IRRIGATION SCHEDULING USING WASHTUB EVAPORATION PANS

BY

AVINASH SADASHIV PATWARDHAN

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ABSTRACT

In many areas of North America and in other areas of the world, available irrigation water supplies are either very low already or are being depleted rapidly. As water supplies diminish, as population increases and as municipal and industrial water needs increase, optimization and improved efficiency of irrigation water use in food and fibre production become increasingly important. Since proper irrigation scheduling can improve the irrigation water use by crops significantly, there is a need to develop an irrigation scheduling method which is not cumbersome, and which will be accepted by the farmers.

An inexpensive method consisting of three styles of washtubs as evaporation pans, namely the above-ground washtub, the sunken washtub and the insulated washtub was proposed and tested. The pans were painted white on the inner and outer side surfaces but the inner bottoms of the pans were painted black.

Changes in the water levels in the washtubs and in the Class A pan, rainfall and the soil moisture were measured and tabulated. Various aspects of the difference in evaporation from the three types of washtubs and the Class A pan were analysed and discussed and the correlation between pan evaporation and the soil moisture depletion was examined.

It was found that there was no reliable correlation between the evaporation from any of the three types of

washtubs or the Class A pan on one hand and the soil moisture depletion from the top 52.5 cm and 60.0 cm of the root zone on the other hand.

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TABLE OF CONTENTS

viii

LIST OF FIGURES

LIST OF TABLES

Chapter I

INTRODUCTION

Energy, water and food shortages frequently make the headlines . Food shortages can be decreased by a number of measures including additional irrigation development. However, with more irrigation, both energy and water shortages may be increased. Water shortages have motivated researchers to design and to operate irrigation systems with the aim of improving water conservation but, until some ten years, ago energy conservation was not a major consideration. Sprinkler irrigation systems effectively control water applications but require considerable energy to provide the necessary water pressure. An effective irrigation scheduling program may aid in increasing production while conserving both energy and water.

Many irrigation scheduling techniques and procedures have been suggested and studied and the term 'scheduling irrigation' has many different meanings. It may refer either to the proper timing of application or to the proper amount of irrigation or both.

In this study it was preferred to define 'scheduling irrigation' as a procedure which not only accounts for or monitors either the soil moisture or the current plant water status but which also forecasts the optimum time for future irrigations.

The differences in the usage of the term "scheduling irrigation" can best be illustrated by an example. If, for example, a sprinkler irrigation system has been designed with automatic controls that are activated by tensiometers installed in the field, the tensiometers automatically start the irrigation when the soil water tension reaches a preset value and the system continues to irrigate until the soil water storage is refilled. This system requires sufficient water supply to permit irrigation upon demand, of all areas controlled by the tensiometers. Although this system is automatic, it does not schedule irrigation because, if water is limited, the entire area cannot be irrigated at the same time and irrigation in some parts of the system must be delayed. In a truly scheduled irrigation system, a central processor would take advance notice of the fact that the soil moisture in an extensive area is approaching the level at which irrigation normally would start and it would compute that irrigation would be required in a few days in an area so large that all parts of the area could not be served simultaneously because of limited water supply capacity of the system. To prevent this crisis, the processor would start irrigation in some parts of the area earlier to distribute the demand for water over a longer time period and to complete irrigation before stress occurs in any part of the area in question.

The importance of systematic scheduling has long been recognized by concerned people. Increasing costs of power and labor and limited supplies of water in some places should encourage further use of scheduling techniques and systems.

Many tools and systems for scheduling have been developed and new ones are still being developed, most of which, if properly used, would accomplish the desired effect. But in reality,although there are many scheduling success stories, acceptance by users is disappointingly slow.

Successful utilization of scheduling has generally resulted from close supervision by outside experts from consulting firms or government agencies and, with most of the present irrigation scheduling methods, it is likely that, even in the future, farmers will have to rely on trained specialists, rather than on themselves.

1.1 PROBLEMS AND QUESTIONS

Optimum crop production under irrigation requires application of the proper amount of water at the proper time. This is a very simple concept, but putting it into practice in irrigation scheduling programs has proven difficult. Numerous scheduling devices and procedures have been used in the past. These include tensiometers, electrical resistance blocks, thermogravimetric moisture monitoring, soil feel and appearance, pan evaporation, very simple to very complex empirical formulae and computer models. These methods have been used and discussed by reseachers, but have gained wider acceptance by farmers only in areas of intensive irrigation development, expensive water or energy and high-valued crops.

It is, therefore, important to find out what will encourage growers to adopt irrigation scheduling more readily and on a broader basis.

1.1.1 Basic concepts and applications

Farmers will not accept a scheduling program unless they first realize its place in meeting their goals, whether it be saving of water, electricity, fertilizer or labor, or to increase yields which all improve net returns.

The fact that many of the present irrigation scheduling methods are time-consuming, need knowledge of instrumentation and are expensive has made them poorly accepted among farmers.

1.1.2 Need for improvement

There is, therefore, a need to develop a scheduling program which is simple, flexible and reliable. Research and field trials have shown that water use by crops depends on a number of factors, including the crop growth stage, soil type and condition, and local weather. Research has shown that crop water use correlates roughly with evaporation from a water surface. Provided that such correlation can be documented and proven reasonably accurate and reliable, evaporation could be measured close to or within an irrigated field and used as a guide for determining when to irrigate and how much water to apply.

1.2 THESIS OBJECTIVES

Since the so-called "washtub method" for scheduling irrigation developed in the United States of America was credited with all three of the before-mentioned attributes, that is simplicity, flexibility, and reliability, there was a hope that it would be widely accepted by Canadian prairie farmers if it proved to be applicable to their conditions.

However, since there were some theoretical reasons to doubt the general applicability of the washtub method, the objective of this project was to verify if a simple method of irrigation scheduling based on water evaporation from washtub-style evaporation pans could be developed for irrigation of potatoes and corn in southern Manitoba.

Chapter II

LITERATURE REVIEW

2.1 GENERAL OVERVIEW

Taking into account the objective, literature was reviewed to find out the various techniques presently used for scheduling irrigation. The various scheduling methods reviewed can be grouped under the following categories:

1. scheduling irrigation using computers,
2. scheduling irrigation using soil moisture or tension measuring instruments and empirical equations,
3 scheduling irrigations using thermal infrared techniques,
4. scheduling irrigation using leaf water potential and
5. scheduling irrigation using evaporation.

2.1.1 Scheduling irrigation using computers

Jensen et al. (1970) reported on a method of irrigation scheduling which used climate-crop-soil data and in which computers were used to facilitate the tedious computations to schedule irrigation.

Jensen and Heermann (1970) reported an irrigation scheduling method which uses meteoreological data and a computer to schedule irrigation.

Buras et al. (1973) used a computer program for planning and updating farm irrigation schedules. In connection with the program, two points were stressed by the authors: (1)

the program does not consider mobile sprinkler systems which require time for moving equipment, nor does it take into account water storage facilities which may exist and be used on the farm and (2) the subroutines included in the program enable it to deal with a broad range of irrigation regimes with different frequencies and depths of applications.

Gear et al. (1977) scheduled irrigation using graphic display of neutron probe measurements. Inconsistent irrigation timing with respect to available moisture was reported by the authors. Consistent timing could improve water use efficiency by more than ten percent.

Crouch et al. (1981) used a desktop data system for irrigation scheduling. Application of scheduling systems can be tailored to meet the needs of an individual user or group of users.

English et al. (1981) proposed that the use of crop stress indicators in combination with data filtering techniques could be the basis for successful irrigation scheduling when economic optimization is the goal.

Phene et al. (1981) reported on scheduling irrigation with the new soil matric potential sensor. These sensors had: (1) a large measurement sensitivity in the soil matric potential range of interest for irrigation control and a wide voltage output range, (2) independence of temperature changes encountered in soils, (3) independence of soil texture and (4) a rapid response to change in soil matric potential. But the authors reported that this method did not show any increase in the yield of crops.

An irrigation scheduling program for large digital computers was developed by Jensen (1969) and Jensen et al. (1970) for the United States Department of Agriculture (USDA). The USDA irrigation scheduling program uses meteorological data to calculate water use and maintains a water budget. It also forecasts the timing of irrigation as well as the amount of irrigation for optimum crop production. Harrington and Heermann (1981) modified the USDA irrigation scheduling program. Their program checks ranges of input data for reliability and accepts either English or metric units. This interactive program is more flexible in providing output to meet the needs of various irrigators and irrigation systems.

Fereres et al. (1981) developed an irrigation management computer program which was based on a water budget concept. As reported by the authors, some refinements in the irrigation management program are still required.

Brase et al. (1981) used the desktop data processing system used by Crop Care Associates to schedule irrigation. As reported by the authors, to be able to use this scheduling procedure, the scheduler needs a good educational background, an ability to communicate well with growers, and several years of experience in irrigation scheduling.

To summarize the above schedulng procedures, it can be said that nearly all of the computer programs have one weakness in common: they predict water loss for an average crop, based on historical empirical relationships that can be modelled. These relationships are almost never able to fit another field and are never able to accomodate differences between cultural practices, even on the same field.

2.1.2 Scheduling irrigation using soil moisture or tension measuring instruments and empirical equations

Ewart (1951) scheduled irrigation utilizing Bouyoucos blocks, which are made of gypsum, and which when placed in the soil tend to equilibrate with the soil moisture suction. A electrical resistance is read on the meter, which has been calibrated to obtain the soil moisture suction, from which we can obtain the soil moisture content. The system was quite flexible and offered promise of farm-scale irrigation scheduling without imposing stringent control. The yields achieved with the program were not known at the time the paper was published and so no impact on the economics of the system could be determined. The disadvantage of using Bouyoucos blocks is that, when the moisture content of the soil is very high such as from saturation to field capacity, the Bouyoucos blocks become insensitive to moisture due to salinity effects.

Pruitt and Jensen (1955), compared actual consumptive use for four crops at Prosser, Washington, with lysimeter tank evaporation and with consumptive use estimated by the Thornthwaite and the Blaney and Criddle methods. They reported that lysimeter tank evaporation, being influenced by most of the same factors determining consumptive use, should be expected to be more effective in estimating water requirements than methods which depend on fewer of the climatic factors involved. The reported work, however, was preliminary in nature and more study is needed before recommendations for the usage should be considered.

Van Bavel and Wilson (1952) reported on a method which used evapotranspiration estimates as a criterion for determining time of irrigation. They used the concept that the soil moisture tension is uniquely related to the soil moisture content. These authors supplied no adequate proof in favour of this evapotranspiration method. However, data available to date were favourable but indicated that considerably more research should be done to determine its usefulness for different crops, soils and areas.

Pruitt (1956) developed a simple irrigation scheduling guide which followed graphically the soil moisture conditions in various fields and used pan evaporation data to estimate consumptive use of water.

Merriam (1960) reported a method which scheduled irrigation using soil moisture and soil appearance. He developed a soil moisture appearance chart which was used to determine the moisture deficiency in the root zone. On this basis the timing of irrigation could then be determined. Concern is sometimes expressed that an accurate figure is not obtained by an inexperienced estimator and that this may lead to crop damage.

Jensen and Haise (1963) proposed a method for estimating short-term water use as a function of solar radiation and average air temperature. Since this method requires only two measurements, it is attractive but limited in accuracy for daily water use estimates.

Hobbs and Krogman (1970) used empirical equations to schedule irrigation and they evaluated these equations by assessing the effects of scheduling on yield and water requirement of crop.

Wilcox (1970) used evapotranspiration and rainfall records to simulate irrigation studies by means of a scheduling technique using account-style balance sheets. Time for irrigation on the balance sheets was based on the peak evapotranspiration for the interval concerned. He concluded that use a of credit depth of 0.90 times the peak evapotranspiration shows good promise for practical use, especially if the peak evapotranspiration of the hottest year recorded is applied to all years.

Brosz and Weirsma (1970) using the procedure of Jensen and Haise (1963), proposed scheduling irrigations using estimated weekly average evaporation data for use by farmers when consulting services were not available.

Woodruff et al. (1972) proposed scheduling irrigation using constant daily evapotranspiration rate versus time. Whenever the two mass curves (evapotranspiration and soil moisture) diverge by a preselected amount, irrigation is recommended. This technique is particularly ineffective when the soil has a lower water holding capacity.

Hiler et al. (1974) proposed a scheduling scheme using stress-day index as a function of growth stage to indicate plant susceptibility to a given water deficit. The stress-day index is determined by multiplying a crop susceptibility factor and a stress factor. Then the product is summed for all the days in each crop growth stage. The crop susceptibility factor is a function of the species and stage of development of crop. The stress factor is a measure of the intensity and duration of the crop deficit. Their concept is particularly valuable for developing irrigation schedules for multiple cropping systems and for deciding which crop should be irrigated first.

Stegman and Ness (1974) compared the effectiveness of five scheduled irrigation systems : the USDA irrigation scheduling model, the stress-day index, the weekly average evapotranspiration scheme, the constant evapotranspiration and a precipitation supplementation scheme (which assumes an irrigation season with a predetermined weekly irrigation schedule with irrigation delayed or eliminated after significant precipitation). They compared these scheduling schemes by simulating irrigation scheduling of a

50.3-hectare centre-pivot system. Simulations included three root-zone water-holding capacities, three pumping rates and two crops. The computed seasonal average of evapotranspiration deficits, applied depths of irrigation water plus precipitaion and the irrigation excess were used to evaluate each scheduling scheme. The USDA irrigation scheduling program resulted in the smallest seasonal average evapotranspiration deficit. The stress-day index concept resulted in considerably larger evapotranspiration deficits. However, Stegman and Ness (1974) assumed that reduction in yield was small since these evapotranspiration deficits did not occur when the crop was most susceptible. For all other techniques they assumed that yields were directly proportional to the average evapotranspiration deficits.

Wright and Jensen (1978) reported on the development and evaluation of evapotranspiration models for irrigation scheduling. They proposed that further improvement in this area is required.

Boggess et al. (1981) proposed a simulation model which is sensitive to photosynthetically active radiation, daily temperature, and soil water stress which is determined by a soil water balance model to schedule irrigation. They reported that the analysis has not progressed far enough at this time to specify optimal irrigation strategy by growth stage. In addition, more data are needed to evaluate the ability of the model to accurately simulate the effects of stress in different growth periods.

Reicosky (1981) used a portable-chamber technique for measuring evapotranspiration on field plots. He reported on the limitations of a portable chamber, specifically the assumption that the environment inside the portable chamber is representative of the natural environment of the plants while in fact the radiation exchange and the turbulent transfer within the chamber are altered. The evapotranspiration obtained by the portable chamber is a point measurement and the integrated values on a daily basis or long-term basis require repeated readings and hence the process is laborious. The portable chamber itself is not practical for determining when to irrigate on a commercial farm but can serve as a useful research tool in the developement of irrigation scheduling criteria.

Cary (1981) investigated problems associated with automating the use of tensiometers and resistance blocks with a microprocessor to read projected irrigation dates. He reported that permanent plastic-tube tensiometers were unsatisfactory for automation because they required weekly service and were sluggish when the soil moisture tension was greater than -60 kPa. They had to be placed 30 cm deep to remain operative for at least the first two thirds of an irrigation cycle. The gypsum resistance blocks have several inherent problems; for example, they are temperature-dependent.

Rhoades et al. (1981) scheduled irrigation from measurements of the soil electrical conductivity. The data presented by them support the idea that measurements of bulk soil electrical conductivity could be used to schedule irrigation.

Slack et al. (1981) illustrated the use of the differences between crop canopy temperature and air temperature as an indicator of crop water stress for irrigation scheduling. They reported that a continued refinement of this procedure should make it more widely applicable to a variety of crops and soils.

Lambert et al. (1981) compared various methods of scheduling irrigation for humid areas. They reported that the pan method is the simplest and easiest to use, but is limited by the assumption of fixed rooting depth and gives little advance information for scheduling irrigation or planning purposes. The computer-based water budget method is powerful for planning, but relies on soil physical parameters and evapotranspiration rates which cannot be determined well. Tensiometer methods apparently result in increased yields for the conditions tested, but require considerable attention and a decision on how many tensiometers to use and where to locate them in the field. Tensiometer methods also give little advance information.

Fischbach (1981) compared four irrigation scheduling procedures for corn, namely: (1) evapotranspiration, for which the determination of crop water use was by the modified Blaney-Criddle method, (2) electrical resistance blocks, (3) stage of growth and (4) irrigation after every 14 days. He reported that there was no significant difference in grain yields from the four irrigation scheduling procedures tested.

Lundstrom et al. (1981) reported on scheduling irrigation by the checkbook method using the Jensen evapotranspiration formula. The checkbook method was compared with other scheduling methods and was found to be equal to the other methods. These authors claim that the checkbook method meets the original objective of providing a system which an irrigator can use to schedule his own irrigations with a reasonable level of accuracy.

McKenzie and Chanasyk (1981) used the neutron probe to measure soil moisture and so to schedule irrigation in Alberta. This method of scheduling irrigation received quite a good response from farmers but, for most of the farmers, the neutron probe itself is too expensive and the operation of it is complicated too.

2.1.3 Scheduling irrigation using thermal infrared techniques

Pitney (1977) scheduled and monitored irrigation with infrared photography. The concept involved was that green healthy plants have the ability to reflect the near infrared rays and appear on the infrared film as bright red. When plants come under stress, they lose their ability to reflect infrared rays and appear as light pink or brown colour on the film. There are some advantages of this technique. However,the limitations play a major role. It must be remembered, that a photograph is only as valuable as the information which can be obtained from it and one must have a good interpretation of photographs; that is how pink is only marginally stressed and how brown is severely stressed?

Hatfield (1981) reported on a method to schedule irrigation with thermal infrared and spectral remote sensing inputs. He proposed the stress-degree-day concept to be a valid indicator of the crop stress as shown by the available soil water and leaf water potential data. Further refinements, such as suggested by Idso et al. (1981) and Jackson et al. (1981) as quoted by Hatfield (1981), appear to improve the suitability of this technique for irrigation scheduling. This approach does not provide a method of early warning but could be used as a method of assessing the impact on yield.

2.1.4 Scheduling irrigation using leaf water potential

Akunda and Kumar (1981) reported a simple technique for determining the time to irrigate coffee using leaf water potential as an indicator of internal water balance. The technique is based on the time in which a dry cobalt chloride disk changes its colour from blue to pink when attached to the abaxial side of the leaf. The above technique,however,does not provide the exact time to irrigate and there are doubts about the said approach.

2.1.5 Scheduling irrigation using evaporation

Interest in using evaporation pans to schedule irrigation is growing. Researchers from various areas of the United States of America report a fairly close relationship between the rate of consumptive use of water by crops (evapotranspiration) and the rate of evaporation from a suitably located evaporation pan. Such correlations would indicate that measurements of pan evaporation might be accurate enough for scheduling irrigation. The method is also cheap and simple.

Jensen et al. (1961) proposed a technique for scheduling irrigation using pan evaporation to estimate daily crop water use. This technique has been quite satisfactory, but the pan must be carefully located to avoid microclimatic variations.

Cripps et al. (1982) scheduled irrigations using pan evaporation. They reported that the Class A pan can be a very good guide for the irrigation of leafy vegetables growing on sandy soils.

According to the Soil Conservation Service of the United States Department of Agriculture (National Engineering Handbook, Section 15, Irrigation, 1964), Hansen at the Utah State University has done research on the relation of evapotranspiration to pan evaporation. His work indicates that measuring evaporation is a practical approach that can be used by the farmers to schedule irrigation. In addition to using weather bureau pan, he found that measurements from a 190-L (US 50-gallon) oil drum buried in soil gave a reasonable correlation with evapotranspiration of the crop but the ratios of drum evaporation to evapotranspiration are somewhat higher than those shown by weather bureau pan data.

According to the Soil Conservation Service of the United States Department of Agriculture (National Engineering Handbook, Section 15, Irrigation, 1964), Shaw at Pennsylvania State University found that using evaporation data from five 0.95-L (US one quart) oil cans 24.1 cm (9.5 in.) high is a successful farm method of determining when to irrigate. The oil cans were painted with metallic zinc paint for uniformity and to prevent rusting. The same author reported that the evaporation from a can set with one fourth of its height in the ground is very close to that from a standard weather bureau evaporation pan.

2.1.5.1 Scheduling irrigation using washtub pans

Preliminary work on scheduling irrigation with washtub evaporation pans was done at Bozeman, Montana, by Westesen and Hanson (1981). Their work is summarized as follows.

A washtub which costs US $10 was used by the researchers to schedule irrigation. The washtub was 50.8 cm (20 in.) in diameter and 25.4 cm (10 in.) deep. The sides were slightly sloping, but as reported by the authors this had minimal effect on accuracy. The tub was covered with wire screen on the top to keep out animals; wooden blocks were used to keep the tub off the ground. They pointed out that the advantages of the washtub pans were that they could be placed in the field actually irrigated, and, as they were cheap, several pans could be placed in large fields. The pans were placed in the fields and two reference marks were established on the pans or on the gage attached to each pan. The reference marks were separated by an amount equal to the allowable soil moisture depletion or the net application made by a centre-pivot unit. The pans functioned also as rain gages and caught all precipitation as well as irrigation water. The pans were set along a radius line from the pivot point so that they could be easily observed.

The authors reported that this method was well received by farmers, because the farmers could see the water level drop or rise in the pans and they were not required to relate water use to some esoteric formulae. They reported that no paid consultants were required to take observations. The pans were suited to the varied soil types and scattered agricultural area in Montana.

