EFFECT OF DIFFERENT TILLAGE METHODS ON PERCOLATION LOSS IN RICE FIELDS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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LIST OF FIGURES

To

My Grandmother

DECLARATION

*I hereby declare that this thesis entitled **"Effect of Different Tillage Methods on Percolation Loss in Rice Fields"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society*

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CERTIFICATE

Certified that this thesis entitled ***"Effect of Different Tillage Methods on Percolation Loss in Rice Fields"*** *is a record of research work done independently by* ***Kum Mini P K*** *under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her*

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Tavanur *MINI P K*

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SYMBOLS AND ABBREVIATIONS

Agric	-	Agricultural
Agron	-	Agronomy
Assoc		Association
atm	-	atmosphere
Bull	-	Bulletin
cm		centimetre
Conserv	-	Conservation
contd	-	continued
C R R I	-	Central Rice Research Institute
Dept		Department
Div		Division
Engng	-	Engineering
Engrs	-	Engineers
E T	-	Evapotranspiration
<u>et al</u>	-	and other people
Fig	-	Figure
Fmg	-	Farming
g/cc	-	grams per cubic centimetre
g/cm^3	-	grams per cubic centimetre
h		hour(s)
ha	-	hectare(s)
I A R I	-	Indian Agricultural Research Institute
i e	-	that is
I I T A		International Institute for Tropical Agriculture
Int	-	International
Instt		Institute
I R R I	-	International Rice Research Institute
J	-	Journal
K A U	-	Kerala Agricultural University
K C A E T	-	Kelappaji College of Agricultural Engineering and Technology
kg	-	kilogram(s)

kg/ha-mm		kilogram per hectare millimetre
m		metre(s)
mgt	-	management
m ha	-	million hectare
m ha m	-	million hectare metre
mm		millimetre(s)
mm/h	-	millimetre per hour
ms^{1}	-	metre per second
m^3/ha		cubic metre per hectare
p p	-	page
Proc	-	Proceedings
q/ha		quintal per hectare
Res		Research
Rs	-	Rupees
Sci		Science
Soc	-	Society
Tech	-	Technical
Univ		University
U S W B	-	United States Weather Bureau
&	-	and
<	-	less than
/		per
%	-	per cent

Introduction

INTRODUCTION

Rice is one of the most important grain for the world s inhabitants Rice occupies one-third of the area planted to cereals in developing countries and covers about 50 per cent more area than wheat the second most important cereal The total area under the rice crop exceeds 129 6 million hectares of which 90 per cent is grown in Asia Yet the demand for rice exceeds the present world supplies The significance of rice is its wide spread use as a staple food by more than half of the world s population It has become a unique major food crop of the world by virtue of the extent and variety of uses and its adaptability to a wide range of climatic soil water and cultural conditions

Over the centuries a number of systems of rice cultivation has evolved to fit the local conditions of climate soil and water Despite wide variations in cultivation there are two main systems which are widely followed in rice cultivating countries They are (1) dry land or upland system and (2) wet land system A major portion of the rice in tropical subtropical and warm temperate parts of the world is grown under wet land system in which the soil is flooded during greater part of the growing season Rice is physiologically and morphologically adapted to grow in wet or flooded soil conditions The flooded culture provides benefits of weed control improved water and air microclimates and a rootzone environment well suited for rice culture From the standpoint of nutrient uptake and yield performance the results indicate that submergence is the best among different moisture regimes

Out of the total culturable area of 181 m ha in the Country paddy covers an area of about 40 19 m ha The irrigated area under paddy is about 13 6 m ha which is approximately 34 0 per cent of the area under paddy crop Owing to low and uncertain rainfall in many regions of the Country irrigation is essential to obtain high yield of crops According to National Commission on Agriculture (1976) total water resources of the country are 185 m ha m comprising 135 m ha m of surface water and 50 m ha-m of ground water Both the water resources cannot be exploited in full for irrigation on account of topographic climatic and soil limitations in the case of surface water and additional limitations of pumping depths and availability of power in the case of ground water Altogether it is estimated that 70 m ha m of surface water and 35 m ha-m of ground water can be utilised for irrigation Efficient management of irrigation water a limited resource as it is is of utmost importance for sustaining and increasing agricultural production

