67 + 60 = 671.67mm

Gross Irri.Req.= 679.63 + 67 = 746.63mm

\* No.of Irri. = 6 (22, 41, 55, 68, 81 and 97 DAS)

Net Irri.water applied = 100 x 6 = 600 + 60 = 666mm

Gross Irri. water applied = 111 x 6 = 666 + 67 = 733mm

APPENDIX 4.1.10  
Groundnut (Summer)

AWC : 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff. Rain <—mm/Std.wk—>	Net Irri.Req.
1 January	3A	3.61	2.89	2.89	0.0	2.89
8	4A	3.61	2.89	20.23	0.0	20.23
15 Jan.-Feb.	5A	4.28	3.42	23.94	0.0	23.94
			3.82x5	19.10		
22 Feb.	6A/B	4.77	3.82x2	7.64	0.0	26.74
29	7B	4.77	3.82	26.74	0.0	26.74*
36	8B	4.77	3.82	26.74	0.0	26.74
43 Feb.-March	9B	5.78	4.62	32.34	0.19	32.15
			4.75x2	9.50		
50 March	10B/C	5.94	6.24x5	31.20	0.36	40.34*
57	11C	5.94	6.24	43.68	0.36	43.32
64	12C	5.94	6.24	43.68	0.36	43.32*
71 March-April	13C	6.09	6.40	44.80	0.18	44.62
78 April	14C	7.03	7.38	51.66	0.0	51.66
85	15C	7.03	7.38	51.66	0.0	51.66*
			7.38x1	7.38		
92	16C/D	7.03	4.22x6	25.32	0.0	32.70*
99	17D	7.03	4.22	29.54	0.0	29.54
106 April-May	18D	7.56	4.53	31.71	0.46	31.25
113 May	19D	7.65	4.59x4	18.36	0.52	17.84
				548.11	2.43	545.68

Net Irri. Req. = 545.68 + 60 = 605.68mm

Gross Irri.Req.= 606.31 + 67 = 673.31mm

\* No.of Irri. = 5 (29, 50, 66, 80, 90 DAS)

Net Irri.water applied = 100 x 5 = 520mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.10  
Mustard (Rabi)

AWC : 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 October	42A	5.52	3.31	23.17	1.81	21.36
14	43A	5.52	3.31	23.17	1.81	21.36
			2.90x6	17.40		
21 Oct.-Nov.	44A/B	4.84	3.87x1	3.87	1.38	19.89
28 November	45B	4.33	3.47	24.29	0.93	23.36
35	46B	4.33	3.47	24.29	0.93	23.36*
42	47B	4.33	3.47	24.29	0.93	23.36
49 Nov.-Dec.	48B	4.22	3.38	23.66	0.55	23.11
			3.15x2	6.30		
56 Dec.	49B/C	3.94	4.14x5	20.70	0.18	26.82
63	50C	3.94	4.14	28.98	0.18	28.80*
70	51C	3.94	4.14	28.98	0.18	28.80
78	52C	3.94	4.14	33.12	0.18	32.94
85 January	1C	3.61	3.79	26.53	0.0	26.53*
92	2C	3.61	3.79	26.53	0.0	26.53
			3.79x3	11.37		
99	3C/D	3.61	3.25x4	13.00	0.0	24.37
106	4D	3.61	3.25	22.75	0.0	22.75
113 Jan.-Feb.	5D	4.28	3.85	26.95	0.0	26.95*
120 Feb.	6D	4.77	4.29	30.03	0.0	30.03
				439.38	9.06	430.32

Net Irri. Req. = 430.32 + 60 = 490.32mm

Gross Irri. Req. = 478.13 + 67 = 545.13mm

\* No. of Irri. = 4 (32, 60, 84, 112 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.10  
Wheat (Rabi)

AWC : 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 Nov.	45A	4.33	2.60	18.20	0.93	17.27
14	46A	4.33	2.60	18.20	0.93	17.27
			2.60x1	2.60		
21	47A/B	4.33	3.46x6	20.76	0.93	22.43
28 Nov.-Dec.	48B	4.22	3.38	23.66	0.55	23.11
35 Dec.	49B	3.94	3.15	22.05	0.18	21.87*
			3.15x5	15.75		
42	50B/C	3.94	4.33x2	8.66	0.18	24.23
49	51C	3.94	4.33	30.31	0.18	30.13
57	52C	3.94	4.33	34.64	0.18	34.46
64 January	1C	3.61	3.97	27.79	0.0	27.79*
71	2C	3.61	3.97	27.79	0.0	27.79
78	3C	3.61	3.97	27.79	0.0	27.79
85	4C	3.61	3.97	27.79	0.0	27.79*
			4.70x5	23.50		
92 Jan.-Feb.	5C/D	4.28	3.42x2	6.84	0.0	30.34
99 Feb.	6D	4.77	3.82	26.74	0.0	26.74
106	7D	4.77	3.82	26.74	0.0	26.74
113	8D	4.77	3.82	26.74	0.0	26.74*
120 Feb.-March	9D	5.78	4.62	32.34	0.19	32.15
				448.89	4.25	444.64

Net Irri. Req. = 444.64 + 60 = 504.64mm

Gross Irri. Req. = 494.04 + 67 = 561.04mm

\* No. of Irri. = 4 (35, 58, 84, 109 DAS)

Net Irri. water applied = 100 x 4 = 400mm + 60 = 460mm

Gross Irri. water applied = 111 x 4 = 444mm + 67 = 511mm

APPENDIX 4.1.10  
Pearl millet (Kharif)

AWC : 200 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.	
4 June	25A	6.43	5.15	20.60	@80%	12.69	7.91
11 June-July	26A	6.20	4.96	34.72	@70%	25.54	9.18
			3.82x4	15.28			
18 July	27A/B	4.77	3.82x3	11.46	@70%	31.45	-4.71
25	28B	4.77	3.82	26.74		31.45	-4.71
32	29B	4.77	3.82	26.74		31.45	-4.71
39	30B	4.77	3.82	26.74		31.45	-4.71
			3.51x1	3.51			
46 July-Aug	31B/C	4.38	4.60x6	27.60		28.14	2.97
53 Aug.	32C	4.23	4.44	31.08	@75%	26.59	4.49
60	33C	4.23	4.44	31.08		26.59	4.49
67	34C	4.23	4.44	31.08		26.59	4.49
74 Aug.-Sept.	35C	4.53	4.76	33.32	@80%	20.47	12.85
			5.57x6	33.42			
81 September	36C/D	5.30	4.77x1	4.77		12.32	25.87
88	37D	5.30	4.77	33.39		12.32	21.07
95	38D	5.30	4.77	33.39		12.32	21.07*
102	39D	5.30	4.77	33.39		12.32	21.07
109 October	40D	5.52	4.96	34.72		1.81	32.91
116	41D	5.52	4.96x1	4.96		0.26	4.70
				497.99		324.92	173.07