One of the problems which the authors reported was that, as the irrigation water was generally not measured, the values obtained were used only for timing of irrigation and not for determining proper application amounts.

2.2 LITERATURE REVIEW CONCLUSIONS

Most experienced irrigation farmers believe that they can schedule their irrigations without the use of any instruments and with very limited supporting data. They will continue this practice unless the reseachers can provide results in some directly measurable form like yield or perceived benefits with little or no additional costs or demands on their time. If benefits are not apparent, the probability of acceptance and continued use of new technology may be very small unless there are indirect benefits to the general public and the service is subsidized. These facts call for the development of a new or improved irrigation scheduling method. The cost of the new method as well as the related operational issues, skill requirements, equipment maintenance and standards of accuracy of required measurements should be taken into consideration. Scheduling irrigation using evaporation pans seems to be best suited to satisfy those requirements.

However, the standard weather bureau pan, which is generally used in research, probably is too cumbersome to be practical for most irrigators to use and its installation is too expensive for a small-scale irrigator. A similar but smaller and cheaper type of evaporation pan that might provide fairly close correlation between evaporation and crop evapotranspiration is needed for farm use.

It can be concluded, therefore, that an inexpensive method for measuring evaporation at off-station sites should be developed and tested for irrigation scheduling.

For those reasons the research into the potential of using washtub evaporation pans for scheduling irrigation for two of the Manitoba's major irrigated crops, potatoes and corn, was selected as the objective of this work.

Chapter III

METHODS AND PROCEDURES

3.1 GENERAL CONSIDERATIONS FOR EVAPORATION STUDIES

Evaporation is a physical process by which water vapor escapes from any free liquid water surface or wet surface at a temperature below the boiling point of water. In the case of growing crops, water is lost by evaporation directly from the soil, but it is also lost by transpiration from vegetation covering the soil or water surface. This combined loss is known as evapotranspiration.

Evapotranspiration is the conversion of water to vapor and transport of that vapor away from the land surface into the atmosphere. The amount of liquid water and the energy to vaporize it will vary both in space and time over the land surface. Evapotranspiration varies spatially as a result of variations in climate, crops, or soils. Climatic variables related to evapotranspiration tend to be conservative and often do not change rapidly or significantly over considerable distance. However, we cannot make generalizations because local elevations, orographic effects and cropping pattern can cause large evapotranspiration changes.

Evaporation and evapotranspiration are the two major components of the water budget, which are indispensable for the solution of numerous water management problems. Reliable evaporation data are required for planning, designing and operating reservoirs, ponds, irrigation and drainage systems. Knowledge of the water requirements of crops depends on the accurate determination of the loss of water by evapotranspiration from cultivated fields.

As the methods and devices for reliable measurement of evapotranspiration to date are cumbersome and expensive, evaporation from an open water surface has often been suggested as a substitute from which evapotranspiration can be easily determined.

Various types of evaporation pans are used all around the world. Most evaporation pans are either above the ground or sunken in the ground but sometimes floating pans or tanks are also used. They vary in size and in some cases in shape. Literature was reviewed to study the various types of evaporation pans, their placement and colors. The advantages and disadvantages of the two frequently used placements are as follows:

The advantages of above-ground pans are:

1. ease in detecting leaks,
2. ease of cleaning and
3. cheaper and easier installation.

The disadvantage of above-ground pans is:

1. the possibility of the pan being exposed to radiation on the sides and bottom, resulting in a higher rate of evaporation.

The advantage of sunken pans is:

1. the claim of similarity with the aerodynamic and

radiation characteristics of a lake.

The disadvantages of sunken pans are:

1. difficulty in detecting leaks,
2. tendency to gather dirt and debris because of proximity to the ground,
3. difficult in cleaning and
4. the extra care required to maintain the surrounding cover to offset the potentially significant effect of wind movement over the pan.

A limited number of floating-type pans or tanks are currently in use throughout the world. However, the wave motion causes the splashing of water in or out of the pan and this causes unreliable results in evaporation observations.

Painting the pans is a frequent cause of inconsistent evaporation records. The color of the pans affects the radiation characteristics and consequently the amount of evaporation. It is, therefore, necessary to specify a standard coloring pattern. The working standard adopted by the World Meteorologicall Organisation in 1966 calls for white paint on the inner and outer surfaces of the sides and black paint at the bottom.

From the literature review it was concluded that the evaporation station should be fairly level and open on all sides to permit free circulation of air. Obstructions, such as trees and buildings, should not be close to the installation. Extreme care should be taken that shadows are not cast over the pan during any part of the day. A pan installed above ground should not be set on concrete slabs, over asphalt or on a layer of crushed rock. Sunken pans should not be located in areas subject to flooding during heavy rains

3.2 EXPERIMENTAL PROCEDURE

Research has shown that washtubs can be used to measure evaporation with acceptable accuracy (Sims and Jackson 1971). The tub they use is about 48 cm in top diameter and 25 cm deep with slightly sloping sides.

Hence according to the thesis objective, galvanised iron washtubs costing about Canadian $15.00 each were purchased. The washtub had a top diameter of 50.8 cm, a bottom diameter of 40.6 cm and was 27.9 cm deep. In accordance with the color standards of the World Meteorological Organisation, the washtubs were painted white on the inner and outer surfaces of the sides and black at the inside bottom.

It was decided to use the washtubs in three different treatments:

1. above the ground resting on wooden planks,
2. sunken in the ground with the top 5 cm above the ground and
3. above the ground but insulated by placing them in an approximately 61-cm x 61-cm x 32-cm box made

of plywood and filling the space between the washtub and the sides of the box with an insulating material, in this case, sawdust.

The first two treatments were chosen to be representative of the pan placements used worldwide. The third treatment, that is the insulated washtub, was developed with the intent to maximize the advantages and to minimize the disadvantages of both the sunken and the above-ground evaporation pans. As the insulated washtubs were installed above the ground, the disadvantages of the sunken pan were overcome and, as they were insulated, they were not exposed to radiation either from the sides or from the bottom. Therefore, the disadvantages of the above-ground were eliminated.

Sawdust was used as insulating material as it is cheap and readily available on farms. Three replications of each treatment were used on two different sites for a total of 18 tubs.

3.2.1 Placement of washtubs

Two sites were available for the evaporation studies, namely the experimental area adjacent to the University of Manitoba, Fort Garry campus, managed by the Faculty of Agriculture and known as "the Point" and a farmer's field near Portage la Prairie. The site at Portage la Prairie was a secondary site as the 100 km distance from the University did not permit daily visits.

At Portage la Prairie, a weather station was operated at the site by a research team of the Department of Agricultural Engineering in connection with another research project and the rainfall and the Class A pan evaporation data were collected regularly.

At the Point, only a rain gage operated by the Department of Plant Science of the University of Manitoba was at the site.

The Portage la Prairie site was irrigated; the Point site was not irrigated.

The actual locations for the placements of the washtubs were selected according to the standards for the evaporation pan sites.

At the Point, three sets of washtubs (each set consisting of one above-ground, one sunken and one insulated washtub) were placed near a corn plot. At Portage la Prairie, two sets of washtubs (each consisting of one above-ground, one sunken and one insulated washtub) were placed near potato plots and one set near a corn plot.

Randomized selection was used to decide upon the sequence of placing the washtubs in each set on both locations.

For the above-ground washtubs, two wooden blocks (each 4 cm x 9.2 cm x 45 cm) were placed parallel to each other on the soil surface 25 cm apart and levelled in both directions. The washtub was then placed on the blocks and again checked for level conditions in all directions.

For the installation of the sunken washtubs, a pit was dug and the washtub was then placed in it so that its top was level and 5 cm above the ground and the space around the washtub was backfilled. Excess soil was removed.

The insulated washtubs were placed on a well levelled field surface.

A wire screen with 2.5 cm hexagonal mesh on a light wooden frame was placed over each tub to keep out birds and animals.

The bulk density of the soil at both sites was determined for later conversion of the gravimetric soil moisture data to volumetric soil moisture. Core sampling method was used to determine the bulk density of the soil. Eight core samples were taken for 15-cm, 30-cm and 45-cm depth of the soil profile. The core dimensions and weight was noted before taking the soil samples, the mass of the core and wet soil was noted and the soil cores were then oven dried for a period of 48 hours at 105 degree centigrade and then the dry mass of the soil was measured. The bulk density was then calculated by dividing the mass of dry soil by the total core volume.

The observations were started by setting the water level at 22 cm from the bottom of the washtubs. This depth represents the field capacity moisture content of the soil in a 60-cm layer which approximately equals the root zone depth of corn. Water levels in the washtubs were measured and recorded periodically. The water depth in the washtubs was measured by placing a rigid measure vertically through the screen to the bottom of the washtubs and then by reading the water level on the measure.

As at Portage la Prairie, the washtubs were placed in an irrigated area, the water level was brought to the 22-cm level after each irrigation because it was assumed that the soil moisture content in the root zone was at field capacity level after each irrigation.

At the Point, the following observations were taken every Tuesday and Friday:

1. water level in each washtub,
2. temperature of water in each washtub (from 23 Aug.) and
3. soil moisture content at the 15-cm, 30-cm and 45-cm depths. In connection with the measurement of soil moisture content soil samples were taken for each depth and the thermogravimetric method was used to determine the soil moisture content.

At Portage la Prairie, the intervals between observations varied for reasons of access, and the following observations were taken:

1. water level in each washtub and
2. temperature of water in each washtub (from 25 Aug.)

The difference in the water levels in the washtubs on two consecutive observations gave the basis for the determination of the amount of water evaporated in that interval of time. If the water level in the washtub exceeded the 22-cm mark due to rain water accumulating in it, water was removed from the washtub to reduce the water level to 22 cm. The washtubs were cleaned every two weeks.

It was assumed that the true rain depth was collected in the washtubs and the following formulae were used, therefore, to calculate the evaporation from washtubs if it rained:

Either 1. Evaporation = Rainfall (as recorded by a rain gage) - Gain of water height in the washtub;

Or 2. Evaporation = Rainfall (as recorded by a rain gage) + Loss of water height in the washtub.

3.2.2 Statistical Analysis

Statistical analysis (Statistical Analysis Systems, 1979) to determine the significance of the data was carried out for the amount of evaporation from three different treatments (washtubs) and for the cumulative moisture loss from the top 60.0 cm of the soil profile, respectively.

Unpaired T-tests were performed to determine significance of the differences in evaporation records obtained from the three different washtub treatments and the Class A pan control. Pearson's correlation analysis was done among:

1. evaporation from each of the three treatments of washtubs.
2. evaporation from the Class A pan,
3. cumulative moisture loss from the top 52.5 cm of the

root zone and

4. cumulative moisture loss from the top 60.0 cm of the root zone.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 EVAPORATION STUDIES

4.1.1 Three treatments of washtubs

Evaporation was measured from the three washtub treatments described earlier, that is, the above-ground washtub, the sunken washtub and the insulated washtub. Data from eighteen washtubs were collected from the two sites, the Point and Portage la Prairie. The changes in water levels in the washtubs from the Point and Portage la Prairie sites are listed in Tables 1, 2 and 3 and Tables 4, 5 and 6, respectively. It was assumed that all the rainfall was collected in the washtubs. There was, therefore, an increase in the water level in the washtubs due to rain but, as the time of rainfall is unpredictable, the water levels in the washtubs just before the rainfall could not be measured to verify the assumptions that the total rainfall was collected in the washtub and that no significant amount of rain was lost due to splashing of water out of the washtubs during the rain.

As the water level in the washtubs was not recorded daily, it was assumed that the rate of daily evaporation from a washtub between two observation dates was uniform over the interval.

The average daily water loss or gain in washtubs for the Point and Portage la Prairie sites is listed in Tables 7, 8 and 9 and Tables 10, 11 and 12, respectively, and also the average daily water loss or gain in washtubs for the Point and Portage la Prairie sites is shown in Figures 1, 2 and 3 and Figures 4, 5 and 6, respectively.

Average daily evaporation from the washtubs was calculated as explained earlier and is shown in Figures 7, 8 and 9 for the Point site and in Figures 10, 11 and 12 for the Portage la Prairie site. The evaporation data are listed in Tables 13, 14 and 15 for the Point site and Tables 16, 17 and 18 for the Portage la Prairie site.

The amount of evaporation from the above-ground washtub was greater than that from the sunken or insulated washtub as shown in Figures 7 through 12. This is logical as the above-ground washtub is more open to the atmosphere and receives radiation on both the sides and the bottom. This is also in accordance with the conclusions given by World Meteorological Organisation,Technical Note # 83, 1966.

The evaporation data from the insulated washtubs are significantly correlated with, and not significantly different from, the evaporation data of the sunken washtub as shown in Table 22 and Table 23 for the Portage la Prairie site and the Point site respectively, and is also justified by Table 25 and Table 24 for the Portage la Prairie and the Point site respectively.

The conclusion drawn above can also be confirmed from Tables 22 and 23, which give the correlation coefficients; furthermore, this is justified from Tables 24 and 25.

Evaporation data for the above-ground washtubs are also significantly correlated with the evaporation from sunken washtub and insulated washtubs. However, from Tables 22 and 23, it can be concluded that the evaporation from the sunken washtubs and the insulated washtubs are more highly correlated than their correlation with above-ground washtub.

From Table 24, it can be concluded that the probability that the amount of evaporation would be the same from the sunken and insulated washtub is higher than the probability that the amount of evaporation from above-ground washtub would be equal to the amount of evaporation from the either the sunken or insulated washtub. This conclusion is justified from Table 25.

However, the measure of best suitability is not the highest correlation with other types of washtubs, but the highest (best) correlation with evapotranspiration(i.e. soil moisture depletion).

4.1.2 Evaporation from washtubs and Class A pan

The evaporation data from the Class A pan were recorded only at the Portage la Prairie site. Change in water level in the Class A pan, the average daily water loss or gain in the Class A pan and the average daily evaporation from the Class A pan are listed in Tables 19, 20 and 21, respectively.

From Figures 11 and 13, it can be noted that the amount of evaporation from the Class A pan is generally higher than that from the sunken washtub or the insulated washtub while, on the other hand, there was not much difference between evaporation from the Class A pan and from the above-ground washtub. This is logical considering that the Class A pan too is placed (on a tripod) above ground and both it and the above-ground washtub are exposed to radiation from all sides.

The larger evaporation area of the Class A pan did not really cause large differences in the amount of evaporation from the above -ground washtub and the Class A pan, as both Class A pan and the above-ground washtub received the same amount of radiation per unit of area .

From the F' and Prob > F' columns of Tables 24 and 25, the above conclusion is justified. Tables 24 and 25 show small F' values for the three treatments and the Class A pan, leading to the conclusion that there is no statistical significant difference between evaporation from the three treatments and the Class A pan.

The only difference is that from the Prob > F' column it can be noted that the probability of observing an equal amount of evaporation from the Class A pan and the above-ground washtub is higher than the probability for the Class A pan and sunken or insulated washtubs.

4.2 SOIL MOISTURE STUDIES

The soil moisture studies were conducted at the Point site only. Soil moisture content was determined periodically by the thermogravimetric method for depths from the surface to 22.5 cm, from 22.5 cm to 37.5 cm and from 37.5 cm to 52.5 cm and recorded on a percent mass basis. Those values are shown in Tables 26, 27 and 28. The soil bulk density was also determined for the same soil layers and used for the conversion of the gravimetric percentages to percent by volume. These volumetric percentages are listed in Tables 29, 30 and 31.

As the soil moisture was not determined daily, it was assumed that the daily soil moisture depletion rate occurring between two observation dates was uniform over the interval.

It was assumed that all the rainfall was effective and that there was no loss of moisture due to surface runoff or deep percolation. With respect to the topography, soil condition and the rainfall pattern, this assumption was quite realistic.

Figures 14, 15 and 16 show the average water depth depleted from or gained by the soil. The average daily moisture depletion for the top 52.5 cm was determined by adding the soil moisture depletion from the surface to 22.5 cm, 22.5 cm to 37.5 cm and 37.5 cm to 52.5 cm below the surface; it is shown in Figure 17 and listed in Table 32.

Soil moisture depletion for a particular layer of soil was calculated using the following equation:

$$MD(d) = MC(d) - MC'(d)$$

where:

MD(d) is soil moisture depletion (volumetric) in a given period of time and soil depletion 'd' in mm of water.

MC(d) is soil moisture content at the start of a given period of time and soil depth 'd' in mm of water.

MC'(d) is soil moisture content at the end of a given period of time and soil depth 'd' in mm of water.

The average daily moisture depletion up to the 60-cm depth of soil was calculated by using the moisture in the 0 to 22.5-cm depth as the profile characteristic moisture. It is listed in Table 33 and shown in Figure 18.

Soil moisture depletion for the 60-cm depth of soil was calculated using the following equation:

$$MD(d) = MC(d) - MC'(d)$$

where:

MD(d) is the soil moisture depletion (volumetric) in a given period of time and soil depth 'd' in mm of water.

MC(d) is the soil moisture content at the start of a given period of time and soil depth 'd' in mm of water.

MC'(d) is the soil moisture content at the end of a given period of time and soil depth 'd' in mm of water.

From Tables 32,33 and 23 it can be concluded that soil moisture depletion in the two root zone depths, 52.5 cm and 60.0 cm, is quite similar.

4.3 EVAPORATION AND SOIL MOISTURE STUDIES

Table 23 lists the Pearson's correlation coefficients among evaporation from the above-ground washtubs, from the sunken washtubs the insulated washtubs and from the cumulative moisture depletion for the top 52.5 cm and from 60.0 cm of root zone. The table indicates that the soil moisture depletion and the rate of evaporation from the washtubs is significantly different, that is, that there is a poor correlation between soil moisture depletion and evaporation from the washtubs.

The World Meteorological Organisation states that the moisture depletion from soil which is at field capacity is similar to the evaporation from a free surface (WMO Tech. Note # 83, 1966). Howe- ver, at the Point, the soil in the plots in which the washtubs were installed never did reach its field capacity. At Portage la Prairie, the soil moisture content was brought up to field capacity by irrigation. However, the soil did not stay at field capacity for a long time due to evapotranspiration moisture loss. When the soil had partially dried, it was supplied with moisture only by capillary ascent of water from beneath. This apparently decreased the evaporation component of evapotranspiration. The rate of transpiration increases if the soil is at or near field capacity but remains suppressed if the soil moisture content is lower.

Evapotranspiration involves two processes, evaporation from the soil surface and transpiration from the plants. The relative amounts of soil evaporation and transpiration usually depend on the amount of ground cover. As plant cover increases, the total amount of evapotranspiration increases if the soil is at or near field capacity, but the amount of evaporation from the soil surface decreases in relative terms due to the leaves shading the ground surface.

The evapotranspiration as represented by the soil moisture depletion did not correlate with the evaporation from the washtubs, as shown in Table 23.

More observations should have been taken for the soil moisture at depths upto 75 cm, which may have indicated a better correlation between soil moisture depletion and the evaporation from the washtubs.

CHAPTER V

CONCLUSIONS

5.1 CONCLUSIONS OF THE STUDY

1. There is no reliable correlation between evaporation from any of the three tested washtub treatments and the depletion of the soil moisture from the top 52.5 cm and top 60.0 cm of the root zone.
2. The amount of evaporation from an above-ground washtub is higher than that from a sunken or insulated washtub.
3. The amount of evaporation from an above-ground washtub is not significantly different from the amount of evaporation from a Class A evaporation pan.
4. The amount of evaporation from an insulated washtub is not significantly different from the amount of evaporation from a sunken washtub.

BIBLIOGRAPHY

Akunda, E.M.W. and D. Kumar. 1981. A simple technique for timing irrigation in coffee using cobalt chloride paper disks. Irrigation Science. 3:57-62.

Boggess, W.G., J.W. Jones, D.P. Swaney and G.D. Lynne. 1981. Evaluating irrigation strategies in soyabeans: a simulation approach. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.45-53.

Brase, R.J., G.L. Jorgensen and G.D. Jardine. 1981. Successful implementation of computerized irrigation scheduling. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.213-218.

Buras, Nathan, Dov Nir and Elyahu Alperovits. 1973. Planning and updating farm irrigation schedules. Amer. Soc. Civil Eng. J. Irrig. and Drain. Div. 14(IR1):43-51.

Brosz, D.D. and J.L. Wiersma. 1970. Scheduling irrigations using climatic data. Paper presented at the ASAE North Central Regional Meeting, Fargo, North Dakota. Paper No. NC70-201.

Cary, J.W. 1981. Irrigation scheduling with soil instruments: Error levels and microprocessing design criteria. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.81-90.

Cripps, J.E.L., P.R. George and A.E. Oakely. 1982. Scheduling irrigation of cabbage using pan evaporation. Irrigation Science. 3(3):185-195.

Crouch, C.E., W.E. Hart, G.D. Jardine and R.J. Brase. 1981. Desktop data system for irrigation scheduling. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.27-35.

English, M., M. Glenn and J. Van Sickle. 1981. Scheduling for optimum use. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.61-72.

Ewart, G.Y. 1951. The mechanics of field irrigation scheduling utilizing Bouyoucos blocks. Agricultural

Engineering. March, 1951. pp.148-151.

Fereres, E., R.E. Goldfien, W.O. Pruitt, D.W. Henderson and R.M. Hagan. 1981. The irrigation management program:a new approach to computer-assisted irrigation scheduling. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp-202-207.

Fischbach, P.E. 1981. A comparision of various irrigation scheduling procedures with corn. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.166-170.