Although irrigation is a major contributor in increasing productivity, inefficient use of water has severely restricted further development of this limited resource Surface irrigation is the most common practice adopted all over the world but is often difficult to implement and manage effectively In India, at present 45 50 per cent of irrigation water is being given to rice fields The irrigated area under rice fields constitute only 1/3rd of about 40 m ha of rice crop in India Rice require adequate water to grow and develop at its maximum potential rate A continuous flooding of 5 to 7 cm of water is desirable on most soils so as to obtain stable high yields Eventhough submergence of water benefits rice crop in several ways, it enhances the percolation loss of water and, thus increases the water needs of rice by 3-6 times as compared to other crops The water requirement of rice worked out by different workers as reported by Dastane et al (1970) varies from 750 mm to as high as 2500 mm Depending upon soil type, the percolation losses may be as much as 50 to 85 per cent of the total water applied This explains the fact that rice alone consumes a major share of the Country s irrigation resources The contribution of rice both from irrigated and rainfed areas to the total food grain production of the Country is only of the order of about 40 per cent Rice, is therefore the most inefficient utiliser of water in terms of production

Out of the three components of water loss evaporation transpiration and percolation the evapotranspirational requirement of rice is not much different from that of other crops This implies that the major loss of water takes place through deep percolation Therefore the water use efficiency of rice crop is much lower compared to other crops This water loss is also accompanied by nutrient losses If the water loss through deep percolation can be checked effectively by some means a large quantity of water can be saved and made available for irrigating more areas thereby leading to higher water use efficiency

An effective water management practice for rice should include suitable practices to minimise wastage of water through deep percolation Reduction of deep percolation of water is generally achieved by soil manipulation of three types viz (i) puddling (ii) compaction (iii) subsurface placement of impermeable materials like bitumen and plastic films Puddling is a common practice in rice cultivation in order to render the soil impermeable and to reduce the percolation loss which is obviously greater in light-textured soil than in heavy textured soil The method has been widely adopted in rice cultivation because it helps to create a hard pan layer condition which reduces irrigation water losses and nutrient losses during the following flooding stages of rice production In addition puddling greately controls the emergence of weeds and the absence of weeds allows the crop plants to utilise the available nutrients and to produce higher yields Studies showed that large losses of water from unpuddled soil caused greater nitrogen losses and less nitrogen uptake by rice at all growth stages As a result rice yield were significantly lower in unpuddled soil than in puddled soil (De Datta and Kevins 1974)

Water loss by deep percolation depends upon land preparation practices soil type and depth of water table Therefore great economy in water use efficiency could be achieved if suitable land preparation practices were adopted Various implements animal drawn as well as power operated are in use for puddling which is the major land preparation practice adopted in rice fields The effectiveness of an implement for puddling can be judged by its field performance in reducing deep percolation loss of water and in increasing crop yield The present study was conducted to compare the performance of animal drawn helical bladed puddler power tiller tractor with cage wheel and soil compaction using roller in comparison with the country plough along with planking which is the local practice followed by farmers The main objective of the study are

1 To assess the water loss through deep percolation in rice fields under different tillage methods

2 To evaluate the effect of different tillage methods on the grain yield

Review of Literature

REVIEW OF LITERATURE

About three quarters of the world rice area is cultivated under flooded condition Therefore the water requirement of rice is much higher than that of other crops In this practice a considerable loss of water takes place through deep percolation In order to get a comprehensive picture of the effect of submergence on growth and yield of rice total water requirement of rice extend of percolation loss in rice field and the control measures followed for reducing this loss a brief review of the research work conducted in these fields are presented in this chapter

2 1 Effect of submergence on growth and yield of rice crop

Cralley and Adair (1943) in a study of irrigation treatments showed that rice plants grown under continuously submerged condition were larger tillered better and produced significantly higher yield and grain to straw ratio than the plants grown on plots which were kept moist but not submerged

Jenkins and Jone (1944) from their six year s studies on the effect of discontinuous versus continuous submergence found the superiority of submergence over intermittent drying and submergence of the land They also indicated that submergence could be delayed 30 to 40 days after seedling emergence provided grasses and semi-aquatic weeds are absent

The work at IRRI (1963) also indicated much higher rice yield in saturated and flooded soils than in aerobic soils This is because of the fact that chemical benefits of flooding could not be attained in aerobic soils

Halm (1967) in his studies with two varieties of rice found that they grew better in submerged or in saturated condition than in soils at moist condition Water regime affected phosphorus uptake and higher phosphorus availability was observed under submergence

The studies conducted by Mane (1969) with the rice variety NP 130 at I A R I revealed that there was a tremendous scope of economising irrigation water in rice culture by scheduling irrigation at 0 5 atm tension instead of going in for continuous flooding

Bhatia and Dastane (1971) reported that grain and straw yield decreased slightly due to application of irrigation water at 0 to 0 4 atm tension as compared to that under submergence (0 4 cm) in the case of NP-130 TN 1 and IR-8 varieties at I A R I