Net Irri. Req. = 173.07 + 60 = 233.07mm

Gross Irri. Req. = 192.30 + 67 = 259.30mm

\* No. of Irri. = 1 (89 DAS)

Net Irri. water applied = 100 + 60 = 160mm

Gross Irri. water applied = 111 + 67 = 178mm

APPENDIX 4.1.10  
Groundnut (Kharif)

AWC : 200 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	6.43	5.15	20.60	@80% 22.21	-1.61
11 June-July	26A	6.20	4.96	34.72	@70% 25.54	9.18
18 July	27A	4.77	3.82	26.74	31.45	-4.71
			3.82x2	7.64		
25	28A/B	4.77	3.82x5	19.10	31.45	-4.71
32	29B	4.77	3.82	26.74	31.45	-4.71
39	30B	4.77	3.82	26.74	31.45	-4.71
			3.51x6	21.06		
46 July-Aug	31B/C	4.38	4.60x1	4.60	28.14	-2.48
53 Aug.	32C	4.23	4.44	31.08	@75% 26.59	4.49
60	33C	4.23	4.44	31.08	26.59	4.49
67	34C	4.23	4.44	31.08	26.59	4.49
74 Aug.-Sept.	35C	4.53	4.76	33.32	@80% 20.47	12.85
81 Sept.	36C	5.30	5.57	38.99	12.32	26.67
			5.57x5	27.85		
88	37C/D	5.30	3.18x2	6.36	12.32	21.89
95	38D	5.30	3.18	22.26	12.32	9.94
102	39D	5.30	3.18	22.26	12.32	9.94
109 October	40D	5.52	3.31	23.17	1.81	21.36*
116	41D	5.52	3.31	23.17	1.81	21.36
123	42D	5.52	3.31x4	13.24	1.03	12.21
				491.80	332.93	158.87

Net Irri. Req. = 157.87 + 60 = 218.87mm

Gross Irri. Req. = 176.52 + 67 = 243.52mm

No. of Irri. = 1 (104 DAS)

Net Irri. water applied = 100 x 1 = 100mm + 60 = 160mm

Gross Irri. water applied = 111 x 1 = 111mm + 67 = 178mm

APPENDIX 4.1.10  
Cotton (Kharif)

AWC : 200 mm/m

LGP : 210 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	6.43	2.89	11.56	@80% 12.69	-1.13
11 June-July	26A	6.20	2.79	19.53	@70% 25.54	-6.01
18 July	27A	4.77	2.15	15.05	31.45	-16.40
25	28A	4.77	2.15	15.05	31.45	-16.40
			2.15x5	10.75		
32	29A/B	4.77	2.67x2	5.34	31.45	-15.36
39	30B	4.77	2.67	18.69	31.45	-12.76
46 July-Aug	31B	4.38	2.45	17.15	28.14	-10.99
53 Aug.	32B	4.23	2.37	16.59	@75% 26.59	-10.00
60	33B	4.23	2.37	16.59	26.59	-10.00
67	34B	4.23	2.37	16.59	26.59	-10.00
74 Aug.-Sept.	35B	4.53	2.54	17.78	@80% 20.47	-2.69
			2.97x6	17.82		
81 Sept.	36B/C	5.30	6.36x1	6.36	12.32	11.86
88	37C	5.30	6.36	44.52	12.32	32.20
95	38C	5.30	6.36	44.52	12.32	32.20
102	39C	5.30	6.36	44.52	12.32	32.20*
109 October	40C	5.52	6.62	46.34	1.81	44.53
116	41C	5.52	6.62	46.34	1.81	44.53*
123	42C	5.52	6.62	46.34	1.81	44.53
130	43C	5.52	6.62	46.34	1.81	44.53
137 Oct.-Nov.	44C	4.84	5.81	40.67	1.38	39.29*
143 Nov.	45C	4.33	5.20	36.40	0.93	35.47
150	46C	4.33	5.20	36.40	0.93	35.47
157	47D	4.33	2.81	19.67	0.93	18.74*
164	48D	4.22	2.74	19.18	0.55	18.63
171	49D	3.94	2.56	17.92	0.18	17.74
178	50D	3.94	2.56	17.92	0.18	17.74
185	51D	3.94	2.56	17.92	0.18	17.74
193	52D	3.94	2.56	20.48	0.18	20.30*
200	1D	3.61	2.35	16.45	0.0	16.45
207	2D	3.61	2.35	16.45	0.0	16.45
214	3D	3.61	2.35x3	7.05	0.0	7.05
				790.28	242.63	547.65

Net Irri. Req. = 547.65 + 60 = 607.65mm

Gross Irri. Req. = 608.50 + 67 = 675.50mm

\* No. of Irri. = 5 (100, 116, 131, 151, 189 DAS)

Net Irri. water applied = 100 x 5 = 500mm + 60 = 560mm

Gross Irri. water applied = 111 x 5 = 555mm + 67 = 622mm

APPENDIX 4.1.11  
Pearl millet (Summer)

AWC : 175 mm/m

LGP : 100 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
1 Feb.	8A	4.98	3.99x1	3.99	0.06	3.93
8 Feb.-March	9A	5.60	4.48	31.36	0.38	30.98
15 March	10A	6.06	4.85	33.95	0.36	33.59
22	11B	6.06	4.85	33.95	0.36	33.59*
29	12B	6.06	4.85	33.95	0.36	33.59
36 March-April	13B	6.26	5.01	35.07	0.28	34.79*
			5.95x4	23.80		
43 April	14B/C	7.43	7.80x3	23.40	0.19	47.01
50	15C	7.43	7.80	54.60	0.19	54.41*
57	16C	7.43	7.80	54.60	0.19	54.41
64	17C	7.43	7.80	54.60	0.19	54.41*
71 April-May	18C	8.14	8.55	59.85	0.64	59.21*
78 May	19C	8.26	8.67	60.69	1.08	59.61
			8.67x2	17.34		
85	20C/D	8.26	7.34x5	37.15	1.08	53.41*
92	21D	8.26	7.43	52.01	1.08	50.93*
99 May-June	22D	7.75	6.97	48.79	6.79	42.00
106 June	23D	7.07	6.36x1	6.36	1.81	4.55
				665.46	15.04	650.42

Net Irri. Req. = 650.42 + 60 = 710.42mm

Gross Irri. Req. = 722.69 + 67 = 789.69mm

\* No. of Irri. = 7 (19, 36, 48, 59, 70, 80, 92 DAS)

Net Irri. water applied = 85.7 x 7 = 612.50 + 60 = 672.50mm

Gross Irri. water applied = 97.22 x 7 = 680.54 + 67 = 747.54mm

APPENDIX 4.1.11  
Mustard (Rabi)