Gear, R.D., A.S. Dransfield and M.D. Campbell. 1977. Irrigation scheduling with neutron probe. Amer. Soc. Civil Eng. J. Irrig. and Drain. Div. 18(IR3):291-298.

Harrington, G.J. and D.F. Heerman. 1981. State of the art irrigation scheduling computer program. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.171-178.

Hatfield, J.L. 1981. Irrigation scheduling with thermal infrared and spectral remote sensing inputs. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.10-17.

Hiler, E.A., T.A. Howell, R.B. Lewis and R.P Boss. 1974. Irrigation timing by stress-day index method. Trans. ASAE. 1974. Vol. 17. Number 3. pp.393-398.

Hobbs, E.H. and K.K. Krogman. 1970. Evaluation of a method of irrigation scheduling. Can. Agr. Eng. 12(1):25-27.

Jensen, M.E. 1969. Scheduling irrigation using computers. J. Soil and Water Conser. 24(8):193-195.

Jensen, M.C., J.E. Middleton and W.O. Pruitt. 1961. Scheduling irrigation from pan evaporation. Circular 386. Washington Agricultural Experiment Station. 1961. 14p.

Jensen, M.E. and H.R. Haise. 1963. Estimating evapotranspiration from solar radiation. Amer. Soc. of

Civil Eng. J. Irrig. and Drain. Div. ASCE. 96(IR1):25-29.

Jensen, M.E. and D.F. Heermann. 1970. Meteorological approaches to irrigation scheduling. ASAE. National Irrigation Symposium. Proc. Lincoln, Nebraska. November, 1970. PP.NN-1 to NN-10.

Jensen, M.E., C.N. Robb and C.E. Franzoy. 1970. Scheduling irrigations using climate-crop-soil data. Amer. Soc. Civil Eng. J. Irrig. and Drain. Div. 96(IR1):25-38.

Lambert, J.R., C.W. Doty and V.L. Quisenberry. 1981. Irrigation scheduling in humid areas. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.132-143.

Lundstrom, D.R., E.C. Stegman and H.D. Werner. 1981. Irrigation scheduling by the checkbook method. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.187-193.

McKenzie, R.H. and D.S. Chanasyk. 1981. On-farm irrigation scheduling in southern Alberta. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.219-224.

Merriam, J.L. 1960. Field method of approximating soil moisture for irrigation. Trans. ASAE. 1960. pp.31-32.

National Engineering Handbook. Section(15). 1964. Irrigation. Soil Conservation Service, United States Department of Agriculture. pp.1-66 to 1-71.

Phene, C.J., J.L. Fouss, T.A. Howell, S.H. Patton, M.W. Fisher, J.O. Bratcher, and J.L. Rose. 1981. Scheduling and monitoring irrigation with the new soil matric potential sensor. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.91-105.

Pitney, M. 1977. Scheduling and monitoring irrigation with infra-red photography. Irrigation Association Annual Tech. Conference. Proc. February, 1977. pp.13-15.

Pruitt, W.O. 1956. Irrigation scheduling guide. Agricultural Engineering. March, 1956. pp.180-181.

Pruitt, W.O. and M.C. Jensen. 1955. Determining when to irrigate. Agricultural Engineering. June, 1955. pp.389-393.

Reicosky, D.C. 1981. A research tool for evapotranspiration measurements for model validation and irrigation scheduling. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.74-80.

Rhoades, J.C., D.L. Corwin and G.F. Hoffman. 1981. Scheduling and controlling irrigations from measurements of soil electrical conductivity. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.106-115.

Sims, J.R. and G.D. Jackson. 1971. Field measurements of pan evaporation. Agron. J. 71:pp.339-340.

Slack, D.C., K.M. Geiser, K.W. Stange, and E.R. Allred. 1981. Irrigation scheduling in sub-humid areas with infrared thermemetry. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.106-115.

Statistical Analysis System. 1979. SAS User's Guide. SAS Institute Inc., Raleigh, N.C.

Stegman, E.L. and L.D. Ness. 1974. Evaluation of alternative scheduling schemes for the centre-pivot sprinkler systems. North Dakota Agricultural Exp. Station Research Project Report No. 48. North Dakota State University. Fargo, North Dakota.

Van Bavel, C.H.M. and T.V. Wilson. 1952. Evapotranspiration estimates as criteria for determining time of irrigation. Agricultural Engineering. July, 1952. pp.417-420..

Westesen, G.L. and T.L. Hanson. 1981. Irrigation scheduling using washtub evaporation pans. Proc. ASAE. Irrigation scheduling conference. Chicago. December, 1981. pp.144-149.

Wilcox, J.C. 1970. Credit to give for an irrigation when scheduling irrigations. Can. Agr. Eng. 12(1):28-32.

Woodruff, C.M., M.R. Peterson, D.H. Schnarre and C.F. Cromwell. 1972. Irrigation scheduling with planned soil soil moisture depletion. Paper presented at ASAE. Winter Meeting. Chicago. Paper No. 72-772.

World Meteorological Organisation. 1966. Tech. Note. Number 83.

Wright, J.L. and M.E. Jensen. 1978. Development and evaluation of evapotranspiration models for irrigation scheduling. Trans. ASAE. 1978. Vol. 15. Number 1. pp.127-135.

FIGURES

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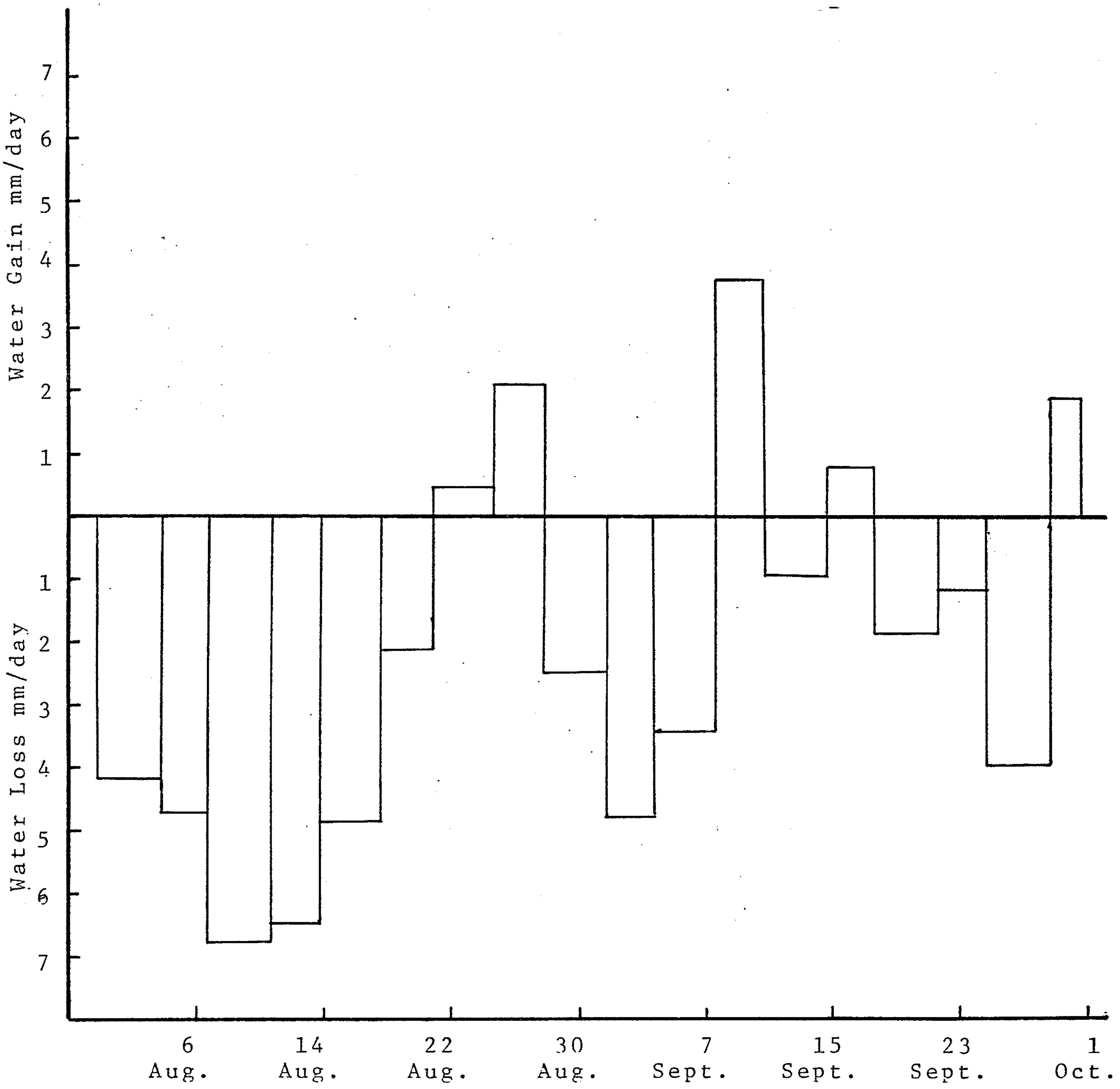

Fig. 1. Average Daily Water Loss or Gain in the Above Ground Washtub (the Point)

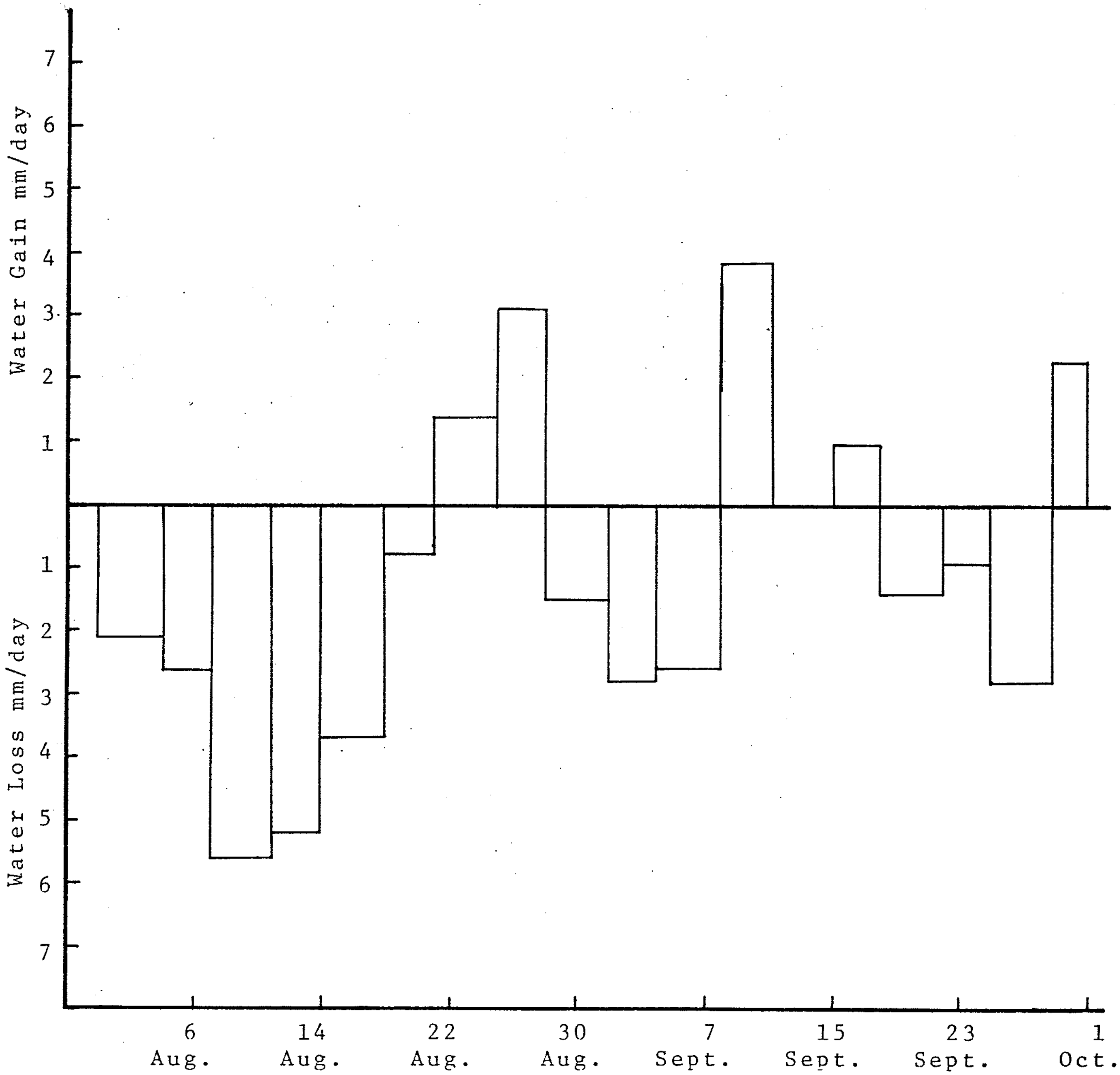

Fig. 2. Average Daily Water Loss or Gain in the Sunken Washtub (the Point)

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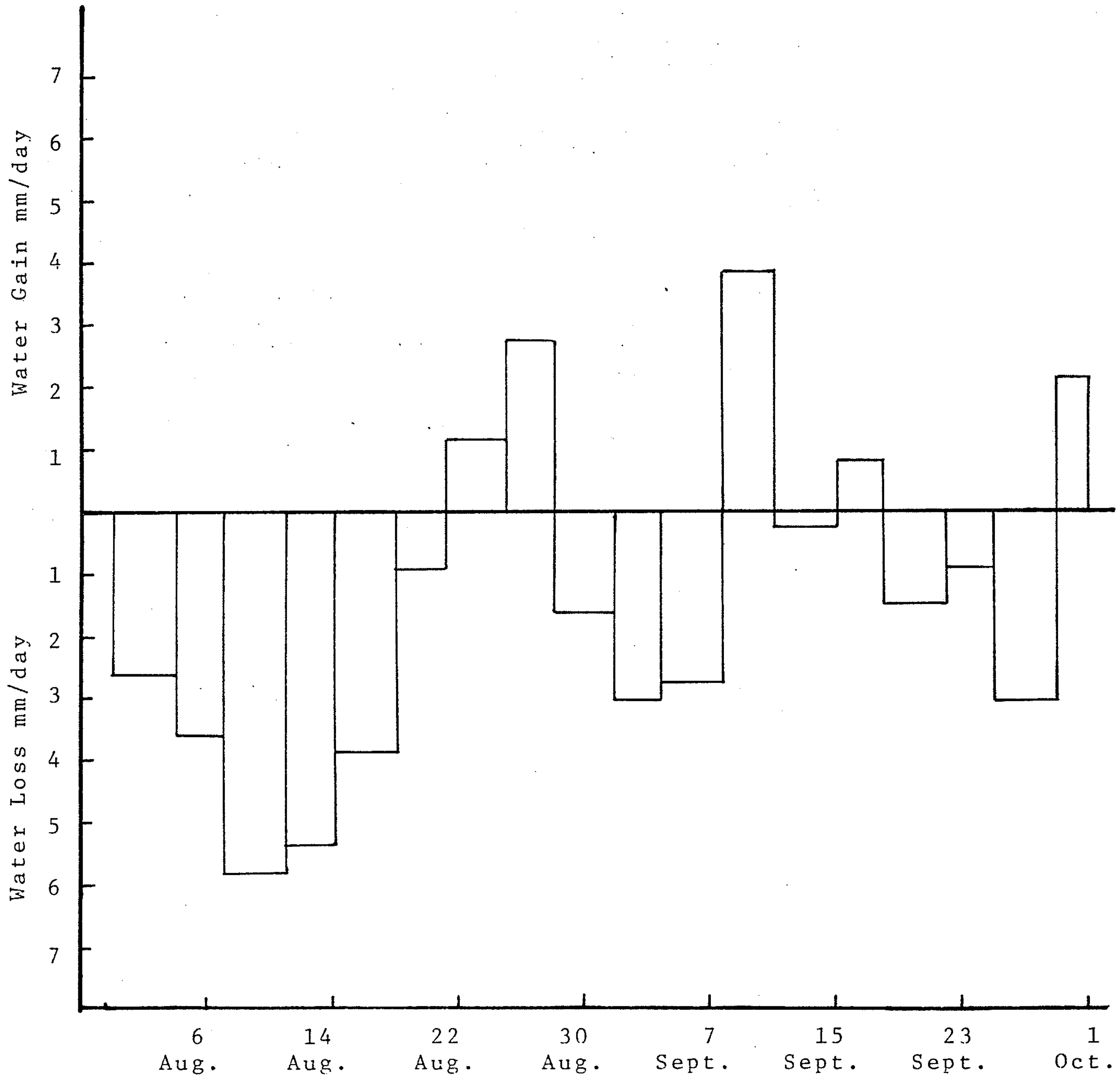

Fig. 3. Average Daily Water Loss or Gain in the Insulated Washtub (the Point)

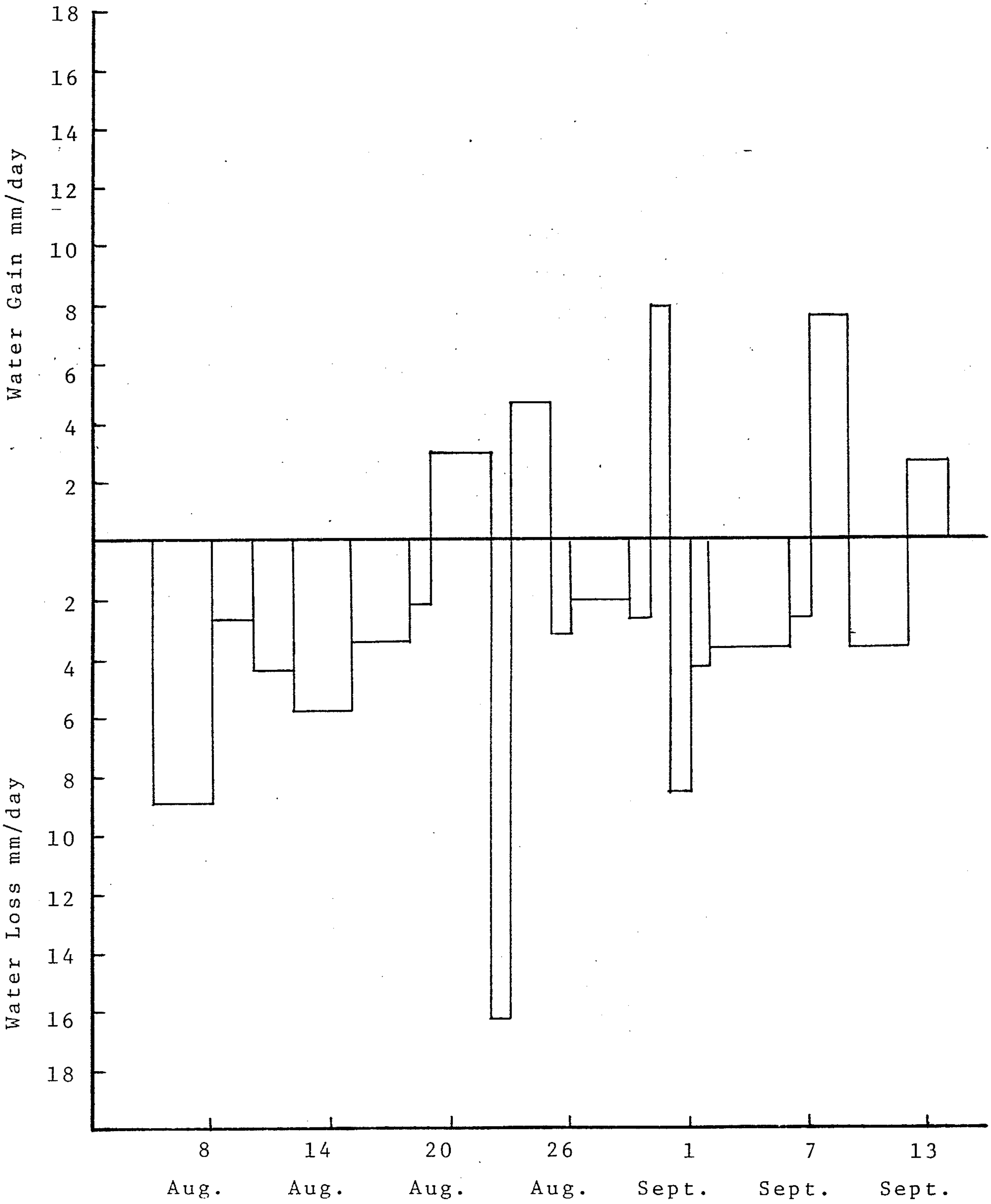

Fig. 4. Average Daily Water Loss or Gain in the Above Ground Washtub (Portage la Prairie)