Hukkeri et al (1972) conducted an experiment on loamy soil at I A R I to study the water use efficiency of different water management practices for rice The practices included for the study were

W_1 - Continuous submergence, 4 0 cm throughout the growth period

W_2 - Partial submergence 4 0 cm from tillering to end of flowering

W_3 - Partial submergence, 4 0 cm during tillering and flowering only

The results showed that the yield under the three practices did not statistically differ The production efficiency (yield per unit amount of water) was naturally more where the practice of submergence was followed only during the critical physiological stages

Kar and Varade (1974) carried out an investigation to assess the influence of soil-air-water regimes on root porosity leaf water deficit and growth of rice The following soil moisture regimes were included 5 ± 1 cm flooding (M_1) 0-20 millibar moisture tension (M_2),60 millibar moisture tension (M_3) 0-350 millibar moisture tension (M_4) alternate flooding and drying (M_5) and continuous circulation of water (M_6) Water deficit in rice leaves increased with an increase in moisture stress and growth period Eventhough rice shoot growth in terms of plant height and dry weight of shoot under M_3 and M_6 was significantly higher than those under M_1 M_2 M_3 and M_4 maximum grain yield occurred under

M_1 treatment The decrease in grain yield under M_2 M_3 M_4 and M_6 was attributed to an increasein leaf water deficit

Sahu and Rao (1974) conducted experiments on three varieties of rice to find the effect of soil moisture stress at different phases of growth of rice in loamy sand soil under Bhubaneswar conditions The results indicated that all the three varieties of rice grew best and produced the highest yield under 5 cm submergence from transplanting to maturity They were also adversely affected by soil moisture stress at any phase of growth and development Stress during the vegetative phase reduced plant height, tiller number delayed maturity and it resulted in highest reduction in yield Reduction in yield varied from 26 to 27 per cent depending upon the plant type Stress during the grain filling and ripening phases resulted in death of ear-bearing tillers reduction in the number of filled grain depending upon the varieties

Experiments were conducted by Yadav (1974) with variety IR-8 in dalva season (January-March) on medium-textured soil at Chakuli (Orissa) and in February-June and July October on lateritic soil at Kharagpur in order to determine whether submergence (5 ± 2 cm) is required through out the growth period or only at certain growth stages so that a suitable schedule for economic utilisation of water can be worked out The analysis of the result revealed that the highest grain yield (57 7 g/ha) at Chakuli was obtained in the treatment wherein soil moisture was maintained at saturation till tillering followed by 5 cm submergence till harvest (M_1) Continuous submergence did not show any advantage though the water requirement was the highest (1529 mm as against 1090 mm in the former treatment) Continuous saturation or prolonged saturation till flowering brought about reduction in yield (yield being 40 7 q/ha and 49 9 q/ha respectively) but the water requirement under continuous saturation was the lowest (368 mm)

At Kharagpur the highest grain yield was obtained during Kharif with the treatment in which saturation was maintained till tillering followed by submergence till harvest (M_1) whereas during rabi season the treatment of submergence till flowering followed by saturation till harvest (M_8) produced the highest grain yield though the treatment of saturation till tillering followed by submergence till harvest (M_1) also produced more or less similar yield Continuous submergence required maximum quantity of water without any additional increase in yield

Sinha and Prasad (1982) studied the water requirement of mid duration rice variety 'sita with reference to water use efficiency The rice variety was subjected to five treatments replicated four times The study indicated that for obtaining maximum grain yield it is advisable to maintain 5 cm standing water in the field

2 2 Total water requirement of rice

Kung et al (1965) reported that the water requirement of rice vary from 800 to 1200 mm and the daily consumptive use vary from 6 mm to 10 mm from the water management studies for rice in Thailand With reference to similar studies in Japan the same authors reported the amount of water required for the short duration crop as 1000 mm medium duration crop as 1200 mm and long duration crop as 1400 mm

Shahu and Rout (1967) reported that the consumptive use of water by rice from transplanting to harvest was 1560 mm under submergence 812 mm at field capacity level and 200 mm at 75 per cent available moisture Under 15 cm submergence consumptive use was 1 2 cm/day during vegetative phase and 0 65 cm/day during yellow ripe stage of crop growth

Pande and Mittra (1969) found that water needs of rice ranged from 950 mm to 2150 mm depending upon the place season and duration of crop

Chandramohan (1970) reported that 1673 mm of water was required for main crop in Coimbatore while 2000 mm for

Karuvai crop and 2650 mr for Samba crop in Pattukottai in Tamil Nadu State

Rao *et al* (1971) found that 200 mm water was needed for nursery 200 mm for puddling and 600 mm to 800 mm during the rest of crop growth respectively depending upon duration