AWC : 175 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	@ 80 % Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
7 October	42A	5.03	3.02	21.14	0.90	20.24
14	43A	5.03	3.02	21.14	0.90	20.24
			2.91x6	17.46		
21 Oct.-Nov.	44A/B	4.84	3.87x1	3.87	1.10	20.23
28 November	45B	4.70	3.76	26.32	1.30	25.02*
35	46B	4.70	3.76	26.32	1.30	25.02
42	47B	4.70	3.76	26.32	1.30	25.02
49 Nov.-Dec.	48B	4.44	3.55	24.85	0.73	24.12
			3.02x1	3.02		
56 Dec.	49B/C	4.77	3.96x6	23.76	0.18	26.60*
63	50C	3.77	3.96	27.72	0.18	27.54
70	51C	3.77	3.96	27.72	0.18	27.54
78	52C	3.77	3.96	31.68	0.18	31.50*
85 January	1C	3.97	4.17	29.19	0.36	28.83
92	2C	3.97	4.17	29.19	0.36	28.83
			4.17x3	12.51		
99	3C/D	3.97	3.57x4	14.28	0.36	26.43*
106	4D	3.97	3.57	24.99	0.36	24.63
113 Jan.-Feb.	5D	4.55	4.09	28.63	0.38	28.25
120 Feb.	6D	4.98	4.48	31.36	0.39	30.97*
				451.47	10.46	441.01

Net Irri. Req. = 441.01 + 60 = 501.01mm

Gross Irri. Req. = 490.01 + 67 = 557.01mm

\* No. of Irri. = 5 (28, 52, 74, 95, 118 DAS)

Net Irri. water applied = 87.5 x 4 = 350 + 60 = 460mm

Gross Irri. water applied = 97.22 x 4 = 388.80 + 67 = 455.88

APPENDIX 4.1.11  
Wheat (Rabi)

AWC : 175 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> ←mm/d→	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain ←mm/Std.wk→	Net Irri. Req.
7 Nov.	45A	4.70	2.82	19.74	1.30	18.44
14	46A	4.70	2.82	19.74	1.30	18.44
			2.82x1	2.82		
21	47A/B	4.70	3.76x6	22.56	1.30	24.08
28 Nov.-Dec.	48B	4.44	3.55	24.85	0.73	24.12*
35 Dec.	49B	3.77	3.02	21.14	0.18	20.96
			3.02x5	15.10		
42	50B/C	3.77	4.15x2	8.30	0.18	23.22
49	51C	3.77	4.15	29.05	0.18	28.87
57	52C	3.77	4.15	33.20	0.18	33.02*
64 January	1C	3.97	4.36	30.52	0.36	30.16
71	2C	3.97	4.36	30.52	0.36	30.16*
78	3C	3.97	4.36	30.52	0.36	30.16
85	4C	3.97	4.36	30.52	0.36	30.16
			5.00x5	25.00		
92 Jan.-Feb.	5C/D	4.55	3.64x2	7.28	0.38	31.90*
99 Feb.	6D	4.98	3.99	27.93	0.39	27.54
106	7D	4.98	3.99	27.93	0.39	27.54
113	8D	4.98	3.99	27.93	0.39	27.54
120 Feb.-March	9D	5.60	4.48	31.36	0.38	30.98*
				466.01	8.72	457.29

Net Irri. Req. = 457.29 + 60 = 517.29mm

Gross Irri. Req. = 508.10 + 67 = 575.10mm

\* No. of Irri. = 5 (28, 51, 71, 91, 116 DAS)

Net Irri. water applied = 87.5 x 5 = 437.60 = 497.50mm

Gross Irri. water applied = 97.22 x 5 = 486.1 + 67 = 553.10mm

APPENDIX 4.1.11  
Pearl millet (Kharif)

AWC : 175 mm/m

LGP : 110 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.07	5.65	22.60	@80% 7.25	15.35
11 June-July	26A	6.76	5.41	37.87	@70% 24.18	13.69
			3.95x4	15.80		
18 July	27A/B	4.94	3.95x3	11.85	36.83	-9.18
25	28B	4.94	3.95	27.65	36.83	-9.18
32	29B	4.94	3.95	27.65	36.83	-9.18
39	30B	4.94	3.95	27.65	36.83	-9.18
			3.58x1	3.58		
46 July-Aug	31B/C	4.47	4.69x6	28.14	@75% 28.62	3.10
53 Aug.	32C	4.29	4.50	31.50	@80% 18.97	12.53
60	33C	4.29	4.50	31.50	18.97	12.53
67	34C	4.29	4.50	31.50	18.97	12.53
74 Aug.-Sept.	35C	4.73	4.97	34.79	16.71	18.08
			6.12x6	36.72		
81 September	36C/D	5.83	5.25x1	5.25	14.37	27.60*
88	37D	5.83	5.25	36.75	14.37	22.38
95	38D	5.83	5.25	36.75	14.37	22.38
102	39D	5.83	5.25	36.75	14.37	22.38
109 October	40D	5.03	4.53	31.71	0.90	30.81*
116	41D	5.03	4.53x1	4.53	0.90	3.63
				520.54	303.55	216.99

Net Irri. Req. = 216.99 + 60 = 276.99mm

Gross Irri. Req. = 241.10 + 67 = 308.10mm

\* No. of Irri. = 2 (81 and 105 DAS)

Net Irri. water applied = 87.5 x 2 = 175 + 60 = 235mm

Gross Irri. water applied = 97.22 x 2 = 194.44 + 67 = 261.44mm

APPENDIX 4.1.11  
Groundnut (Kharif)

AWC : 175 mm/m

LGP : 120 Days

Days/Month	Std. Week	ET <sub>o</sub> <—mm/d—>	ET <sub>c</sub>	ET <sub>c</sub>	Eff. Rain <—mm/Std.wk—>	Net Irri. Req.
4 June	25A	7.07	5.65	22.60	7.25	15.35
11 June-July	26A	6.76	5.41	37.87	24.18	13.69
18 July	27A	4.94	3.95	27.65	36.83	-9.18
			3.95x2	7.90		
25	28A/B	4.94	3.95x5	19.75	36.83	-9.18
32	29B	4.94	3.95	27.65	36.83	-9.18
39	30B	4.94	3.95	27.65	36.83	-9.18
			3.58x6	21.48		
46 July-Aug	31B/C	4.47	4.69x1	4.69	28.62	-2.45
53 Aug.	32C	4.29	4.50	31.50	18.97	12.53
60	33C	4.29	4.50	31.50	18.97	12.53
67	34C	4.29	4.50	31.50	18.97	12.53
74 Aug.-Sept.	35C	4.73	4.97	34.79	16.71	18.08
81 Sept.	36C	5.83	6.12	42.84	14.37	28.47
			6.12x4	24.48		
88	37C/D	5.83	3.50x3	10.50	14.37	20.61*
95	38D	5.83	3.50	24.50	14.37	10.13
102	39D	5.83	3.50	24.50	14.37	10.13
109 October	40D	5.03	3.02	21.14	0.90	20.24
116	41D	5.03	3.02	21.14	0.90	20.24
123	42D	5.03	3.02x4	12.08	0.90	11.18*
				507.71	302.00	205.71