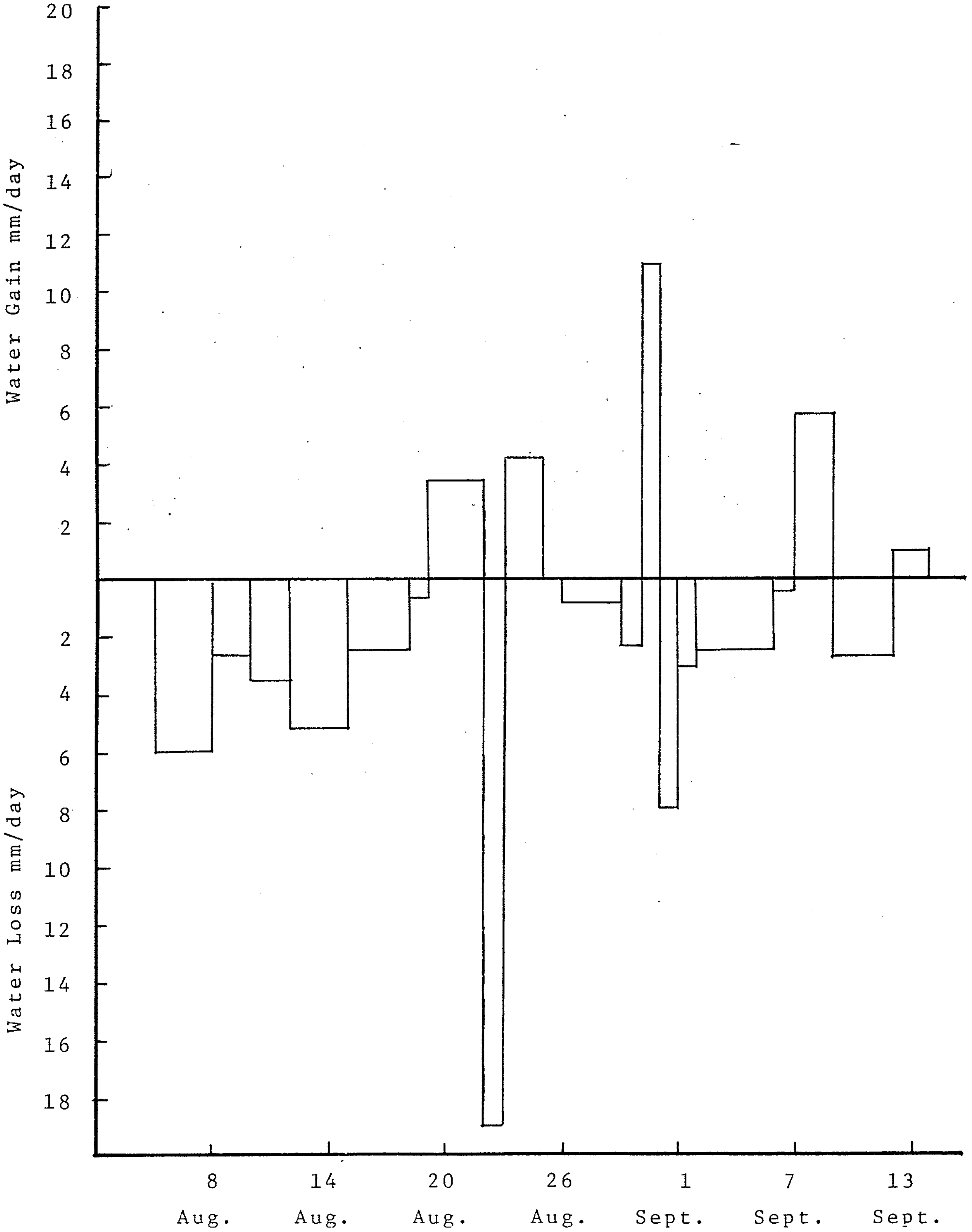

Fig. 5. Average Daily Water Loss or Gain in the Sunken Washtub (Portage la Prairie)

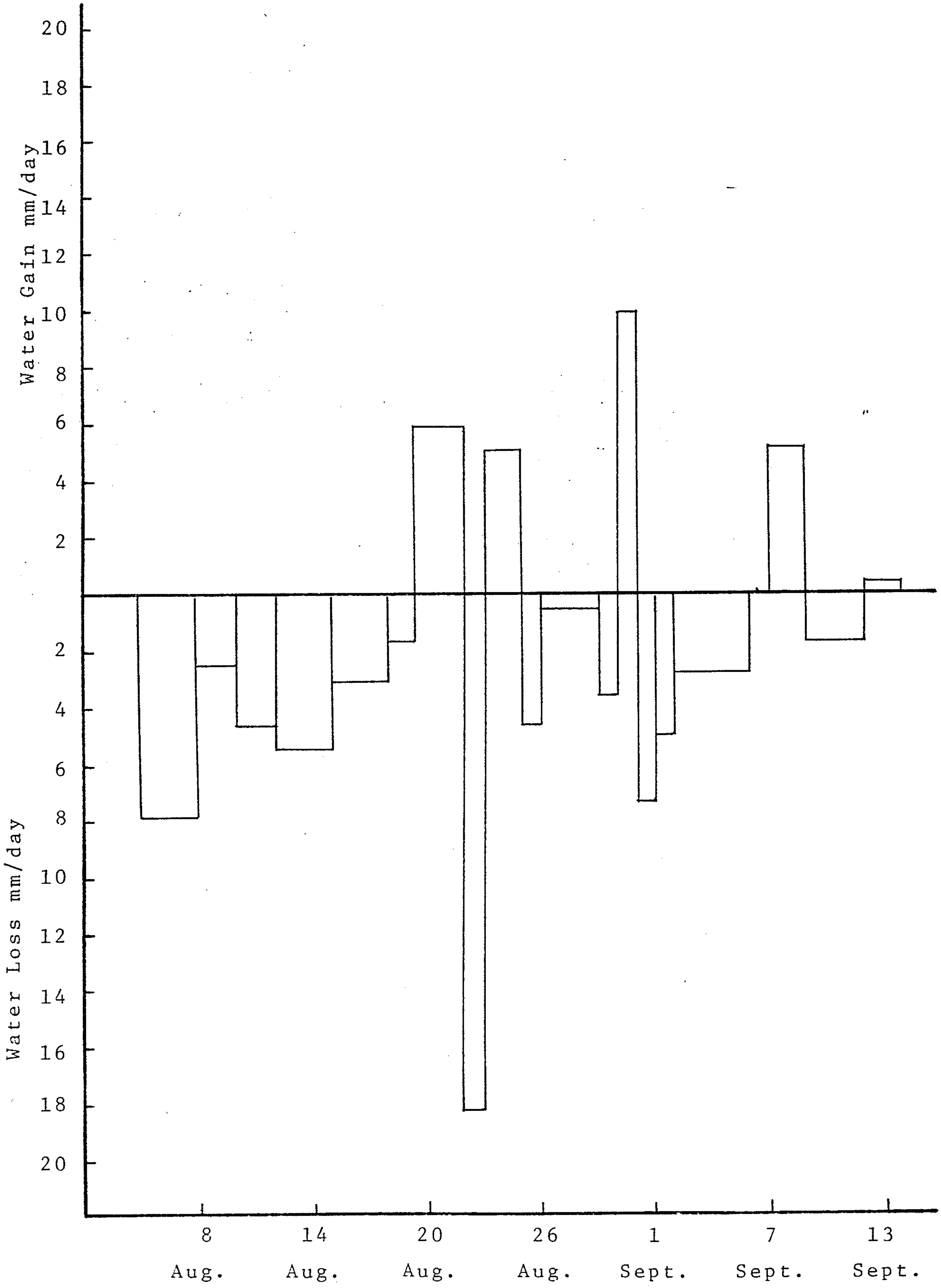

Fig. 6. Average Daily Water Loss or Gain in the Insulated Washtub (Portage la Prairie)

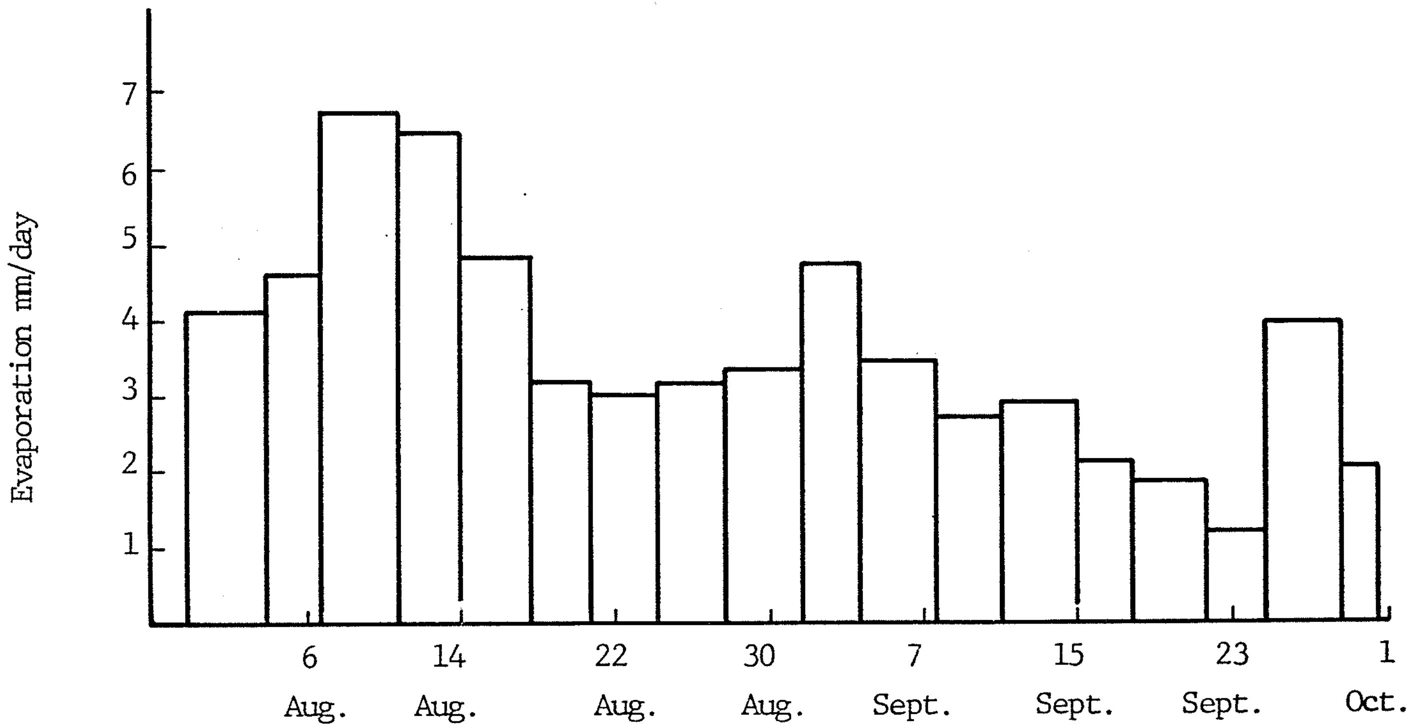

Fig. 7. Average Daily Evaporation from the Above Ground Washtub (the Point)

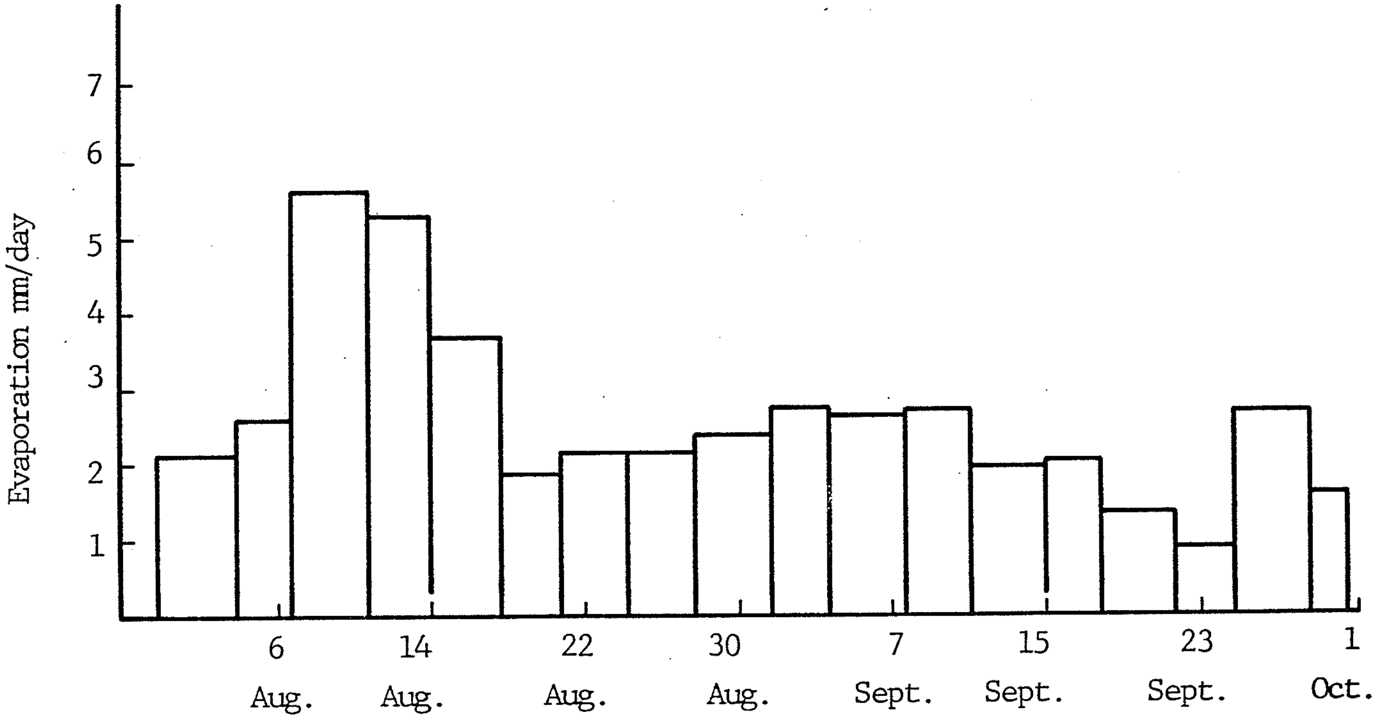

Fig. 8. Average Daily Evaporation from the Sunken Washtub (the Point)

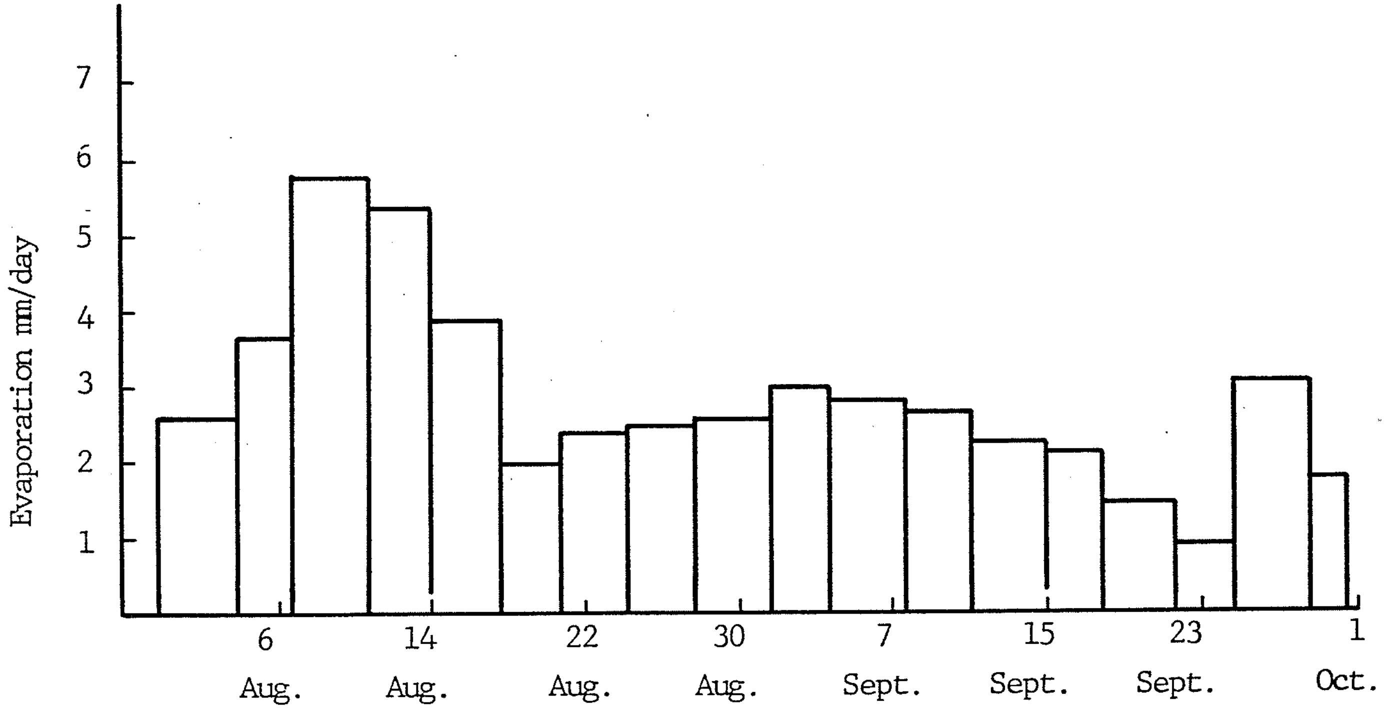

Fig. 9. Average Daily Evaporation from the Insulated Washtub (the Point)

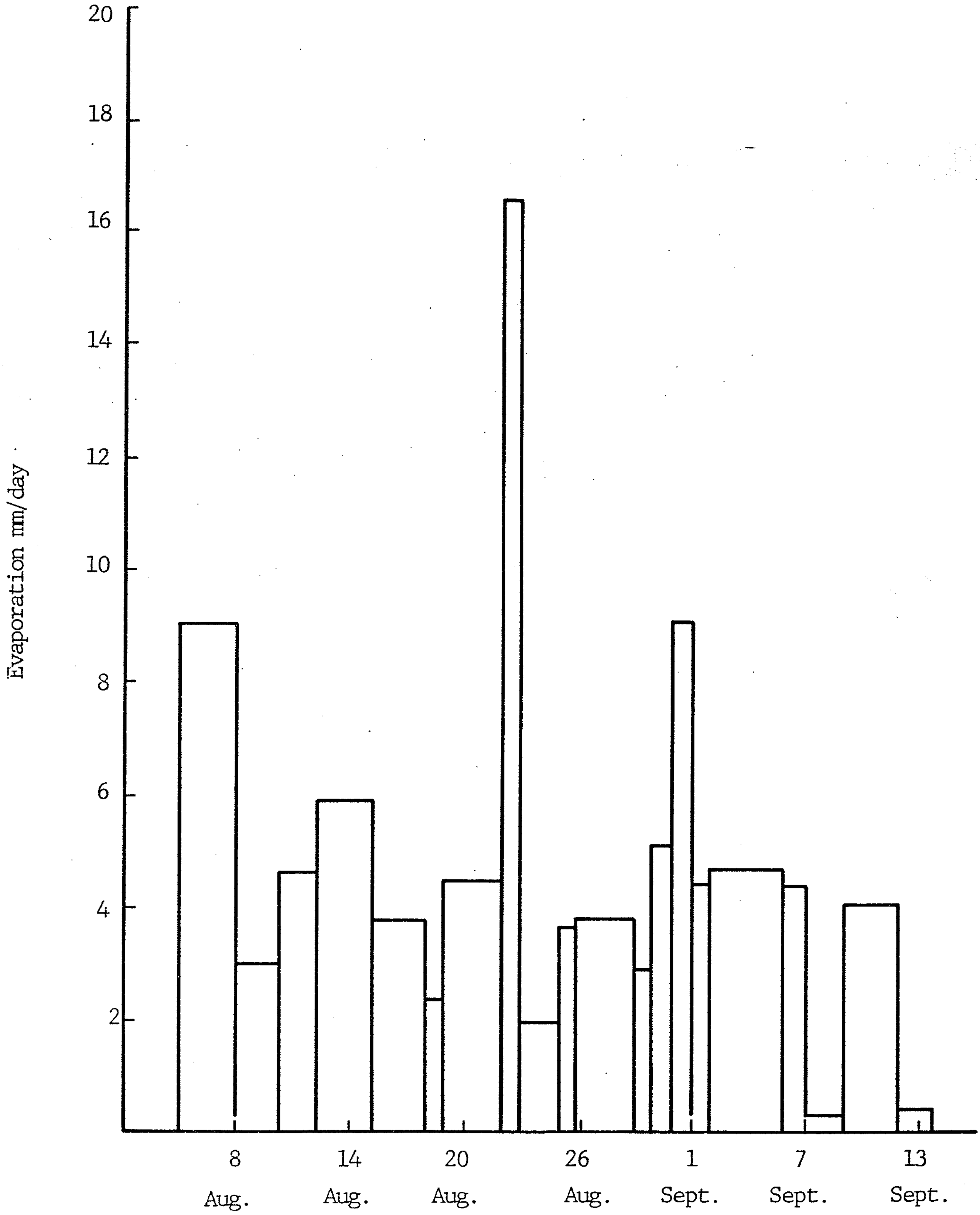

Fig. 10. Average Daily Evaporation from the Above Ground Washtub (Portage la Prairie)