Net Irri. Req. = 157.87 + 60 = 218.87mm

Gross Irri. Req. = 176.52 + 67 = 243.52mm

\* No. of Irri. = 2 (82 and 120 DAS)

Net Irri. water applied = 87.5 x 2 = 175 + 60 = 235mm

Gross Irri. water applied = 97.22 x 2 = 194.44 + 67 = 261.44mm

APPENDIX 4.1.11  
Cotton (Kharif)

AWC : 175 mm/m

LGP : 210 Days

Days/Month	Std. Week	ETo <—mm/d—>	ETc	ETc	Eff.Rain <—mm/Std.wk—>	Net Irri.Req.
4 June	25A	7.07	3.18	12.72	@80% 7.25	5.47
11 June-July	26A	6.76	3.04	21.28	@70% 24.18	-2.9
18 July	27A	4.94	2.22	15.54	36.83	-21.29
25	28A	4.94	2.22	15.54	36.83	-21.29
			2.22x5	11.10		
32	29A/B	4.94	2.77x2	5.54	36.83	-20.19
39	30B	4.94	2.77	19.39	36.83	-17.44
46 July-Aug	31B	4.47	2.51	17.57	@75% 28.62	-11.05
53 Aug.	32B	4.29	2.40	16.80	@80% 18.97	-2.17
60	33B	4.29	2.40	16.80	18.97	-2.17
67	34B	4.29	2.40	16.80	18.97	-2.17
74 Aug.-Sept.	35B	4.73	2.65	18.55	16.71	1.84
			3.27x6	19.62		
81 Sept.	36B/C	5.83	7.00x1	7.00	14.37	12.25
88	37C	5.83	7.00	49.00	14.37	34.63
95	38C	5.83	7.00	49.00	14.37	34.63*
102	39C	5.83	7.00	49.00	14.37	34.63
109 October	40C	5.03	6.04	42.28	0.90	41.38*
116	41C	5.03	6.04	42.28	0.90	41.38
123	42C	5.03	6.04	42.28	0.90	41.38
130	43C	5.03	6.04	42.28	0.90	41.38*
137 Oct.-Nov.	44C	4.84	5.81	40.67	1.10	39.57
144 Nov.	45C	4.70	5.64	39.48	1.30	38.18*
			5.64x6	33.84		
151	46C/D	4.70	3.06x1	3.06	1.30	35.60
158	47D	4.70	3.06	21.42	1.30	20.12
165 Nov.-Dec.	48D	4.44	2.88	20.16	0.73	19.43*
172 Dec.	49D	3.77	2.45	17.15	0.18	16.97
179	50D	3.77	2.45	17.15	0.18	16.97
186	51D	3.77	2.45	17.15	0.18	16.97*
194	52D	3.77	2.45	19.60	0.18	19.42
201 Jan.	1D	3.97	2.58	18.06	0.36	17.70
208	2D	3.97	2.58	18.06	0.36	17.70
215	3D	3.97	2.58x2	5.16	0.10	5.06
				801.33	248.67	552.66

Net Irri. Req. = 552.66 + 60 = 612.66mm

Gross Irri.Req.= 614.07 + 67 = 681.07mm

\* No.of Irri. = 6 (93, 109, 124, 144, 182 DAS)

Net Irri.water applied = 87.5 x 6 = 525 + 60 = 585mm

Gross Irri. water applied = 97.22x 6 = 583.32 + 67 = 650.32mm

APPENDIX 4.2.

MONTHWISE CROP WATER REQUIREMENTS (mm) AND RELATIVE  
IRRIGATION REQUIREMENTS OF DISTRICTS IN NARMADA COMMAND

1. KHEDA
2. AHMEDABAD AND GANDHINAGAR
3. BARODA
4. BHARUCH
5. PANCHMAHALS
6. MEHSANA
7. BANASKANTHA
8. BHAVNAGAR
9. KUTCH
10. RAJKOT
11. SURENDRANAGAR

CROPS :

SUMMER(S)	RABI(R)	KHARIF(K)
GROUNDNUT	MUSTARD	PIGEONPEA
PEARL MILLET	WHEAT	COTTON
		CASTOR
		PEARL MILLET
		GROUNDNUT

mm/d = millimeter per day  
mm/m = millimeter per month  
l/s/ha = litres per second per hectare  
l/ha/d = litres per hectare per day  
M.Cu.M/d = Million Cubic Meter per day  
M.Cm.M./m = Million Cubic Meter per month  
Area % = Area in per cent

APPENDIX 4.2.1

KHEDA

MONTHS

Crops	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<b>MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)</b>													
Groundnut (S)	-	58.00	151.60	220.29	116.67	-	-	-	-	-	-	-	546.76
Pearl millet (S)	-	32.12	149.15	220.79	198.65	-	-	-	-	-	-	-	600.71
Mustard (R)	119.39	60.83	-	-	-	-	-	-	-	33.67	76.87	109.23	399.99
Wheat (R)	131.41	118.09	56.50	-	-	-	-	-	-	-	35.73	95.61	437.34
Cotton (K)	58.86	-	-	-	-	13.30	35.91	18.10	102.38	190.18	142.46	73.18	634.37
Pigeonpea(K)	83.68	28.21	-	-	-	-	-	27.27	72.21	178.43	152.03	85.42	627.25
Castor (K)	131.49	92.29	118.67	-	-	-	-	36.78	76.13	120.47	145.29	129.39	850.51
<b>MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS</b>													
Groundnut (S)	-	0.12	0.16	0.23	0.16	-	-	-	-	-	-	-	-
Pearl millet (S)	-	0.14	0.17	0.26	0.22	-	-	-	-	-	-	-	-
Mustard (R)	0.10	0.11	-	-	-	-	-	-	-	0.07	0.07	0.09	-
Wheat (R)	0.95	0.92	1.15	-	-	-	-	-	-	-	0.44	0.69	-
Cotton (K)	0.72	-	-	-	-	0.65	1.09	0.32	1.19	1.50	1.16	0.58	-
Pigeonpea(K)	0.04	0.05	-	-	-	-	-	0.03	0.06	0.09	0.08	0.04	-
Castor (K)	0.09	0.07	0.09	-	-	-	-	0.03	0.08	0.08	0.10	0.09	-
Total mm/d	1.90	1.41	1.57	0.49	0.38	0.65	1.09	0.38	1.33	1.74	1.85	1.49	-
Total mm/m	58.90	40.19	48.67	14.70	11.78	19.50	33.79	11.78	38.90	53.94	55.50	46.19	-
l/s/ha	0.22	0.16	0.16	0.06	0.04	0.075	0.13	0.04	0.15	0.20	0.21	0.17	-
Area x	53.10	35.4	31.1	6.70	6.70	24.40	24.40	28.10	28.10	30.80	53.10	53.10	-
l/s/ha	0.41	0.45	0.58	0.89	0.60	0.31	0.53	0.14	0.53	0.65	0.39	0.32	-
l/ha/d	35424	38880	50112	74304	51840	26784	45792	12096	45792	66160	33696	27848	-
M.Cu.M/d	4.11	4.51	5.81	8.62	6.01	3.11	5.31	1.40	5.31	6.51	3.91	3.21	-
M.Cu.M/m	127.41	128.53	180.11	258.60	186.31	93.30	164.61	43.40	159.30	201.81	117.30	99.51	-

APPENDIX 4.2.2  
AHMEDABAD AND GANDHINAGAR

MONTHS

Crops	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Groundnut (S)	12.48	130.92	124.14	183.81	47.23	-	-	-	-	-	-	-	498.58
Pearl millet (S)	-	14.22	99.19	222.31	236.15	20.14	-	-	-	-	-	-	592.01
Mustard (R)	120.90	20.69	-	-	-	-	-	-	-	49.71	101.54	118.31	411.15
Wheat (R)	134.66	111.56	13.69	-	-	-	-	-	-	-	73.67	111.20	444.78
Groundnut(K)	-	-	-	-	-	17.75	1.03	4.02	18.73	50.63	-	-	92.16
Cotton (K)	40.46	-	-	-	-	1.62	-	-	76.96	179.88	128.27	76.92	501.11
Pearl millet (K)	-	-	-	-	-	17.75	1.03	4.02	57.23	34.58	-	-	114.61

MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS

Groundnut (S)	0.04	0.15	0.13	0.20	0.14	-	-	-	-	-	-	-	-
Pearl millet (S)	-	0.12	0.11	0.21	0.27	0.14	-	-	-	-	-	-	-
Mustard (R)	0.11	0.04	-	-	-	-	-	-	-	0.08	0.09	0.10	-
Wheat (R)	0.97	0.87	0.61	-	-	-	-	-	-	-	0.63	0.80	-
Groundnut(K)	-	-	-	-	-	0.07	0.04	0.03	0.08	0.07	-	-	-
Cotton (K)	0.85	-	-	-	-	0.07	-	-	0.67	1.42	1.02	0.61	-
Pearl millet (K)	-	-	-	-	-	0.13	0.08	0.05	0.14	0.29	-	-	-
Total mm/d	1.67	1.16	0.85	0.41	0.41	0.41	0.12	0.08	0.89	1.86	1.74	1.51	-
Total mm/m	51.77	33.63	26.35	12.30	12.71	12.30	3.72	2.48	26.70	57.66	52.20	46.81	-
l/s/ha	0.19	0.14	0.098	0.047	0.047	0.047	0.01	0.009	0.10	0.22	0.20	0.17	-
Area %	52.60	31.70	29.0	6.70	6.70	39.70	11.80	11.80	36.20	36.90	49.40	49.40	-
l/s/ha	0.36	0.44	0.34	0.70	0.70	0.12	0.08	0.08	0.28	0.56	0.40	0.34	-
l/ha/d	31104	38016	29376	60480	60480	10368	6912	6912	24192	48384	34560	29376	-
M.Cu.M/d	10.57	12.93	9.99	20.56	20.56	3.53	2.35	2.35	8.23	16.45	11.75	9.99	-
M.Cu.M/m	327.67	368.51	309.69	616.80	616.80	105.90	72.85	72.85	246.90	509.95	352.50	309.69	-

APPENDIX 4.2.3  
RAJODA

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Pearl millet (S)	-	17.11	146.90	222.04	239.58	18.86	-	-	-	-	-	-	644.47
Groundnut (S)	36.01	102.97	184.45	184.12	49.04	-	-	-	-	-	-	-	556.59
Mustard (R)	121.60	47.23	-	-	-	-	-	-	43.87	96.37	113.57	-	422.64
Wheat (R)	135.92	114.77	22.32	-	-	-	-	-	-	72.11	106.46	-	451.58
Groundnut(K)	-	-	-	-	-	12.24	0.54	1.56	49.07	55.31	-	-	118.72
Cotton (K)	40.87	-	-	-	-	-	-	-	83.02	170.94	122.63	69.40	486.86
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Pearl millet (S)	-	0.15	0.17	0.26	0.27	0.13	-	-	-	-	-	-	-
Groundnut (S)	0.10	0.12	0.19	0.20	0.14	-	-	-	-	-	-	-	-
Mustard (R)	0.11	0.12	-	-	-	-	-	-	0.07	0.09	0.10	-	-
Wheat (R)	0.98	0.90	0.99	-	-	-	-	-	-	0.62	0.77	-	-
Groundnut(K)	-	-	-	-	-	0.05	0.02	0.01	0.07	0.12	-	-	-
Cotton (K)	0.55	-	-	-	-	-	-	-	0.72	1.35	1.00	0.55	-
Total mm/d	1.74	1.29	1.35	0.46	0.41	0.18	0.02	0.01	0.79	1.54	1.71	1.42	-
Total mm/m	53.94	36.77	41.85	13.80	12.71	5.40	0.62	0.31	23.70	47.74	51.30	44.02	-
l/s/ha	0.20	0.15	0.16	0.05	0.047	0.02	0.002	0.001	0.09	0.18	0.20	0.16	-
Area %	52.60	31.70	29.00	6.70	6.70	3.50	4.2	4.2	28.6	31.30	49.40	49.40	-
l/s/ha	0.38	0.47	0.55	0.75	0.70	0.57	0.048	0.024	0.31	0.58	0.40	0.32	-
l/ha/d	32832	40608	47520	64800	60480	49248	4147.2	2073.6	2678.4	50112	34560	27648	-
M.Cu.M/d	11.16	13.81	16.16	22.03	20.56	16.74	1.41	0.71	9.11	17.04	11.75	9.40	-
M.Cu.M/m	345.96	393.59	500.96	660.9	637.36	502.20	43.71	22.01	273.30	528.24	352.50	291.40	-