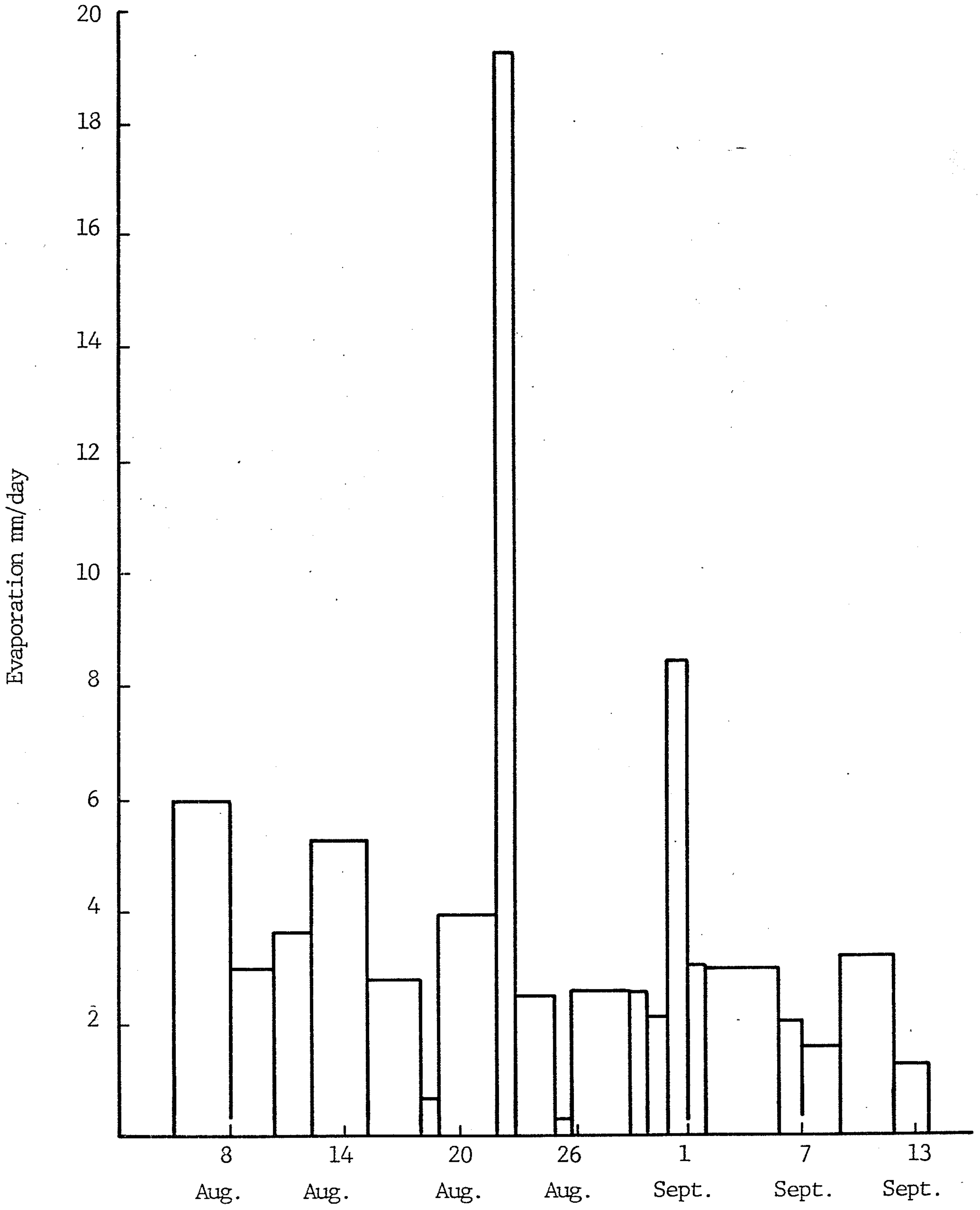

Fig.11. Average Daily Evaporation from the Sunken Washtub (Portage la Prairie)

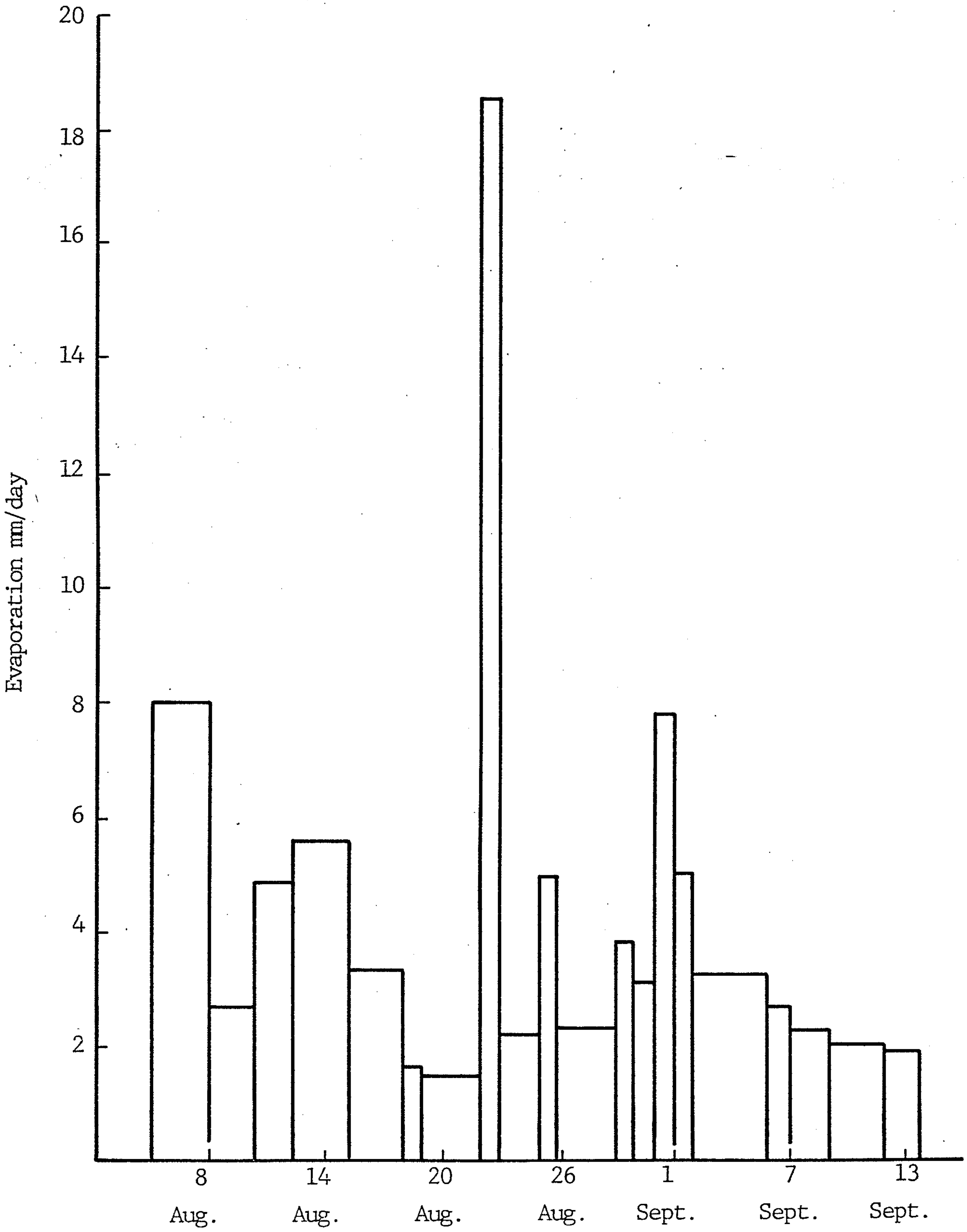

Fig. 12. Average Daily Evaporation from the Insulated Washtub (Portage la Prairie)

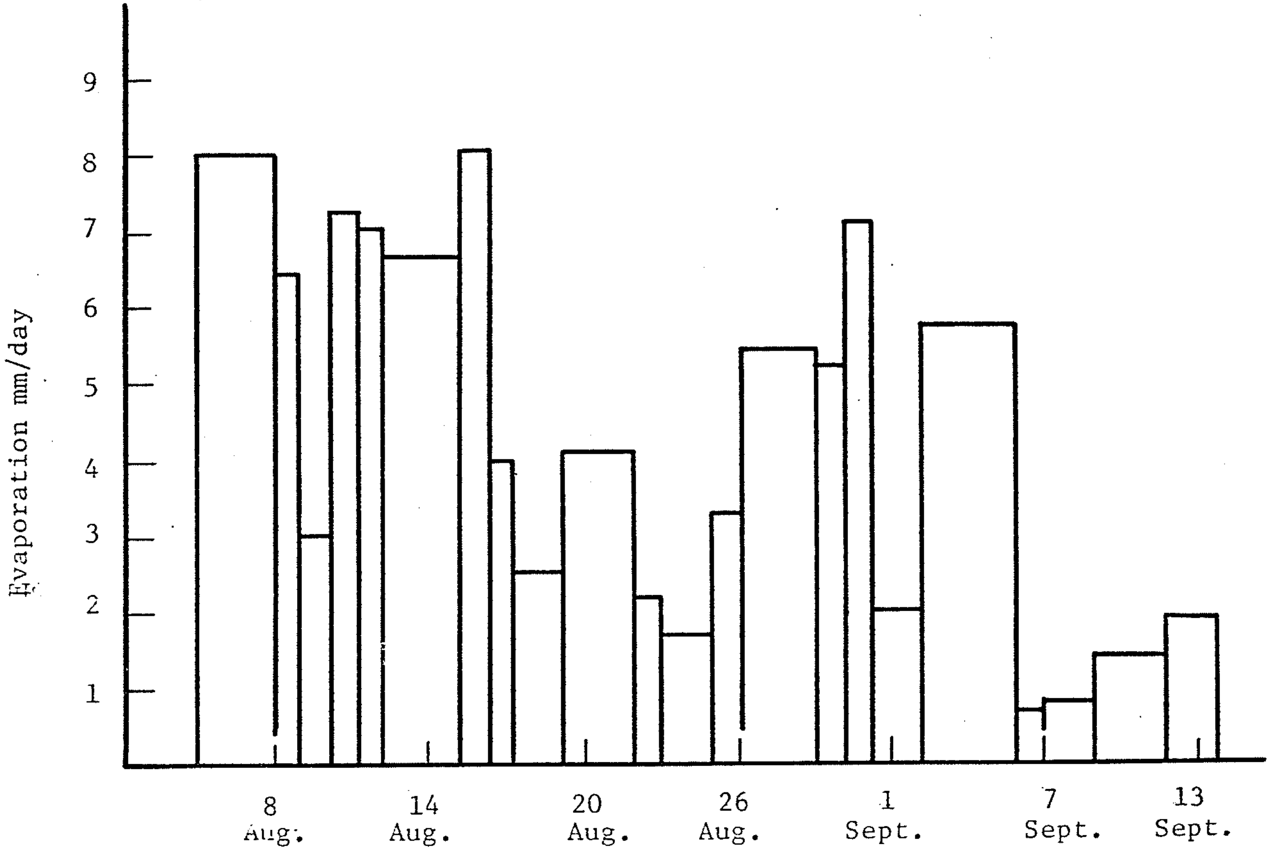

Fig. 13. Average Daily Evaporation from the Class A Evaporation Pan (Portage la Prairie)

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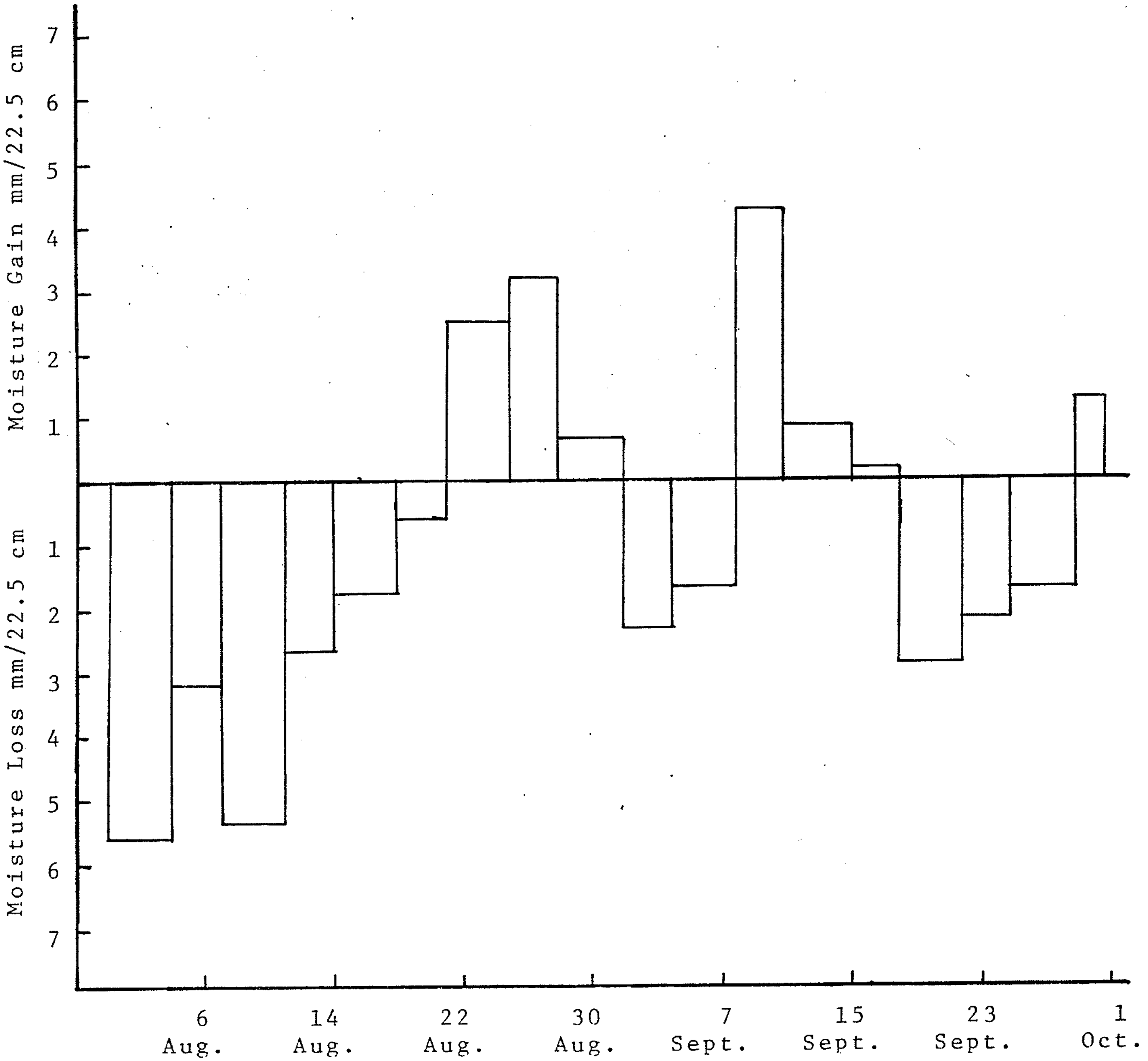

Fig. 14. Average Daily Depth of Soil Moisture Depletion or Gain from 0.0 cm to 22.5 cm (the Point)

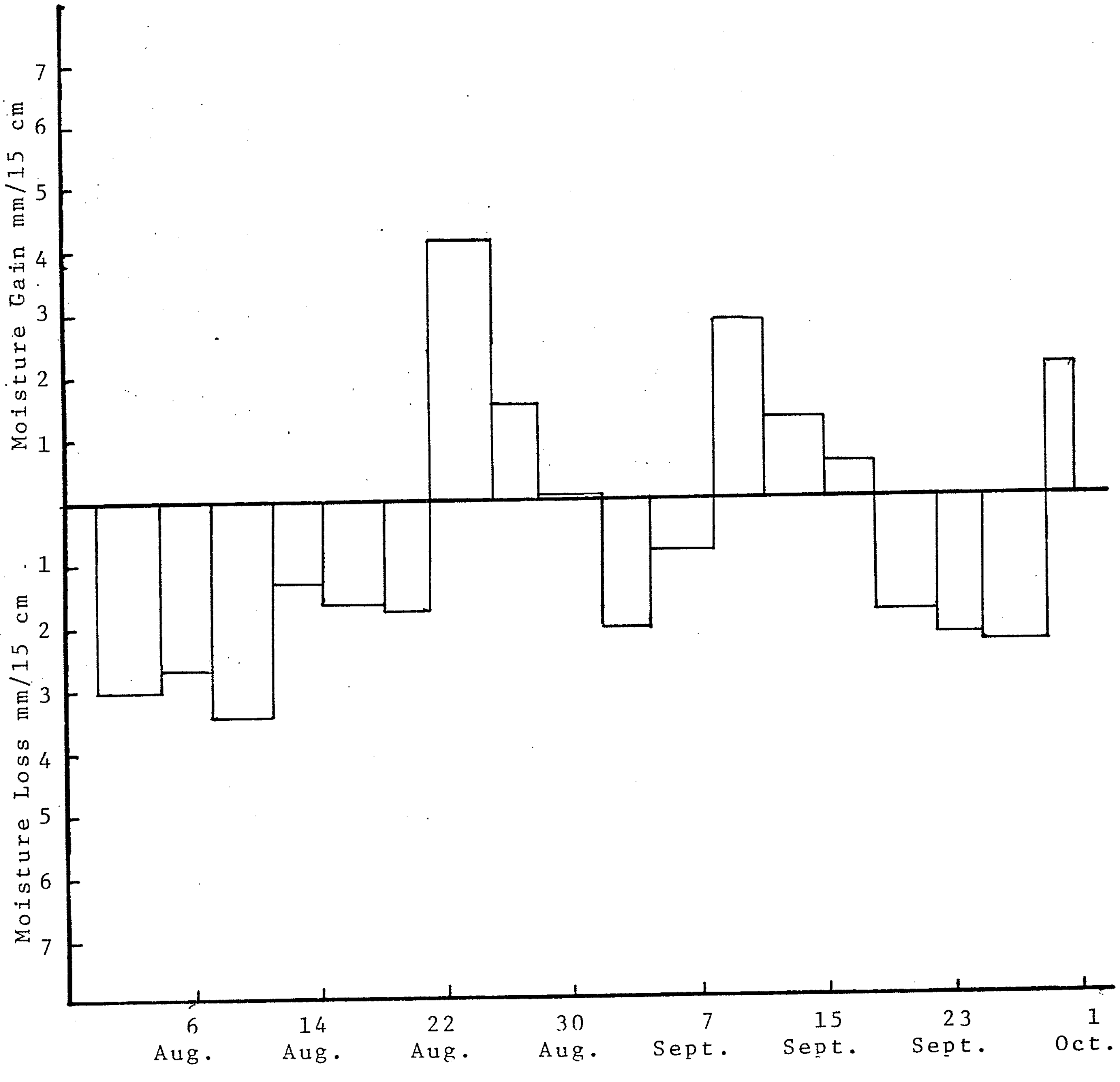

Fig. 15. Average Daily Depth of Soil Moisture Depletion or Gain from 22.5 cm to 37.5 cm (the Point)

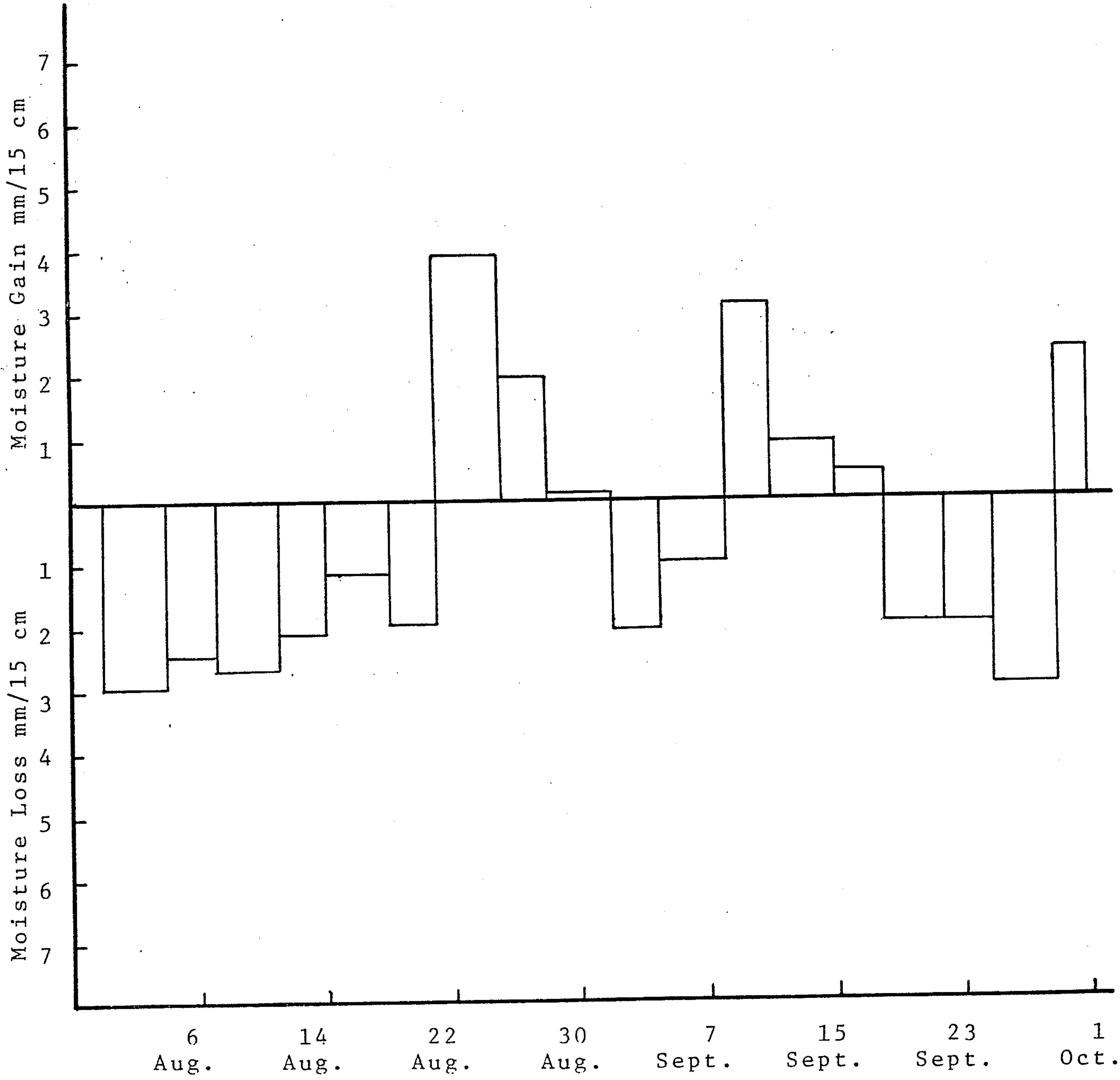

Fig. 16. Average Daily Depth of Soil Moisture Depletion or Gain from 37.5 cm to 52.5 cm (the Point)