APPENDIX 4.2.4  
BHARUCH

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Wheat (R)	142.47	117.94	18.79	-	-	-	-	-	-	-	78.68	121.65	479.53
Pearl millet (K)	-	-	-	-	-	8.39	0.3	-	28.42	32.49	-	-	69.60
Cotton (K)	42.90	-	-	-	-	-	-	-	50.40	177.18	131.84	81.36	483.68
Pigeonpes (K)	91.37	27.21	-	-	-	-	-	-	3.64	174.61	162.87	91.19	551.09
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Wheat (R)	1.02	0.92	0.64	-	-	-	-	-	-	-	0.67	0.88	-
Pearl millet (K)	-	-	-	-	-	0.06	0.02	-	0.10	0.31	-	-	-
Cotton (K)	0.58	-	-	-	-	-	-	-	0.59	1.39	1.07	0.64	-
Pigeonpes (K)	0.047	0.048	-	-	-	-	-	-	0.003	0.09	0.087	0.047	-
Total mm/d	1.647	0.968	0.64	-	-	0.06	0.02	-	0.693	1.79	1.827	1.567	-
Total mm/m	51.06	27.59	26.04	-	-	1.80	0.62	-	20.79	55.49	54.81	48.58	-
l/s/ha	0.19	0.11	0.097	-	-	0.007	0.602	-	0.08	0.21	0.21	0.18	-
Area X	48.30	23.90	22.30	-	-	7.60	7.60	-	33.60	33.60	26.00	26.00	-
l/s/ha	0.39	0.46	0.43	-	-	0.09	0.03	-	0.24	0.62	0.81	0.69	-
l/ha/d	33696	39744	37152	-	-	7766	2592	-	20736	53568	69864	59616	-
M.Cu.M/d	3.30	3.89	3.64	-	-	0.76	0.25	-	2.03	5.25	6.86	5.84	-
M.Cu.M/m	102.3	110.87	112.84	-	-	22.80	7.75	-	60.90	162.75	205.80	181.04	-

APPENDIX 4.2.5  
PANCHMAHALS

MONTHS

Crops	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Groundnut (S)	36.30	111.77	186.31	184.15	48.61	-	-	-	-	-	-	-	567.14
Pearl millet (S)	-	18.09	148.57	222.10	236.83	18.31	-	-	-	-	-	-	643.90
Wheat (R)	135.85	115.66	18.84	-	-	-	-	-	-	-	71.82	111.90	453.57
Groundnut(K)	-	-	-	-	-	13.44	0.69	-	24.04	45.85	-	-	84.02
Cotton (K)	43.86	-	-	-	-	-	-	-	62.16	170.10	121.60	74.84	472.62
Pearl millet (K)	-	-	-	-	-	13.44	0.69	-	39.38	32.22	-	-	85.73
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Groundnut (S)	0.11	0.13	0.19	0.20	0.14	-	-	-	-	-	-	-	-
Pearl millet (S)	-	0.16	0.17	0.26	0.27	0.13	-	-	-	-	-	-	-
Wheat (R)	0.98	0.90	0.84	-	-	-	-	-	-	-	0.61	0.80	-
Groundnut(K)	-	-	-	-	-	0.06	0.03	-	0.04	0.10	-	-	-
Cotton (K)	0.59	-	-	-	-	-	-	-	0.72	1.34	0.99	0.59	-
Pearl millet (K)	-	-	-	-	-	0.10	0.05	-	0.11	0.31	-	-	-
Total mm/d	1.68	1.19	1.20	0.46	0.41	0.29	0.08	-	0.87	1.75	1.60	1.39	-
Total mm/m	52.08	33.92	37.20	13.80	12.71	8.70	2.48	-	28.10	54.25	48.00	43.10	-
l/s/ha	0.19	0.14	0.14	0.05	0.047	0.033	0.009	-	0.10	0.20	0.19	0.16	-
Area %	49.90	29.00	29.00	6.70	6.70	15.30	11.8	-	36.20	36.20	46.7	46.7	-
l/s/ha	0.38	0.48	0.48	0.75	0.70	0.22	0.07	-	0.28	0.55	0.41	0.34	-
l/ha/d	32832	41472	41472	64800	60480	19008	6048	-	24192	47520	35424	29376	-
M.Cu.M/d	0.33	0.41	0.41	0.65	0.61	0.19	0.06	-	0.24	0.48	0.35	0.29	-
M.Cu.M/m	10.23	11.69	12.71	19.50	18.91	5.70	1.86	-	7.20	14.88	10.50	8.99	-

APPENDIX 4.2.6  
MEHSANA

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Pearl millet (S)	-	17.17	147.59	222.65	234.59	22.19	-	-	-	-	-	-	644.19
Wheat (R)	135.33	113.98	17.54	-	-	-	-	-	-	-	78.27	112.90	458.02
Mustard (R)	121.57	47.12	-	-	-	-	-	-	48.23	103.74	120.01	440.67	
Cotton (K)	43.42	-	-	-	-	6.88	0.25	-	71.07	178.93	132.33	75.84	508.72
Pearl millet (K)	-	-	-	-	-	30.72	3.56	7.10	53.49	34.49	-	-	129.36
Castor (K)	134.61	96.19	116.05	-	-	-	-	-	29.84	122.26	154.41	135.05	788.41
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Pearl millet (S)	-	0.15	0.17	0.26	0.26	0.16	-	-	-	-	-	-	-
Wheat (R)	0.97	0.89	0.78	-	-	-	-	-	-	-	0.67	0.81	-
Mustard (R)	0.11	0.12	-	-	-	-	-	-	0.08	0.09	0.10	-	-
Cotton (K)	0.59	-	-	-	-	0.17	0.06	-	0.83	1.41	1.08	0.60	-
Pearl millet (K)	-	-	-	-	-	0.23	0.09	0.17	0.44	1.05	-	-	-
Castor (K)	0.09	0.07	0.09	-	-	-	-	-	0.02	0.08	0.11	0.09	-
Total mm/d	1.76	1.23	1.04	0.26	0.26	0.56	0.069	0.17	1.29	2.62	1.95	1.60	-
Total mm/m	54.56	35.06	32.24	7.80	8.06	16.80	2.14	5.27	38.70	81.22	58.50	49.60	-
l/s/ha	0.20	0.14	0.12	0.03	0.03	0.06	0.008	0.02	0.15	0.30	0.23	0.19	-
Area X	51.50	30.60	27.90	3.50	3.50	35.50	32.00	7.60	34.10	36.80	51.50	51.50	-
l/s/ha	0.39	0.46	0.43	0.86	0.86	0.17	0.03	0.26	0.44	0.81	0.45	0.37	-
l/ha/d	33686	39744	37152	74304	74304	14668	2592	22484	38016	69984	38880	31968	-
M.Cu.M/d	5.05	5.96	5.57	11.15	11.15	2.20	0.39	3.37	5.70	10.50	5.83	4.80	-
M.Cu.M/m	156.55	169.86	172.67	334.50	345.65	66.00	12.09	104.47	171.00	325.50	174.90	148.80	-