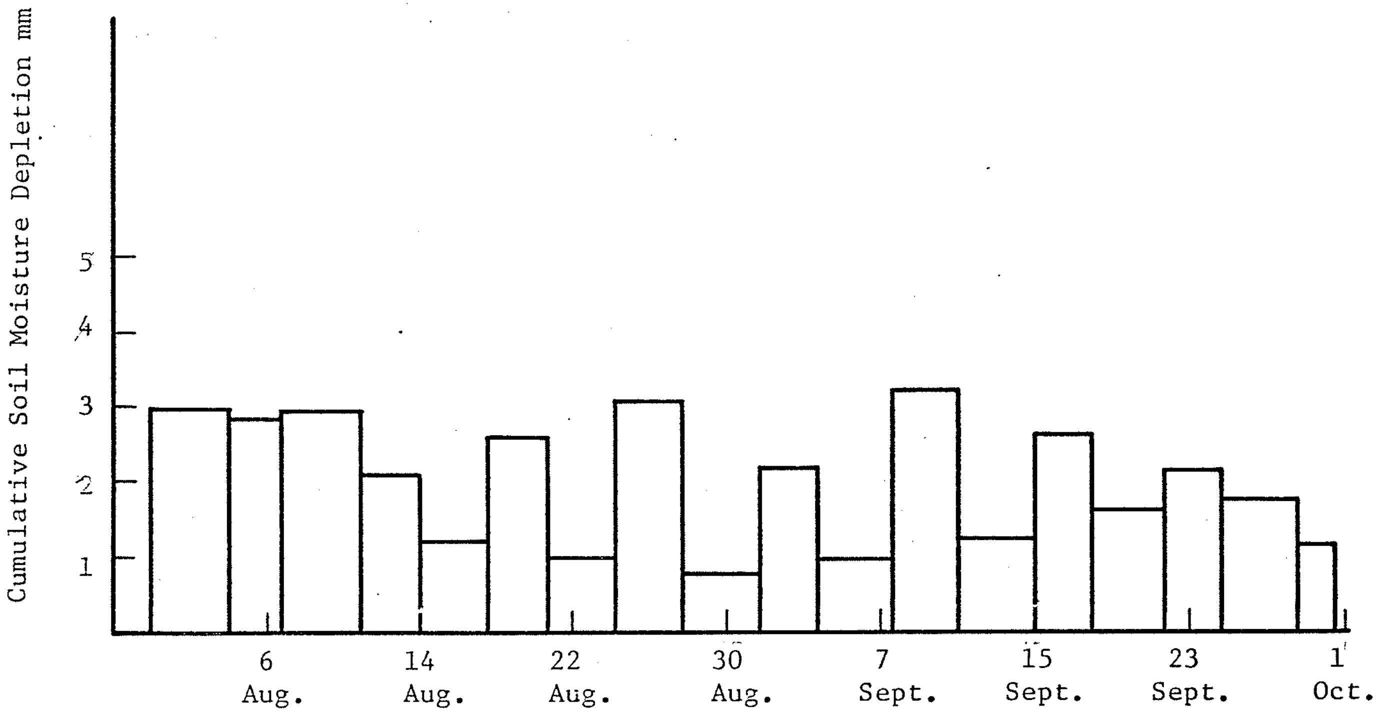

Fig. 17. Average Daily Cumulative Depth of Soil Moisture Depletion from 0.0 cm to 52.5 cm (the Point)

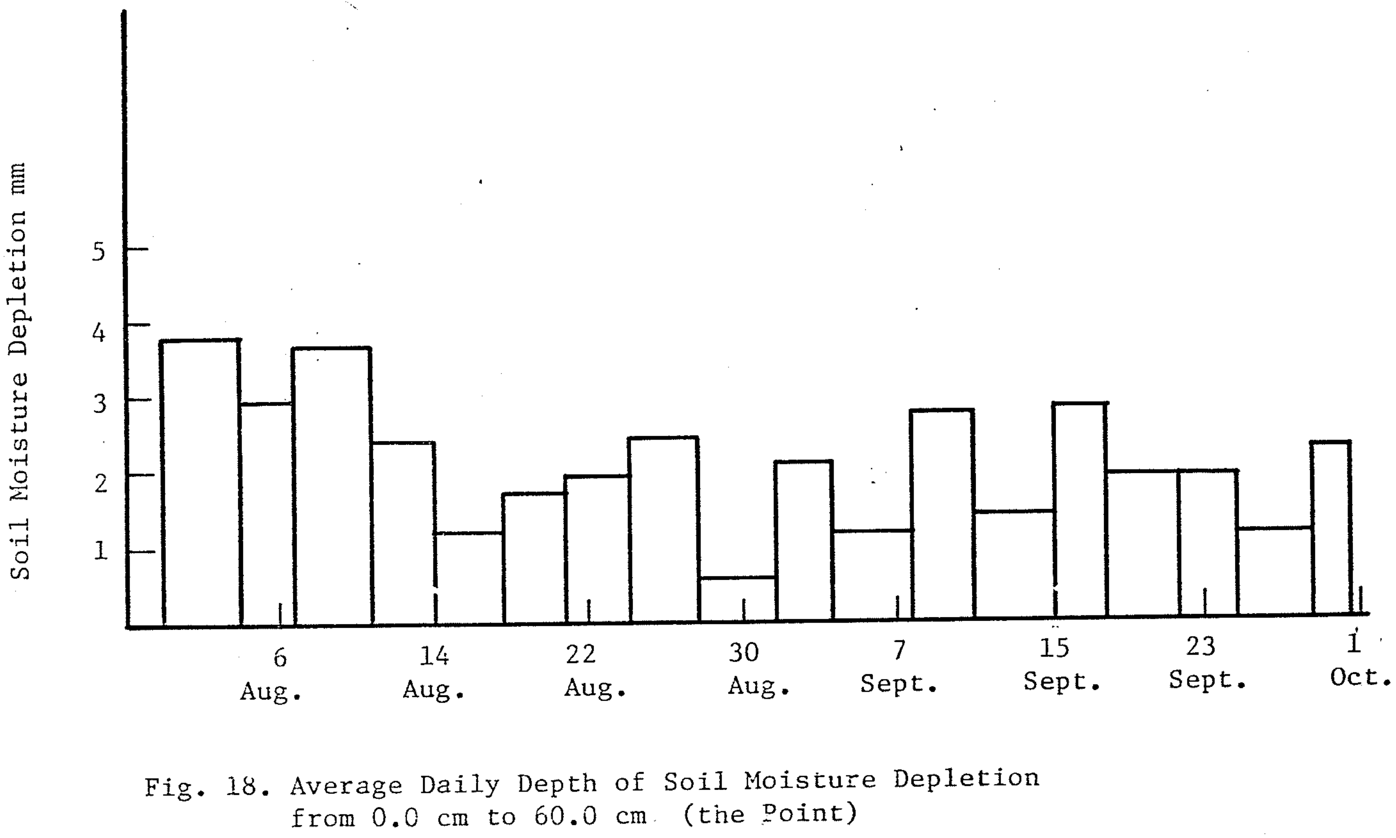

Fig. 18. Average Daily Depth of Soil Moisture Depletion from 0.0 cm to 60.0 cm (the Point)

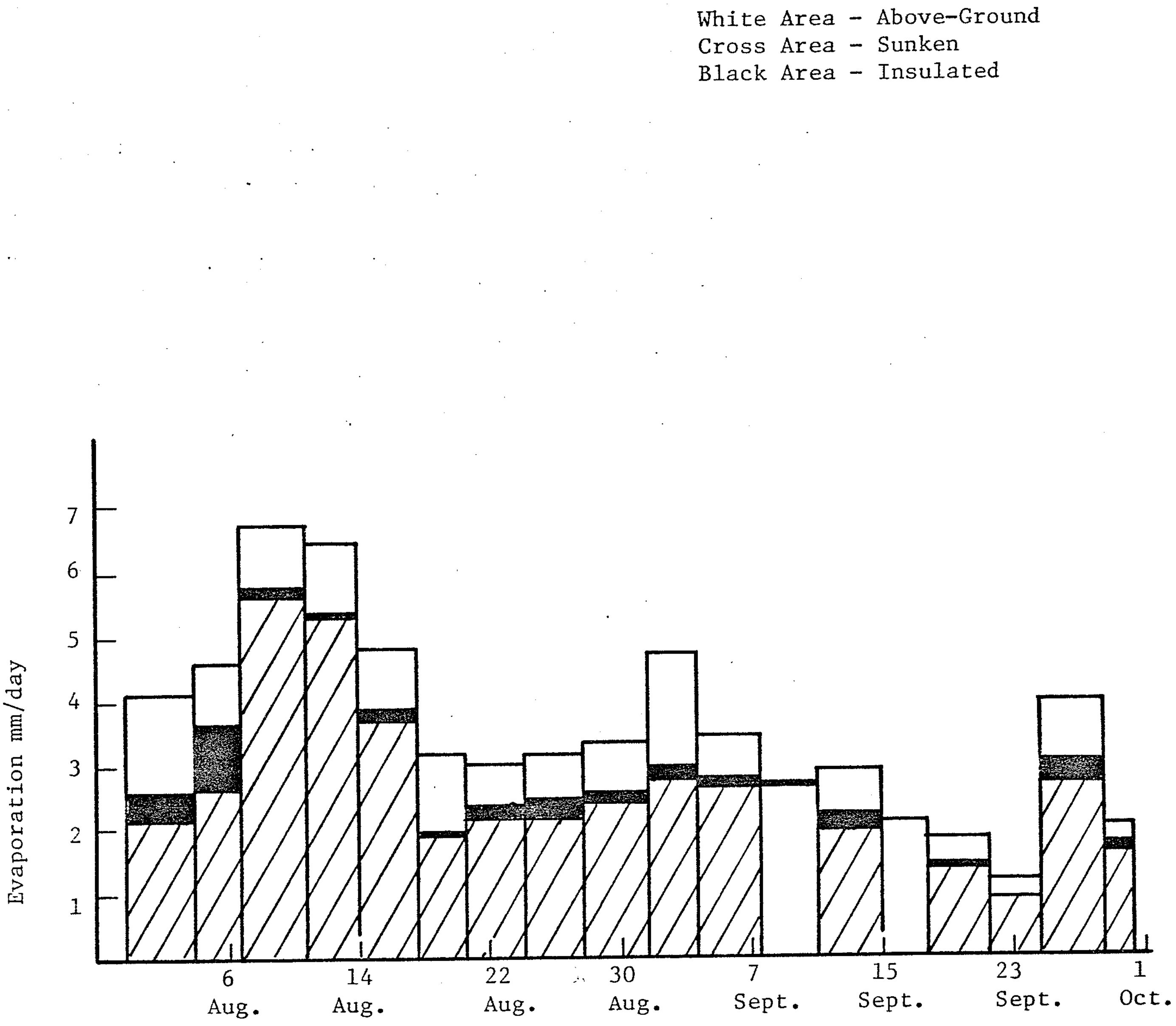

Fig. 19. Average Daily Evaporation from the Above-Ground, Sunken and Insulated Washtubs (the Point)

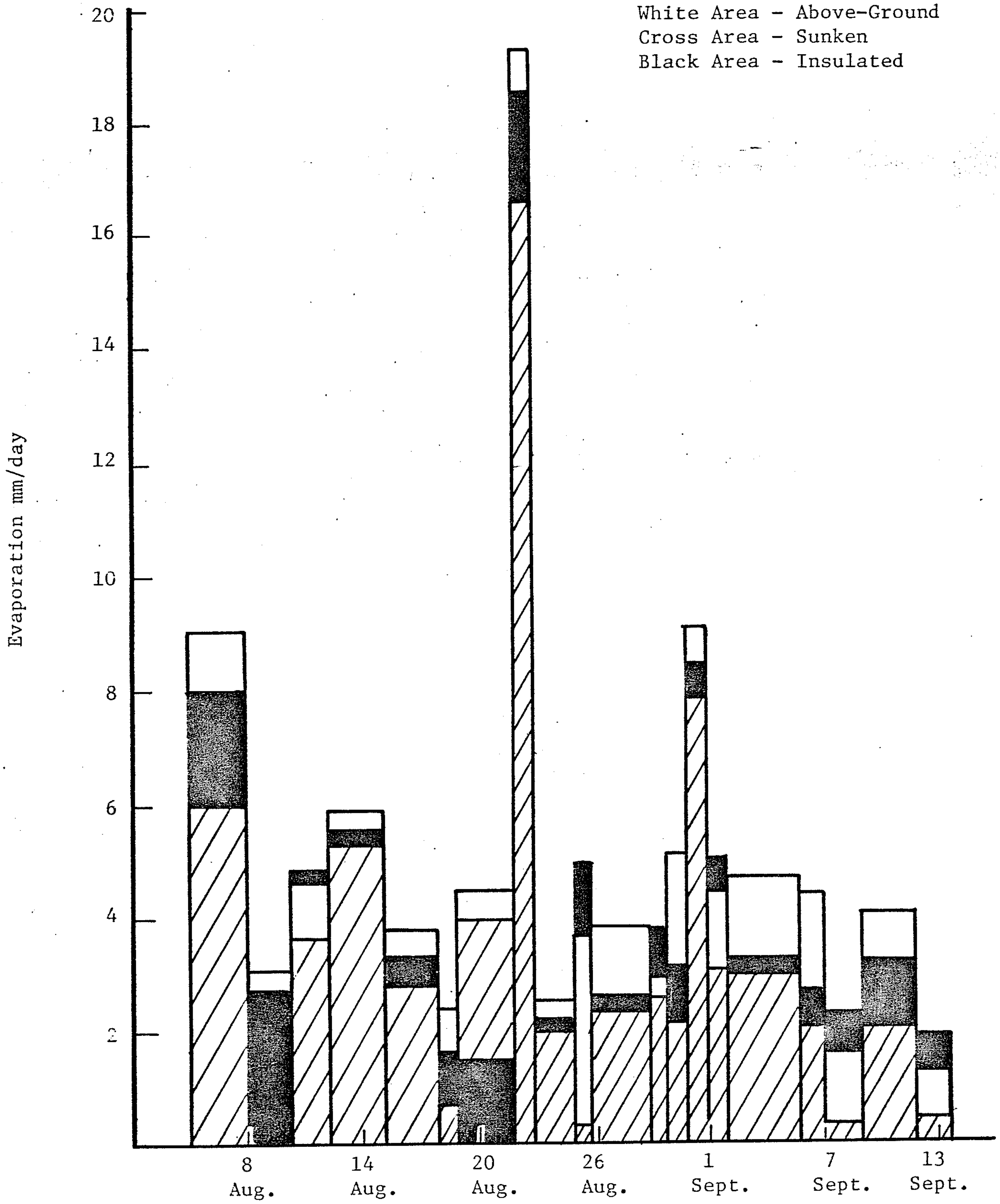

Fig. 20. Average Daily Evaporation from the Above-Ground, Sunken and Insulated Washtubs (the Point)

TABLES

TABLE 1. DROP IN WATER LEVEL

ABOVE-GROUND WASHTUB

THE POINT

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
02 AUG.	4	17.00	16.00	17.00	16.67
05 AUG.	3	15.00	14.00	13.00	14.00
09 AUG.	4	28.00	26.00	27.00	27.00
12 AUG.	3	19.00	19.00	20.00	19.34
16 AUG.	4	19.00	20.00	19.00	19.34
19 AUG.	3	06.00	06.00	07.00	06.33
23 AUG.	4	(03.00)	(02.00)	(01.00)	(02.00)
26 AUG.	3	(06.00)	(06.00)	(07.00)	(06.33)
30 AUG.	4	10.00	09.00	10.00	09.67
02 SEPT.	3	14.00	14.00	15.00	14.33
06 SEPT.	4	14.00	14.00	13.00	13.66
09 SEPT.	3	(11.00)	(11.00)	(12.00)	(11.33)
13 SEPT.	4	04.00	03.00	05.00	04.00
16 SEPT.	3	(02.00)	(02.00)	(03.00)	(02.33)
20 SEPT.	4	08.00	08.00	07.00	07.66
23 SEPT.	3	04.00	04.00	03.00	03.66
27 SEPT.	4	15.00	16.00	17.00	16.00
29 SEPT.	2	(04.00)	(03.00)	(04.00)	(03.67)

* Figure in parentheses indicate rise of water level in the washtub.

NOTE : Observations as of 29 July, when water level in the washtub was at 22 cm.

TABLE 2. DROP IN WATER LEVEL

SUNKEN WASHTUB

THE POINT

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
02 AUG.	4	08.00	08.00	09.00	08.33
05 AUG.	3	08.00	08.00	07.00	07.66
09 AUG.	4	23.00	22.00	22.00	22.33
12 AUG.	3	16.00	16.00	15.00	15.66
16 AUG.	4	15.00	15.00	14.00	14.66
19 AUG.	3	02.00	01.00	04.00	02.33
23 AUG.	4	(05.00)	(06.00)	(06.00)	(05.66)
26 AUG.	3	(09.00)	(09.00)	(10.00)	(09.33)
30 AUG.	4	07.00	06.00	05.00	06.00
02 SEPT.	3	09.00	08.00	08.00	08.33
06 SEPT.	4	10.00	11.00	10.00	10.33
09 SEPT.	3	(12.00)	(11.00)	(12.00)	(11.66)
13 SEPT.	4	00.00	00.00	00.00	00.00
16 SEPT.	3	(03.00)	(03.00)	(02.30)	(02.77)
20 SEPT.	4	04.00	06.00	06.00	05.33
23 SEPT.	3	03.00	03.00	02.00	02.66
27 SEPT.	4	11.00	12.00	10.00	11.00
29 SEPT.	2	(05.00)	(05.00)	(04.00)	(04.66)

* Figures in parentheses indicate rise of water level in the washtub.

<u>NOTE</u> : Observations as of 29 July, when water level in the washtub was at 22 cm.

TABLE 3. DROP IN WATER LEVEL

INSULATED WASHTUB

THE POINT

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
02 AUG.	4	10.00	11.00	10.00	10.33
05 AUG.	3	12.00	10.00	10.00	10.66
09 AUG.	4	24.00	23.00	22.00	23.00
12 AUG.	3	16.00	16.00	16.00	16.00
16 AUG.	4	14.00	16.00	16.00	15.33
19 AUG.	3	03.00	03.00	02.00	02.66
23 AUG.	4	(05.00)	(05.00)	(04.00)	(04.66)
26 AUG.	3	(08.00)	(09.00)	(08.00)	(08.33)
30 AUG.	4	07.00	06.00	06.00	06.33
02 SEPT.	3	09.00	09.00	09.00	09.00
06 SEPT.	4	11.00	11.00	11.00	11.00
09 SEPT.	3	(12.00)	(12.00)	(11.00)	(11.66)
13 SEPT.	4	01.00	01.00	01.00	01.00
16 SEPT.	3	(02.60)	(02.60)	(02.30)	(02.50)
20 SEPT.	4	05.00	06.00	05.00	05.66
23 SEPT.	3	03.00	02.00	03.00	02.66
27 SEPT.	4	12.00	12.00	12.00	12.00
29 SEPT.	2	(04.00)	(04.00)	(05.00)	(04.33)

* Figures in parentheses indicate rise of water level in the washtub.

<u>NOTE</u> : Observations as of 29 July, when water level in the washtub was at 22 cm.

TABLE 4. DROP IN WATER LEVEL

ABOVE-GROUND WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
08 AUG.	3	21.00	20.00	40.00	27.00
10 AUG.	2	07.00	04.00	-----	05.50
12 AUG.	2	08.00	10.00	-----	09.00
15 AUG.	3	19.00	17.00	17.00	17.66
18 AUG.	3	11.00	12.00	09.00	10.66
19 AUG.	1	03.00	02.00	02.00	02.33
22 AUG.	3	(17.00)	(15.00)	05.00	(09.00)
23 AUG.	1	16.00	15.00	18.00	16.33
25 AUG.	2	(05.00)	(19.00)	(04.00)	(09.33)
26 AUG.	1	01.00	04.00	05.00	03.33
29 AUG.	3	08.00	05.00	05.00	06.00
30 AUG.	1	02.00	05.00	01.00	03.66
31 AUG.	1	(08.00)	(10.00)	(06.00)	(08.00)
01 SEPT.	1	08.00	09.00	09.00	08.66
02 SEPT.	1	06.00	04.00	03.00	04.33
06 SEPT.	4	11.00	20.00	14.00	15.00
07 SEPT.	1	02.00	05.00	01.00	02.66
09 SEPT.	2	(07.00)	(07.00)	(32.00)	(15.33)
12 SEPT.	3	14.00	08.00	11.00	11.00
14 SEPT.	2	(07.00)	(04.00)	(05.00)	(05.33)

* Figures in parentheses indicate rise; ---- No readings recorded of water level in the washtub.