APPENDIX 4.2.7  
BANASKANTRA

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Pearl millet (S)	-	16.93	145.45	203.49	224.07	23.46	-	-	-	-	-	-	613.40
Wheat (R)	131.41	112.28	17.44	-	-	-	-	-	-	-	61.41	97.92	420.46
Mustard (R)	107.96	45.48	-	-	-	-	-	-	46.30	83.64	104.10	387.48	
Castor (K)	118.97	87.24	106.62	-	-	-	5.66	78.62	120.13	129.16	117.18	763.58	
Cotton (K)	46.87	-	-	-	-	-	0.94	103.81	178.62	121.04	63.93	517.21	
Pearl millet (K)	-	-	-	-	-	32.61	4.20	50.07	102.55	34.45	-	-	223.88
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Pearl millet (S)	-	0.15	0.16	0.24	0.25	0.16	-	-	-	-	-	-	-
Wheat (R)	0.95	0.88	0.78	-	-	-	-	-	-	0.53	0.07	0.73	-
Mustard (R)	0.09	0.11	-	-	-	-	-	-	0.07	0.07	0.09	0.09	-
Castor (K)	0.08	0.06	0.08	-	-	-	0.02	0.06	0.08	0.09	0.08	0.08	-
Cotton (K)	0.57	-	-	-	-	-	0.05	0.84	1.41	1.05	0.92	0.92	-
Pearl millet (K)	-	-	-	-	-	0.23	0.16	0.12	0.26	0.33	-	-	-
Total mm/d	1.69	1.20	1.02	0.24	0.25	0.39	0.16	0.19	1.16	1.89	1.74	1.82	-
Total mm/m	52.39	34.20	31.62	7.20	7.75	11.70	4.96	5.89	34.80	58.59	52.20	56.42	-
l/s/ha	0.20	0.14	0.12	0.03	0.03	0.05	0.02	0.02	0.13	0.22	0.20	0.21	-
Area %	51.50	30.60	27.90	3.50	3.50	11.10	7.60	34.10	34.10	36.80	51.50	51.50	-
l/s/ha	0.39	0.46	0.43	0.66	0.66	0.45	0.26	0.06	0.38	0.60	0.39	0.41	-
l/ha/d	33696	39744	37152	74304	74304	36880	22464	5184	32832	51840	33696	35424	-
M.Cu.M/d	10.55	12.44	11.63	23.26	23.26	12.17	7.03	1.62	10.26	16.22	10.55	11.09	-
M.Cu.M/m	327.05	354.54	360.53	697.80	697.80	365.10	217.93	50.22	308.40	502.82	316.50	343.79	-

APPENDIX 4.2.8  
BHAVNAGAR

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Groundnut (S)	35.28	107.50	191.18	183.34	46.76	-	-	-	-	-	-	-	564.06
Mustard (R)	119.47	45.97	-	-	-	-	-	-	-	53.99	101.17	124.44	445.04
Wheat (R)	132.31	110.67	17.81	-	-	-	-	-	-	-	75.00	116.76	452.57
Groundnut (K)	-	-	-	-	-	21.87	2.02	24.51	52.56	57.98	-	-	158.94
Pearl millet (K)	-	-	-	-	-	38.76	3.37	27.90	75.80	39.13	-	-	184.96
Castor (K)	134.21	93.98	117.37	1.91	-	-	0.24	50.33	136.65	152.35	139.90	-	826.94
Cotton (K)	40.23	-	-	-	-	-	-	94.24	201.62	128.27	75.71	-	540.07
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Groundnut (S)	0.10	0.12	0.20	0.20	0.14	-	-	-	-	-	-	-	-
Mustard (R)	0.10	0.11	-	-	-	-	-	-	-	0.09	0.09	0.11	-
Wheat (R)	0.95	0.87	0.79	-	-	-	-	-	-	-	0.64	0.84	-
Groundnut (K)	-	-	-	-	-	0.09	0.08	0.04	0.07	0.13	-	-	-
Pearl millet (K)	-	-	-	-	-	0.29	0.09	0.07	0.19	0.33	-	-	-
Castor (K)	0.09	0.07	0.08	0.04	-	-	-	0.001	0.04	0.09	0.11	0.09	-
Cotton (K)	0.54	-	-	-	-	-	-	-	0.77	1.50	1.04	1.10	-
Total mm/d	1.78	1.17	1.07	0.24	0.14	0.38	0.17	0.11	1.07	2.23	1.88	2.14	-
Total mm/m	55.18	33.35	33.17	7.20	4.34	11.40	5.27	3.44	32.1	69.13	56.40	66.34	-
1/s/ha	0.21	0.14	0.12	0.03	0.016	0.04	0.02	0.013	0.12	0.26	0.22	0.25	-
Area X	54.70	30.30	27.60	5.30	3.20	11.80	13.90	38.30	41.00	51.50	51.50	51.50	-
1/s/ha	0.38	0.46	0.43	0.57	0.50	0.34	0.17	0.09	0.31	0.63	0.43	0.48	-
1/ha/d	32832	39744	37152	49248	43200	29376	14688	7776	26784	54432	37152	41472	-
M.Cu.M/d	1.58	1.91	1.76	2.36	2.07	1.41	0.71	0.37	1.29	2.61	1.76	1.99	-
M.Cu.M/m	48.98	54.44	55.18	70.80	64.17	42.30	22.01	11.47	38.70	80.91	53.40	61.69	-

APPENDIX 4.2.9  
KUTCH

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Groundnut (S)	33.38	102.79	182.62	179.69	44.58	-	-	-	-	-	-	-	543.06
Mustard (R)	112.55	43.70	-	-	-	-	-	-	-	51.16	103.00	123.58	433.99
Wheat (R)	124.98	106.36	17.04	-	-	-	-	-	-	76.17	116.42	-	440.97
Groundnut (K)	-	-	-	-	-	41.41	50.64	84.63	132.91	37.13	-	-	346.72
Pearl millet (K)	-	-	-	-	-	41.41	48.79	80.03	109.77	53.13	-	-	333.13
Castor (K)	126.88	90.93	122.95	-	-	-	31.21	107.79	127.11	147.51	138.79	-	893.17
Cotton (K)	40.29	-	-	-	-	15.67	3.10	7.88	149.41	194.41	127.42	78.56	616.74
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Groundnut (S)	0.097	0.11	0.19	0.19	0.13	-	-	-	-	-	-	-	-
Mustard (R)	0.098	0.11	-	-	-	-	-	-	-	0.08	0.09	0.11	-
Wheat (R)	0.90	0.83	0.76	-	-	-	-	-	-	-	0.65	0.84	-
Pearl millet (K)	-	-	-	-	-	0.29	0.12	0.21	0.34	0.31	-	-	-
Groundnut (K)	-	-	-	-	-	0.16	0.07	0.11	0.15	0.12	-	-	-
Castor (K)	0.09	0.07	0.08	-	-	-	0.02	0.02	0.08	0.08	0.10	0.09	-
Cotton (K)	0.32	-	-	-	-	0.35	0.02	0.06	1.22	1.53	1.04	0.62	-
Total mm/d	1.51	1.12	1.03	0.19	0.13	0.80	0.21	0.40	1.79	2.13	1.88	1.66	-
Total mm/m	46.81	31.92	31.93	5.70	4.03	24.0	6.51	12.4	53.70	66.03	56.40	51.46	-
l/s/ha	0.17	0.13	0.12	0.02	0.015	0.09	0.02	0.046	0.21	0.25	0.22	0.19	-
Area %	66.50	30.30	27.6	3.2	3.2	36.2	36.2	38.3	38.3	41.0	51.50	51.50	-
l/s/ha	0.26	0.43	0.43	0.63	0.47	0.25	0.06	0.12	0.55	0.61	0.43	0.37	-
l/ha/d	22464	37152	37152	54432	40608	21600	5184	10368	47520	52704	37152	31988	-
M.Cu.M/d	0.83	1.37	1.37	2.01	1.50	0.80	0.19	0.38	1.76	1.95	1.37	1.18	-
M.Cu.M/m	25.73	39.05	42.47	60.3	46.50	24.0	5.89	11.78	52.80	60.45	41.10	36.58	-