<u>NOTE</u> : Observations as of 05 Aug.,when water level in the washtub was at 22 cm.

TABLE 5. DROP IN WATER LEVEL

SUNKEN WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
08 AUG.	3	14.00	15.00	25.00	18.00
10 AUG.	2	06.00	05.00	-----	05.50
12 AUG.	2	07.00	07.00	-----	07.00
15 AUG.	3	14.00	18.00	15.00	15.66
18 AUG.	3	02.00	12.00	09.00	07.66
19 AUG.	1	01.00	00.00	01.00	00.66
22 AUG.	3	(17.00)	(19.00)	04.00	(10.66)
23 AUG.	1	18.00	19.00	20.00	19.00
25 AUG.	2	(01.00)	(19.00)	(20.00)	(19.00)
26 AUG.	1	00.00	00.00	00.00	00.00
29 AUG.	3	01.00	02.00	04.00	02.33
30 AUG.	1	02.00	04.00	01.00	02.33
31 AUG.	1	(13.00)	(13.00)	(07.00)	(11.00)
01 SEPT.	1	04.00	12.00	08.00	08.00
02 SEPT.	1	06.00	00.00	03.00	03.00
06 SEPT.	4	08.00	12.00	10.00	10.00
07 SEPT.	1	00.00	01.00	00.00	00.33
09 SEPT.	2	(04.00)	(05.00)	(26.00)	(11.66)
12 SEPT.	3	08.00	08.00	09.00	08.33
14 SEPT.	2	(04.00)	(01.00)	(02.00)	(02.33)

* Figures in parentheses indicate rise;---- No readings recorded of water level in the washtub.

<u>NOTE</u> : Observations as of 05 Aug.,when water level in the washtub was at 22 cm.

TABLE 6. DROP IN WATER LEVEL

INSULATED WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	INTERVAL DAYS	DROP IN WATER LEVEL (MM) *			
		REP.1	REP.2	REP.3	AVERAGE
08 AUG.	3	18.00	17.00	35.00	23.66
10 AUG.	2	05.00	05.00	-----	05.00
12 AUG.	2	09.00	10.00	-----	09.50
15 AUG.	3	15.00	18.00	17.00	16.66
18 AUG.	3	11.00	11.00	06.00	09.33
19 AUG.	1	01.00	04.00	00.00	01.66
22 AUG.	3	(16.00)	(21.00)	(17.00)	(18.00)
23 AUG.	1	18.00	19.00	18.00	18.33
25 AUG.	2	(02.00)	(23.00)	(06.00)	(10.33)
26 AUG.	1	04.00	05.00	05.00	04.66
29 AUG.	3	05.00	(03.00)	03.00	01.66
30 AUG.	1	02.00	04.00	05.00	03.66
31 AUG.	1	(09.00)	(10.00)	(11.00)	(10.00)
01 SEPT.	1	06.00	08.00	08.00	07.33
02 SEPT.	1	08.00	03.00	04.00	05.00
06 SEPT.	4	09.00	15.00	10.00	11.33
07 SEPT.	1	(02.00)	03.00	(01.00)	00.00
09 SEPT.	2	(03.00)	(03.00)	(26.00)	(10.66)
12 SEPT.	3	09.00	(01.00)	07.00	05.00
14 SEPT.	2	(04.00)	02.00	(01.00)	01.00

* Figures in parentheses indicate rise; ---- No readings recorded of water level in the washtub.

NOTE : Observations as of 05 Aug.,when water level in the washtub was at 22 cm.

TABLE 7. AVERAGE DAILY DROP IN WATER LEVEL

ABOVE-GROUND WASHTUB

THE POINT

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	4.25	4.00	4.25	4.17
05 AUG.	5.00	4.66	4.33	4.66
09 AUG.	7.00	6.50	6.75	6.75
12 AUG.	6.33	6.66	6.33	6.45
16 AUG.	4.75	4.75	5.00	4.84
19 AUG.	2.00	2.00	2.33	2.11
23 AUG.	(0.75)	(0.50)	(0.25)	(0.50)
26 AUG.	(2.00)	(2.00)	(2.33)	(2.11)
30 AUG.	2.50	2.25	2.50	2.42
02 SEPT.	4.66	4.66	5.00	4.77
06 SEPT.	3.50	3.50	3.25	3.41
09 SEPT.	(3.66)	(3.66)	(4.00)	(3.78)
13 SEPT.	1.00	0.75	1.25	1.00
16 SEPT.	(0.66)	(0.66)	(1.00)	(0.77)
20 SEPT.	2.00	2.00	1.75	1.92
23 SEPT.	1.33	1.33	1.00	1.22
27 SEPT.	3.75	4.00	4.25	4.00
29 SEPT.	(2.00)	(1.50)	(2.00)	(1.84)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 8. AVERAGE DAILY DROP IN WATER LEVEL

SUNKEN WASHTUB

THE POINT

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	2.00	2.00	2.25	2.08
05 AUG.	2.66	2.66	2.33	2.56
09 AUG.	5.75	5.50	5.50	5.58
12 AUG.	5.33	5.33	5.00	5.22
16 AUG.	3.75	3.50	3.67	3.50
19 AUG.	0.67	0.33	1.33	0.78
23 AUG.	(1.25)	(1.50)	(1.50)	(1.42)
26 AUG.	(3.00)	(3.00)	(3.33)	(3.11)
30 AUG.	1.75	1.50	1.25	1.50
02 SEPT.	3.00	2.66	2.66	2.77
06 SEPT.	2.50	2.75	2.50	2.58
09 SEPT.	(4.00)	(3.66)	(4.00)	(3.89)
13 SEPT.	0.00	0.00	0.00	0.00
16 SEPT.	(1.00)	(1.00)	(0.76)	(0.92)
20 SEPT.	1.00	1.50	1.50	1.33
23 SEPT.	1.00	1.00	0.66	0.89
27 SEPT.	2.75	3.00	2.50	2.75
29 SEPT.	(2.50)	(2.50)	(2.00)	(2.33)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 9. AVERAGE DAILY DROP IN WATER LEVEL

INSULATED WASHTUB

THE POINT

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	2.50	2.75	2.50	2.58
05 AUG.	4.00	3.33	3.33	3.56
09 AUG.	6.00	5.75	5.50	5.75
12 AUG.	5.33	5.33	5.33	5.33
16 AUG.	3.50	4.00	4.00	3.84
19 AUG.	1.00	1.00	0.67	0.89
23 AUG.	(1.25)	(1.25)	(1.00)	(1.17)
26 AUG.	(2.66)	(3.00)	(2.66)	(2.78)
30 AUG.	1.75	1.50	1.50	1.58
02 SEPT.	3.00	3.00	3.00	3.00
06 SEPT.	2.75	2.75	2.75	2.75
09 SEPT.	(4.00)	(4.00)	(3.66)	(3.89)
13 SEPT.	0.25	0.25	0.25	0.25
16 SEPT.	(0.85)	(0.85)	(0.75)	(0.82)
20 SEPT.	1.25	1.50	1.50	1.42
23 SEPT.	1.00	0.66	1.00	0.89
27 SEPT.	3.00	3.00	3.00	3.00
29 SEPT.	(2.00)	(2.00)	(2.50)	(2.16)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 10. AVERAGE DAILY DROP IN WATER LEVEL

ABOVE-GROUND WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	07.00	06.66	13.33	09.00
10 AUG.	03.50	02.00	-----	02.75
12 AUG.	04.00	05.00	-----	04.50
15 AUG.	06.33	05.66	05.66	05.88
18 AUG.	03.66	04.00	03.00	03.55
19 AUG.	03.00	02.00	02.00	02.33
22 AUG.	(05.66)	(05.00)	01.66	(03.00)
23 AUG.	16.00	15.00	18.00	16.33
25 AUG.	(02.50)	(09.50)	(02.00)	(04.66)
26 AUG.	01.00	04.00	05.00	03.33
29 AUG.	02.66	01.66	01.66	02.00
30 AUG.	02.00	05.00	01.00	02.66
31 AUG.	(08.00)	(10.00)	(06.00)	(08.00)
01 SEPT.	08.00	09.00	09.00	08.66
02 SEPT.	06.00	04.00	03.00	04.33
06 SEPT.	02.75	05.00	03.50	03.75
07 SEPT.	02.00	05.00	01.00	02.66
09 SEPT.	(03.50)	(03.50)	(16.00)	(07.66)
12 SEPT.	04.66	02.66	03.66	03.66
14 SEPT.	(03.50)	(02.00)	(02.50)	(02.66)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 11. AVERAGE DAILY DROP IN WATER LEVEL

SUNKEN WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	04.66	05.00	08.33	06.00
10 AUG.	03.00	02.50	-----	02.75
12 AUG.	03.50	03.50	-----	03.50
15 AUG.	04.66	06.00	05.00	05.22
18 AUG.	00.66	04.00	03.00	02.55
19 AUG.	01.00	00.00	01.00	00.66
22 AUG.	(05.66)	(06.33)	01.33	(03.55)
23 AUG.	18.00	19.00	20.00	19.00
25 AUG.	(00.50)	(09.50)	(03.00)	(04.33)
26 AUG.	00.00	00.00	00.00	00.00
29 AUG.	00.33	00.66	01.33	00.77
30 AUG.	02.00	04.00	01.00	02.33
31 AUG.	(13.00)	(13.00)	(07.00)	(11.00)
01 SEPT.	04.00	12.00	08.00	08.00
02 SEPT.	06.00	00.00	03.00	03.00
06 SEPT.	02.00	03.00	02.50	02.50
07 SEPT.	00.00	01.00	00.00	00.33
09 SEPT.	(02.00)	(02.50)	(13.00)	(05.83)
12 SEPT.	02.66	02.66	03.00	02.76
14 SEPT.	(02.00)	(00.50)	(01.00)	(01.16)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 12. AVERAGE DAILY DROP IN WATER LEVEL

INSULATED WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	WATER LOSS / GAIN (MM / DAY) *			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	06.00	06.00	11.66	07.88
10 AUG.	02.50	02.50	-----	02.50
12 AUG.	04.50	05.00	-----	04.75
15 AUG.	05.00	06.00	05.66	05.55
18 AUG.	03.66	03.66	02.00	03.10
19 AUG.	01.00	04.00	00.00	01.66
22 AUG.	(05.33)	(07.00)	(05.66)	(06.00)
23 AUG.	18.00	19.00	18.00	18.33
25 AUG.	(01.00)	(11.50)	(03.00)	(05.16)
26 AUG.	04.00	05.00	05.00	04.66
29 AUG.	01.66	(01.00)	01.00	00.55
30 AUG.	02.00	04.00	05.00	03.66
31 AUG.	(09.00)	(10.00)	(11.00)	(10.00)
01 SEPT.	06.00	08.00	08.00	07.33
02 SEPT.	08.00	03.00	04.00	05.00
06 SEPT.	02.25	03.75	02.50	02.83
07 SEPT.	(02.00)	03.00	(01.00)	00.00
09 SEPT.	(01.50)	(01.50)	(13.00)	(05.33)
12 SEPT.	03.00	(00.33)	02.33	01.66
14 SEPT.	(02.00)	01.00	(00.50)	(00.50)

* Figures in parentheses indicate rise of water level in the washtub.

TABLE 13. AVERAGE DAILY EVAPORATION

ABOVE-GROUND WASHTUB

THE POINT

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	4.25	4.00	4.25	4.17
05 AUG.	5.00	4.66	4.33	4.66
09 AUG.	7.00	6.50	6.75	6.75
12 AUG.	6.33	6.66	6.33	6.45
16 AUG.	4.75	4.75	5.00	4.84
19 AUG.	3.10	3.10	3.43	3.21
23 AUG.	2.81	3.06	3.33	3.07
26 AUG.	3.24	3.24	2.91	3.13
30 AUG.	3.46	3.21	3.46	3.38
02 SEPT.	4.66	4.66	5.00	4.77
06 SEPT.	3.56	3.56	3.31	3.47
09 SEPT.	2.88	2.88	2.55	2.77
13 SEPT.	2.97	2.73	3.22	2.97
16 SEPT.	2.30	2.30	1.97	2.20
20 SEPT.	2.00	2.00	1.75	1.92
23 SEPT.	1.33	1.33	1.00	1.22
27 SEPT.	3.75	4.00	4.25	4.00
29 SEPT.	2.01	2.51	2.01	2.17

TABLE 14. AVERAGE DAILY EVAPORATION

SUNKEN WASHTUB

THE POINT

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	2.00	2.00	2.25	2.08
05 AUG.	2.66	2.66	2.33	2.56
09 AUG.	5.75	5.50	5.50	5.58
12 AUG.	5.33	5.33	5.00	5.22
16 AUG.	3.75	3.75	3.50	3.67
19 AUG.	1.77	1.43	2.43	1.88
23 AUG.	2.31	2.06	2.06	2.14
26 AUG.	2.24	2.24	1.91	2.13
30 AUG.	2.71	2.46	2.21	2.46
02 SEPT.	3.00	2.66	2.66	2.77
06 SEPT.	2.56	2.81	2.56	2.64
09 SEPT.	2.55	2.88	2.55	2.66
13 SEPT.	1.98	1.98	1.98	1.98
16 SEPT.	1.97	1.97	2.20	2.06
20 SEPT.	1.00	1.50	1.50	1.33
23 SEPT.	1.00	1.00	0.66	0.89
27 SEPT.	2.75	3.00	2.50	2.75
29 SEPT.	1.51	1.51	2.01	1.68

TABLE 15. AVERAGE DAILY EVAPORATION

INSULATED WASHTUB

THE POINT

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
02 AUG.	2.50	2.75	2.50	2.58
05 AUG.	4.00	3.33	3.33	3.56
09 AUG.	6.00	5.75	5.50	5.75
12 AUG.	5.33	5.33	5.33	5.33
16 AUG.	3.50	4.00	4.00	3.84
19 AUG.	2.10	2.10	1.77	1.99
23 AUG.	2.31	2.31	2.56	2.39
26 AUG.	2.57	2.24	2.57	2.46
30 AUG.	2.71	2.46	2.46	2.54
02 SEPT.	3.00	3.00	3.00	3.00
06 SEPT.	2.81	2.81	2.81	2.81
09 SEPT.	2.55	2.55	2.88	2.66
13 SEPT.	2.23	2.23	2.23	2.23
16 SEPT.	2.10	2.10	2.20	2.13
20 SEPT.	1.25	1.50	1.50	1.42
23 SEPT.	1.00	0.66	1.00	0.89
27 SEPT.	3.00	3.00	3.00	3.00
29 SEPT.	2.01	2.01	1.51	1.84

TABLE 16. AVERAGE DAILY EVAPORATION

ABOVE-GROUND WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	07.06	06.73	13.40	09.06
10 AUG.	03.70	02.20	-----	02.95
12 AUG.	04.10	05.10	-----	04.60
15 AUG.	06.33	05.66	05.66	05.88
18 AUG.	03.86	04.20	03.20	03.75
19 AUG.	03.00	02.00	02.00	02.33
22 AUG.	01.80	02.46	09.16	04.47
23 AUG.	16.20	15.20	18.20	16.53
25 AUG.	01.70	-----	02.20	01.95
26 AUG.	01.30	04.30	05.30	03.63
29 AUG.	04.43	03.43	03.43	03.76
30 AUG.	02.20	05.20	01.20	02.86
31 AUG.	05.10	03.10	07.10	05.10
01 SEPT.	08.40	09.40	09.40	09.06
02 SEPT.	06.00	04.00	03.00	04.33
06 SEPT.	03.20	05.45	05.26	04.64
07 SEPT.	03.70	06.70	02.70	04.37
09 SEPT.	00.30	00.30	-----	00.30
12 SEPT.	05.06	03.06	04.06	04.06
14 SEPT.	-----	00.40	-----	00.40

TABLE 17. AVERAGE DAILY EVAPORATION

SUNKEN WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	04.73	05.06	08.06	05.95
10 AUG.	03.20	02.70	-----	02.95
12 AUG.	03.60	03.60	-----	03.60
15 AUG.	04.66	06.00	05.00	05.22
18 AUG.	00.86	04.20	03.20	02.75
19 AUG.	01.00	00.00	01.00	00.66
22 AUG.	01.80	01.13	08.80	03.91
23 AUG.	18.20	19.20	20.20	19.20
25 AUG.	03.70	-----	01.20	02.45
26 AUG.	00.30	00.30	00.30	00.30
29 AUG.	02.10	02.43	03.10	02.54
30 AUG.	02.20	04.20	01.20	02.53
31 AUG.	00.10	00.10	06.10	02.10
01 SEPT.	04.40	12.40	08.40	08.40
02 SEPT.	06.00	00.00	03.00	03.00
06 SEPT.	02.45	03.45	02.95	02.95
07 SEPT.	01.70	02.70	01.70	02.03
09 SEPT.	01.80	01.30	-----	01.55
12 SEPT.	03.06	03.06	03.40	03.17
14 SEPT.	00.40	01.90	01.40	01.23

TABLE 18. AVERAGE DAILY EVAPORATION

INSULATED WASHTUB

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	EVAPORATION (MM / DAY)			
	REP. 1	REP. 2	REP. 3	AVERAGE
08 AUG.	06.06	06.06	11.73	07.95
10 AUG.	02.70	02.70	-----	02.70
12 AUG.	04.60	05.10	-----	04.85
15 AUG.	05.00	06.00	05.66	05.55
18 AUG.	03.86	03.86	02.20	03.31
19 AUG.	01.00	04.00	00.00	01.66
22 AUG.	02.13	00.46	01.80	01.46
23 AUG.	18.20	19.20	18.20	18.53
25 AUG.	03.20	-----	01.20	02.20
26 AUG.	04.30	05.30	05.30	04.96
29 AUG.	03.43	00.76	02.76	02.32
30 AUG.	02.20	04.20	05.20	03.86
31 AUG.	04.10	03.10	02.10	03.10
01 SEPT.	06.40	08.40	08.40	07.73
02 SEPT.	08.00	03.00	04.00	05.00
06 SEPT.	02.70	04.20	02.95	03.28
07 SEPT.	-----	04.70	00.70	02.70
09 SEPT.	02.30	02.30	-----	02.30
12 SEPT.	03.40	00.06	02.73	02.06
14 SEPT.	00.40	03.40	01.90	01.90

TABLE 19. DROP IN WATER LEVEL

CLASS A EVAPORATION PAN

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	INTERVAL DAYS	CHANGE IN WATER LEVEL MM *
08 AUG.	3	24.00
09 AUG.	1	06.00
10 AUG.	1	03.00
11 AUG.	1	07.00
12 AUG.	1	07.00
15 AUG.	3	20.00
16 AUG.	1	08.00
17 AUG.	1	04.00
19 AUG.	2	05.00
22 AUG.	3	(10.00)
23 AUG.	1	02.00
25 AUG.	2	(05.00)
26 AUG.	1	03.00
29 AUG.	3	11.00
30 AUG.	1	05.00
31 AUG.	1	(06.00)
02 SEPT.	2	02.00
06 SEPT.	4	21.00
07 SEPT.	1	(01.00)
09 SEPT.	2	(06.00)
12 SEPT.	3	03.00
14 SEPT.	2	(01.00)

* Figures in parentheses indicate rise of water level in the pan.

NOTE : Observations as of 05 Aug. when water level in the pan was at 20 cm

TABLE 20. AVERAGE DAILY DROP IN WATER LEVEL

CLASS A EVAPORATION PAN

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	WATER LOSS / GAIN MM/DAY*
08 AUG.	08.00
09 AUG.	06.00
10 AUG.	03.00
11 AUG.	07.00
12 AUG.	07.00
15 AUG.	06.66
16 AUG.	08.00
17 AUG.	04.00
19 AUG.	02.50
22 AUG.	(03.33)
23 AUG.	02.00
25 AUG.	(02.50)
26 AUG.	03.00
29 AUG.	03.66
30 AUG.	05.00
31 AUG.	(06.00)
02 SEPT.	01.00
06 SEPT.	05.70
07 SEPT.	(01.00)
09 SEPT.	(03.00)
12 SEPT.	01.00
14 SEPT.	(00.50)

* Figures in parentheses indicate rise of water level in the pan.