APPENDIX 4.2.10  
RAJKOT

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Groundnut (S)	33.38	107.68	183.61	176.39	44.63	-	-	-	-	-	-	-	545.69
Pearl millet (S)	-	17.60	146.10	212.35	218.64	16.97	-	-	-	-	-	-	611.66
Mustard (R)	111.73	45.43	-	-	-	-	-	-	-	51.24	97.96	123.96	430.32
Wheat (R)	124.16	111.34	18.37	-	-	-	-	-	-	-	73.48	117.29	444.64
Cotton (K)	39.95	-	-	-	-	-	-	-	108.46	194.96	125.44	76.84	547.65
Pearl millet (K)	-	-	-	-	-	15.78	2.16	24.77	92.75	37.61	-	-	173.07
Groundnut (K)	-	-	-	-	-	7.87	1.31	22.65	72.11	54.93	-	-	158.87
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Groundnut (S)	0.097	0.12	0.19	0.19	0.13	-	-	-	-	-	-	-	-
Pearl millet (S)	-	0.14	0.16	0.24	0.25	0.12	-	-	-	-	-	-	-
Mustard (R)	0.097	0.11	-	-	-	-	-	-	-	0.09	0.09	0.11	-
Wheat (R)	0.89	0.87	0.82	-	-	-	-	-	-	-	0.66	0.84	-
Cotton (K)	0.54	-	-	-	-	-	-	-	0.95	1.53	0.99	0.62	-
Pearl millet (K)	-	-	-	-	-	0.12	0.055	0.06	0.23	0.32	-	-	-
Groundnut (K)	-	-	-	-	-	0.05	0.055	0.03	0.10	0.12	-	-	-
Total mm/d	1.62	1.24	1.17	0.43	0.38	0.29	0.11	0.09	1.28	2.06	1.74	1.57	-
Total mm/m	50.34	35.34	36.27	12.90	11.78	8.99	3.41	2.79	38.4	63.86	52.20	48.67	-
l/s/ha	0.19	0.14	0.14	0.05	0.04	0.03	0.013	0.01	0.15	0.24	0.20	0.18	-
Area %	56.10	31.70	29.00	6.70	6.7	15.3	11.8	11.8	36.2	38.9	49.4	49.4	-
l/s/ha	0.34	0.44	0.48	0.75	0.60	0.20	0.11	0.08	0.41	0.62	0.40	0.36	-
l/ha/d	29376	38016	41472	64800	51840	17280	9504	6912	35424	53568	34560	31104	-
M.Cu.M/d	9.99	12.93	14.10	22.03	17.63	5.88	3.23	2.39	12.04	18.21	11.75	10.58	-
M.Cu.M/m	309.69	368.51	437.10	660.90	546.53	176.40	100.13	72.85	361.20	564.51	352.50	327.98	-

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APPENDIX 4.2.11  
SURENDRANAGAR

Crops	MONTHS												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
MONTHLY CROP WATER REQUIREMENTS OF INDIVIDUAL CROPS (mm)													
Pearl millet (S)	-	17.21	148.29	223.67	238.70	22.55	-	-	-	-	-	-	650.42
Mustard (R)	120.83	47.11	-	-	-	-	-	-	-	49.15	103.85	120.07	441.01
Wheat (R)	134.31	114.13	17.70	-	-	-	-	-	-	-	78.19	112.96	457.29
Cotton (K)	40.46	-	-	-	-	5.47	-	1.31	116.67	182.48	130.39	75.88	552.66
Pearl millet (K)	-	-	-	-	-	27.08	2.85	52.71	99.91	34.44	-	-	216.99
Groundnut (K)	-	-	-	-	-	27.08	1.96	50.50	74.51	51.66	-	-	205.71
MONTHWISE RELATIVE IRRIGATION REQUIREMENTS OF INDIVIDUAL CROPS													
Pearl millet (S)	-	0.15	0.15	0.26	0.27	0.16	-	-	-	-	-	-	-
Mustard (R)	0.11	0.12	-	-	-	-	-	-	-	0.08	0.09	0.10	-
Wheat (R)	0.97	0.82	0.79	-	-	-	-	-	-	-	0.70	0.81	-
Cotton (K)	0.62	-	-	-	-	0.15	-	0.06	0.87	1.44	1.06	0.60	-
Pearl millet (K)	-	-	-	-	-	0.23	0.11	0.13	0.25	0.29	-	-	-
Groundnut (K)	-	-	-	-	-	0.13	0.08	0.08	0.10	0.11	-	-	-
Total mm/d	1.70	1.09	0.94	0.26	0.27	0.67	0.19	0.27	1.22	1.92	1.85	1.51	-
Total mm/m	52.70	31.07	29.14	7.80	8.37	20.10	5.89	8.37	36.60	59.52	55.50	46.81	-
l/s/ha	0.20	0.13	0.11	0.03	0.03	0.08	0.02	0.03	0.14	0.22	0.21	0.17	-
Area %	49.4	28.50	25.80	3.50	3.50	39.7	11.8	36.2	38.9	38.9	61.20	49.40	-
l/s/ha	0.40	0.46	0.43	0.86	0.86	0.20	0.17	0.08	0.39	0.57	0.34	0.34	-
l/ha/d	34560	39744	37152	74304	74304	17280	14888	6912	33696	49248	29376	29376	-
M.Cu.M/d	10.51	12.08	11.29	22.59	22.59	5.25	4.47	2.10	10.24	14.97	8.93	8.93	-
M.Cu.M/m	325.81	344.28	349.99	677.70	700.29	157.50	138.57	65.10	307.20	484.07	267.50	276.83	-