TABLE 21. AVERAGE DAILY EVAPORATION

CLASS A EVAPORATION PAN

PORTAGE LA PRAIRIE

DATE OF OBSERVATION	EVAPORATION MM / DAY
08 AUG.	08.00
09 AUG.	06.00
10 AUG.	03.00
11 AUG.	07.20
12 AUG.	07.00
15 AUG.	06.66
16 AUG.	08.00
17 AUG.	04.60
19 AUG.	02.50
22 AUG.	04.10
23 AUG.	02.20
25 AUG.	01.70
26 AUG.	03.30
29 AUG.	05.40
30 AUG.	05.20
31 AUG.	07.10
02 SEPT.	02.00
06 SEPT.	05.70
07 SEPT.	00.70
09 SEPT.	00.80
12 SEPT.	01.40
14 SEPT.	01.90

TABLE 22. PEARSON CORRELATION COEFFICIENTS

PORTAGE LA PRAIRIE

TREATMENT #	EVAN	EVAS	EVAI
EVAN *	1.000	0.931	0.926
EVAS *	0.931	1.000	0.935
EVAI *	0.926	0.935	1.000

* - Significant at Alpha = 0.05

\# - EVAN = Evaporation from above-ground washtub
EVAS = Evaporation from sunken washtub
EVAI = Evaporation from insulated washtub

TABLE 23. PEARSON CORRELATION COEFFICIENTS

THE POINT

TREATMENT #	EVAN	EVAS	EVAI	ML52.5	ML60.0
EVAN	*1.000	*0.921	*0.959	0.190	0.274
EVAS	*0.921	*1.000	*0.982	0.143	0.241
EVAI	*0.959	*0.982	*1.000	0.189	0.300
ML52.5	0.190	0.143	0.189	*1.000	*0.781
ML60.0	0.274	0.241	0.300	*0.781	*1.000

* - Significant at Alpha=0.05

\# - EVAN = Evaporation from abovve-ground washtub

EVAS = Evaporation from sunken washtub

EVAI = Evaporation from insulated washtub

ML52.5 = Soil moisture depletion from 52.5 cm

ML60.0 = Soil moisture depletion from 60.0 cm

TABLE 24. STATISTICAL ANALYSIS OF EVAPORATION DATA

T-TEST PROCEDURE

THE POINT

TREATMENT	F'	DF	PROB > F'
ABOVE-GROUND AND SUNKEN WASHTUB	1.52	17	0.396
ABOVE-GROUND AND INSULATED WASHTUB	1.46	17	0.440
INSULATED AND SUNKEN WASHTUB	1.04	17	0.939

TABLE 25. STATISTICAL ANALYSIS OF EVAPORATION DATA

T-TEST PROCEDURE

PORTAGE LA PRAIRIE

TREATMENT	F'	DF	PROB > F'
ABOVE-GROUND AND SUNKEN WASHTUB	1.31	19	0.566
ABOVE-GROUND AND INSULATED WASHTUB	1.15	19	0.761
ABOVE-GROUND AND CLASS A PAN	1.96	19	0.150
SUNKEN AND INSULATED WASHTUB	1.13	19	0.787
SUNKEN AND CLASS A PAN	2.48	19	0.060
INSULATED AND CLASS A PAN	2.26	19	0.083

TABLE 26. PERCENT SOIL MOISTURE CONTENT (MASS)

THE POINT

DEPTH: 0 TO 22.5 CM

DATE OF OBSERVATION	OBSERVATION							
	1	2	3	4	5	6	7	8
29 JUL.	34.41	34.41	33.01	35.44	34.76	35.30	33.20	33.15
02 AUG.	32.17	31.46	32.32	30.41	30.84	32.46	32.28	30.77
05 AUG.	28.99	31.01	29.20	30.04	30.33	30.09	30.00	30.88
09 AUG.	25.97	28.14	27.14	27.06	27.19	30.07	27.38	27.52
12 AUG.	26.07	25.82	27.06	26.26	27.01	26.14	26.51	25.49
16 AUG.	24.33	25.69	25.63	24.83	24.50	24.33	25.67	27.64
19 AUG.	24.48	25.84	26.55	23.38	25.77	25.51	24.93	24.68
23 AUG.	26.49	26.00	25.68	26.88	26.91	25.63	25.99	26.70
26 AUG.	26.91	27.61	28.37	27.97	26.73	29.52	28.66	26.46
30 AUG.	27.85	31.19	27.10	25.31	27.85	27.79	26.77	30.69
02 SEPT.	28.02	27.15	26.01	27.59	25.09	26.65	28.05	27.27
06 SEPT.	26.56	25.52	25.94	25.84	24.82	28.10	26.86	25.95
09 SEPT.	27.35	28.15	28.30	29.29	27.19	28.11	28.94	28.13
13 SEPT.	28.23	27.96	28.33	28.57	27.65	27.01	30.99	30.02
16 SEPT.	28.72	28.08	28.73	29.18	28.07	29.49	28.58	28.56
20 SEPT.	28.52	27.51	26.64	26.54	27.36	27.85	27.33	27.03
23 SEPT.	26.26	25.99	26.52	26.49	25.26	26.10	26.59	27.62
27 SEPT.	25.84	24.47	25.14	25.00	25.17	25.08	26.72	27.07
29 SEPT.	26.35	26.91	25.19	26.54	25.58	25.98	25.41	27.49

TABLE 27. PERCENT SOIL MOISTURE CONTENT (MASS)

THE POINT

DEPTH: 22.5 TO 37.5 CM

DATE OF	OBSERVATION							
OBSERVATION	1	2	3	4	5	6	7	8
29 JUL.	31.56	32.39	32.97	32.30	32.90	31.96	32.98	31.90
02 AUG.	30.63	30.83	31.39	31.86	29.15	28.98	29.84	29.88
05 AUG.	28.50	28.14	29.32	29.21	27.54	28.05	28.45	28.88
09 AUG.	26.40	25.40	25.78	25.63	27.41	26.61	26.09	26.35
12 AUG.	26.44	25.31	25.04	24.93	25.55	24.34	25.19	25.60
16 AUG.	24.31	23.18	24.90	23.96	24.48	24.20	23.88	24.64
19 AUG.	22.48	23.57	22.66	23.89	22.68	23.23	22.66	22.87
23 AUG.	26.64	25.86	25.63	24.34	25.70	25.66	25.57	26.80
26 AUG.	28.11	26.66	26.79	25.38	26.87	27.67	24.67	28.00
30 AUG.	28.33	26.65	26.91	27.18	26.71	25.49	28.29	24.77
02 SEPT.	25.24	26.02	25.87	25.42	24.82	25.80	24.49	25.46
06 SEPT.	24.42	24.21	24.70	25.52	25.71	24.56	24.65	24.80
09 SEPT.	27.65	27.05	26.72	26.96	25.69	26.39	26.37	26.94
13 SEPT.	28.18	26.81	27.69	28.67	26.64	26.96	27.45	27.91
16 SEPT.	27.52	27.53	27.94	26.83	27.63	29.08	28.89	27.68
20 SEPT.	28.08	26.96	25.50	26.36	26.59	26.49	26.91	26.98
23 SEPT.	25.64	24.48	25.60	25.46	24.94	25.35	24.83	25.86
27 SEPT.	23.24	24.56	23.83	23.81	23.68	23.53	23.32	23.88
29 SEPT.	24.63	25.30	25.01	25.85	24.03	26.14	25.28	24.74

TABLE 28. PERCENT SOIL MOISTURE CONTENT (MASS)

THE POINT

DEPTH: 37.5 TO 52.5 CM

DATE OF OBSERVATION	OBSERVATION							
	1	2	3	4	5	6	7	8
29 JUL.	31.75	32.94	30.92	33.21	30.08	32.10	33.75	33.14
02 AUG.	30.70	29.95	30.89	30.92	29.70	29.37	30.58	30.40
05 AUG.	29.03	28.32	30.04	28.99	28.33	27.71	28.09	28.28
09 AUG.	26.16	26.58	26.76	26.84	26.96	27.11	26.97	27.02
12 AUG.	25.78	25.47	26.45	25.82	25.13	24.47	25.34	24.54
16 AUG.	25.18	23.89	24.75	24.96	24.34	24.87	24.39	24.24
19 AUG.	23.69	23.45	22.91	22.63	23.41	23.63	23.09	23.23
23 AUG.	26.85	25.83	25.60	26.44	24.87	25.43	26.10	25.53
26 AUG.	27.09	26.98	26.57	26.59	26.87	28.48	27.00	27.41
30 AUG.	27.90	26.65	27.18	27.19	27.45	26.87	27.19	27.13
02 SEPT.	25.43	26.22	25.89	25.58	25.83	26.43	25.14	26.07
06 SEPT.	24.86	25.40	25.37	25.84	24.36	25.23	25.24	25.06
09 SEPT.	26.89	26.68	27.77	27.50	27.95	26.62	26.84	27.41
13 SEPT.	27.11	27.09	27.63	27.54	28.00	29.06	28.88	27.14
16 SEPT.	26.85	27.09	28.37	28.48	29.13	28.07	28.42	28.12
20 SEPT.	27.23	26.49	26.79	26.38	26.70	26.50	27.21	26.51
23 SEPT.	25.56	26.14	24.58	25.57	25.05	24.94	25.58	25.70
27 SEPT.	23.82	22.37	23.87	23.52	22.54	23.38	23.53	24.16
29 SEPT.	24.83	25.19	24.64	25.48	25.08	24.68	24.69	25.25

TABLE 29. PERCENT SOIL MOISTURE CONTENT (VOLUMETRIC)

THE POINT

DEPTH: 0 TO 22.5 CM

DATE OF OBSERVATION	OBSERVATION							
	1	2	3	4	5	6	7	8
29 JUL.	32.86	32.87	31.53	33.85	33.20	33.72	31.71	31.66
02 AUG.	30.73	30.05	30.87	29.05	29.46	31.00	30.83	29.39
05 AUG.	27.69	29.62	27.89	28.70	28.97	28.74	28.65	29.49
09 AUG.	24.80	26.88	25.92	25.85	25.97	28.72	26.15	26.29
12 AUG.	24.90	24.66	25.85	25.08	25.80	24.97	25.32	24.25
16 AUG.	23.24	24.54	24.48	23.72	23.40	23.24	24.52	26.40
19 AUG.	23.38	24.68	25.36	22.33	24.61	24.37	23.81	23.57
23 AUG.	25.30	24.83	24.53	25.67	25.70	24.48	24.83	25.50
26 AUG.	25.70	26.37	27.10	26.72	25.33	28.20	27.37	25.27
30 AUG.	26.60	29.79	25.89	24.18	26.60	26.54	25.57	29.31
02 SEPT.	26.76	25.93	24.85	26.35	23.97	25.45	26.79	26.05
06 SEPT.	25.37	24.38	24.78	24.68	23.73	26.84	25.66	24.79
09 SEPT.	26.12	26.89	27.03	27.98	25.97	26.85	27.64	26.87
13 SEPT.	26.96	26.71	27.06	27.29	26.41	25.80	29.60	28.68
16 SEPT.	27.43	26.82	27.44	27.87	26.81	28.17	27.30	27.28
20 SEPT.	27.24	26.28	25.44	25.35	26.13	26.60	26.10	25.82
23 SEPT.	25.08	24.83	25.33	25.30	24.13	24.93	25.40	26.38
27 SEPT.	24.68	23.37	24.01	23.88	24.04	23.96	25.52	25.86
29 SEPT.	25.17	25.70	24.06	25.35	24.43	24.81	24.27	26.26

TABLE 30. PERCENT SOIL MOISTURE CONTENT (VOLUMETRIC)

THE POINT

DEPTH: 22.5 TO 37.5 CM

DATE OF OBSERVATION	OBSERVATION 1	2	3	4	5	6	7	8
29 JUL.	31.56	32.39	32.97	32.30	32.90	31.96	32.98	31.90
02 AUG.	30.63	30.83	31.39	31.86	29.15	28.98	29.84	29.88
05 AUG.	28.50	28.14	29.32	29.21	27.54	28.05	28.45	28.88
09 AUG.	26.40	25.40	25.78	25.63	27.41	26.61	26.09	26.35
12 AUG.	26.44	25.31	25.04	24.93	25.55	24.34	25.19	25.60
16 AUG.	24.31	23.18	24.90	23.96	24.48	24.20	23.88	24.64
19 AUG.	22.48	23.57	22.66	23.89	22.68	23.23	22.66	22.87
23 AUG.	26.64	25.86	25.63	24.34	25.70	25.66	25.57	26.80
26 AUG.	28.11	26.66	26.79	25.38	26.87	27.67	24.67	28.00
30 AUG.	28.33	26.65	26.91	27.18	26.71	25.49	28.29	24.77
02 SEPT.	25.24	26.02	25.87	25.42	24.82	25.80	24.49	25.46
06 SEPT.	24.42	24.21	24.70	25.52	25.71	24.56	24.65	24.80
09 SEPT.	27.65	27.05	26.72	26.96	25.69	26.39	26.37	26.94
13 SEPT.	28.18	26.81	27.69	28.67	26.64	26.96	27.45	27.91
16 SEPT.	27.52	27.53	27.94	26.83	27.63	29.08	28.89	27.68
20 SEPT.	28.08	26.96	25.50	26.36	26.59	26.49	26.91	26.98
23 SEPT.	25.64	24.48	25.60	25.46	24.94	25.35	24.83	25.86
27 SEPT.	23.24	24.56	23.83	23.81	23.68	23.53	23.32	23.88
29 SEPT.	24.63	25.30	25.01	25.85	24.03	26.14	25.28	24.74

TABLE 31. PERCENT SOIL MOISTURE CONTENT (VOLUMETRIC)

THE POINT

DEPTH: 37.5 TO 52.5 CM

DATE OF OBSERVATION	OBSERVATION							
	1	2	3	4	5	6	7	8
29 JUL.	31.50	32.68	30.68	32.95	29.84	31.85	33.48	32.38
02 AUG.	30.46	29.71	30.15	30.68	29.47	29.14	30.34	30.16
05 AUG.	28.80	28.10	29.80	28.76	28.11	27.49	27.87	28.06
09 AUG.	25.95	26.37	26.55	26.63	26.75	26.90	26.76	26.81
12 AUG.	25.58	25.27	26.22	25.62	24.93	24.28	25.14	24.35
16 AUG.	24.98	23.70	24.55	24.76	24.15	24.67	24.20	24.05
19 AUG.	23.50	23.27	22.73	22.45	23.22	23.44	22.91	23.05
23 AUG.	26.64	25.63	25.40	26.23	24.67	25.23	25.89	25.33
26 AUG.	26.88	26.77	26.36	26.38	26.66	28.26	26.79	27.19
30 AUG.	27.68	26.44	26.97	26.98	27.23	26.66	26.98	26.92
02 SEPT.	25.23	26.01	25.69	25.38	25.63	26.22	24.94	25.86
06 SEPT.	24.66	25.20	25.17	25.64	24.17	25.03	25.04	24.86
09 SEPT.	26.68	26.47	27.55	27.28	27.73	26.41	26.63	27.19
13 SEPT.	26.90	26.88	27.41	27.32	27.78	28.83	28.66	26.93
16 SEPT.	26.64	26.88	28.15	28.26	28.90	27.85	28.20	27.90
20 SEPT.	27.02	26.28	26.58	26.18	26.49	26.29	27.00	26.30
23 SEPT.	25.36	25.94	24.39	25.37	24.85	24.74	25.38	25.50
27 SEPT.	23.63	22.19	23.68	23.33	22.36	23.20	23.34	23.97
29 SEPT.	24.64	24.99	24.44	25.28	24.88	24.48	24.50	25.05

TABLE 32. AVERAGE DAILY DEPTH OF SOIL MOISTURE DEPLETION

THE POINT

DEPTH : 0.0 TO 52.5 CM

DATE OF OBSERVATION	AVERAGE DAILY DEPLETION MM
02 AUG.	2.92
05 AUG.	2.81
09 AUG.	2.88
12 AUG.	2.07
16 AUG.	1.17
19 AUG.	2.58
23 AUG.	0.94
26 AUG.	3.04
30 AUG.	0.77
02 SEPT.	2.16
06 SEPT.	0.94
09 SEPT.	3.17
13 SEPT.	1.22
16 SEPT.	2.60
20 SEPT.	1.60
23 SEPT.	2.11
27 SEPT.	1.74
29 SEPT.	1.13

TABLE 33. AVERAGE DAILY DEPTH OF SOIL MOISTURE DEPLETION

THE POINT

DEPTH : 0 TO 60 CM

DATE OF OBSERVATION	AVERAGE DAILY DEPLETION MM
02 AUG.	3.77
05 AUG.	2.90
09 AUG.	3.60
12 AUG.	2.40
16 AUG.	1.20
19 AUG.	1.72
23 AUG.	1.91
26 AUG.	2.40
30 AUG.	0.54
02 SEPT.	2.08
06 SEPT.	1.17
09 SEPT.	2.77
13 SEPT.	1.39
16 SEPT.	2.81
20 SEPT.	1.91
23 SEPT.	1.90
27 SEPT.	1.13
29 SEPT.	2.24

TABLE 34. AVERAGE PERCENT SOIL MOISTURE CONTENT (MASS)

THE POINT

DATE OF OBSERVATION	DEPTH OF OBSERVATION 0 TO 22.5 CM	22.5 TO 37.5 CM	37.5 TO 52.5 CM
29 JUL.	34.22	32.37	32.24
02 AUG.	31.97	30.32	30.25
05 AUG.	30.07	28.51	28.60
09 AUG.	27.56	26.21	26.80
12 AUG.	26.30	25.30	25.37
16 AUG.	25.46	24.19	24.57
19 AUG.	25.14	23.01	23.25
23 AUG.	26.29	25.78	25.83
26 AUG.	27.77	26.77	27.12
30 AUG.	28.07	26.79	27.20
02 SEPT.	26.98	25.39	25.82
06 SEPT.	26.21	24.82	25.17
09 SEPT.	28.19	26.72	27.20
13 SEPT.	28.59	27.54	27.81
16 SEPT.	28.67	27.89	28.07
20 SEPT.	27.35	26.72	26.73
23 SEPT.	26.35	25.27	25.39
27 SEPT.	25.37	23.73	23.39
29 SEPT.	26.19	25.12	24.98

TABLE 35. AVERAGE PERCENT SOIL MOISTURE CONTENT (VOLUMETRIC)

THE POINT

DATE OF OBSERVATION	DEPTH OF OBSERVATION		
	0 TO 22.5 CM	22.5 TO 37.5 CM	37.5 TO 52.5 CM
29 JUL.	32.68	32.37	31.98
02 AUG.	30.17	30.32	30.01
05 AUG.	28.72	28.51	28.37
09 AUG.	26.32	26.21	26.59
12 AUG.	25.12	25.30	25.17
16 AUG.	24.32	24.19	24.38
19 AUG.	24.01	23.01	23.07
23 AUG.	25.11	25.78	25.63
26 AUG.	26.53	26.77	26.91
30 AUG.	26.81	26.79	26.98
02 SEPT.	25.77	25.39	25.62
06 SEPT.	25.03	24.82	24.97
09 SEPT.	26.92	26.72	26.99
13 SEPT.	27.31	27.54	27.59
16 SEPT.	27.39	27.89	27.85
20 SEPT.	26.12	26.72	26.52
23 SEPT.	25.17	25.27	25.19
27 SEPT.	24.42	23.73	23.21
29 SEPT.	25.01	25.12	24.78

TABLE 36. AVERAGE DEPTH OF SOIL MOISTURE DEPLETION

THE POINT

DATE OF	SOIL DEPTH *		
OBSERVATION	0.0 TO 22.5 CM MM/22.5 CM	22.5 TO 37.5 CM MM/15 CM	37.5 TO 52.5 CM MM/15 CM
02 AUG.	5.65	3.08	2.96
05 AUG.	3.26	2.72	2.46
09 AUG.	5.40	3.45	2.67
12 AUG.	2.70	1.37	2.13
16 AUG.	1.80	1.67	1.19
19 AUG.	0.70	1.77	1.97
23 AUG.	(2.47)	(4.15)	(3.84)
26 AUG.	(3.19)	(1.49)	(1.92)
30 AUG.	(0.63)	(0.03)	(0.11)
02 SEPT.	2.34	2.10	2.04
06 SEPT.	1.67	0.86	0.98
09 SEPT.	(4.25)	(2.85)	(3.03)
13 SEPT.	(0.88)	(1.23)	(0.90)
16 SEPT.	(0.18)	(0.53)	(0.39)
20 SEPT.	2.86	1.76	2.00
23 SEPT.	2.14	2.18	2.00
27 SEPT.	1.69	2.31	2.97
29 SEPT.	(1.33)	(2.09)	(2.35)

* Figures in parentheses indicate moisture gain by the soil

TABLE 37. DEPTH OF SOIL MOISTURE DEPLETION

THE POINT

DEPTH : 0 TO 52.5 CM

DATE OF OBSERVATION	CUMULATIVE MOISTURE DEPLETION OR GAIN MM / 52.5 CM *	CUMULATIVE MOISTURE DEPLETION MM/52.5 CM
02 AUG.	11.69	11.69
05 AUG.	08.44	08.44
09 AUG.	11.52	11.52
12 AUG.	06.20	06.20
16 AUG.	04.66	04.66
19 AUG.	04.44	04.44
23 AUG.	(10.46)	(03.76)
26 AUG.	(06.60)	(09.12)
30 AUG.	(00.77)	(03.07)
02 SEPT.	06.48	06.48
06 SEPT.	03.51	03.51
09 SEPT.	(10.13)	(09.51)
13 SEPT.	(03.01)	(04.89)
16 SEPT.	(01.10)	(07.81)
20 SEPT.	06.62	06.62
23 SEPT.	06.32	06.32
27 SEPT.	06.97	06.97
29 SEPT.	05.77	05.77

* Figures in parentheses indicate moisture gain by the soil

TABLE 38. DEPTH OF SOIL MOISTURE DEPLETION

THE POINT

DEPTH : 0 TO 60 CM

DATE OF OBSERVATION	SOIL MOISTURE DEPLETION TO 60 CM (MM / 60 CM) *
02 AUG.	15.06
05 AUG.	08.70
09 AUG.	14.40
12 AUG.	07.20
16 AUG.	04.80
19 AUG.	01.86
23 AUG.	(06.60)
26 AUG.	(08.52)
30 AUG.	(01.68)
02 SEPT.	06.24
06 SEPT.	04.44
09 SEPT.	(11.34)
13 SEPT.	(02.34)
16 SEPT.	(00.48)
20 SEPT.	07.62
23 SEPT.	05.70
27 SEPT.	04.50
29 SEPT.	(03.54)

* Figures in parentheses indicate moisture gain by the soil.