2 2 1 Components of water loss

The two major components of water loss are evapotranspiration and deep percolation Unlike in other crops deep percolation loss in rice greatly exceeds evapotranspiration In recent studies at different centres throughout the country percolation rates were found to vary from 52 to 83 per cent of the total water expense

McCalla (1944) studied about the factors affecting percolation of water in the soil He came to the conclusion that total percolation decreased from 109 73 cm in normal soil to 15 0 cm in the soil puddled to 15 cm depth

Experiments conducted by Vamadevan and Dastane (1968) in Delhi showed that 1683 mm of water was required during the eighty seven days from transplanting to maturity Of which 493 mm was lost by evapotranspiration

Pande and Mittra (1971) from Kharagpur reported that percolation loss was 64 mm and 84 mm during 'Aus' and Boro' seasons respectively

Gupta (1972) observed that deep percolation loss was of the order of 25 to 50 per cent in sandy soils, 15 to 25 per cent in sandy loam, 10 to 20 per cent in fine sandy loam and 5 to 15 per cent in heavy clay soils of Uttar Pradesh

Vamadevan et al (1972) conducted studies at C R R I , Cuttack which indicated that the horizontal seepage was a major fraction in the different components of water loss The horizontal percolation was 2 5 times to that of vertical percolation

In an experiment conducted by De Datta and Kerims (1974) in Maahas clay soil, water lost through deep percolation was considerably higher in unpuddled soil than in puddled soil, so unpuddled soil received twice as much water (1180 mm) as puddled soil (588 mm) Rice in puddled soil had 2 5 times the efficiency of water use (7.9 kg/ha-mm of water) compared to unpuddled soil (2 9 kg/ha-mm of water) (Fig 1)

George et al (1976-77) conducted studies on total water requirement and various forms of water loss in rice fields in virippu', 'mundakan and punja seasons at Agronomic Research Station of KAU at Chalakudy The loss of

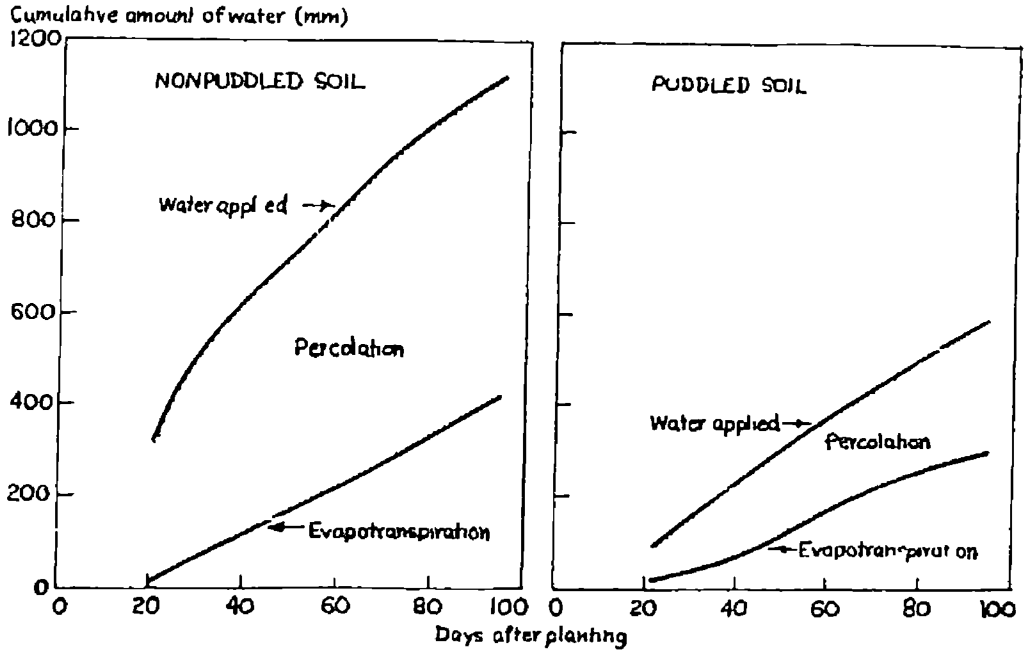


FIG.1 COMPARISON OF CUMULATIVE WATER APPLIED, EVAPOTRANSPIRATION AND PERCOLATION LOSS IN PUDDLED AND NON-PUDDLED SOILS CONTINUALLY FLOODED AT 5 cm

water due to evaporation in the field was maximum immediately after transplanting and the loss was 48 mm/day The maximum rate of transpiration was 6 3 mm/day The percolation loss was 76 40 per cent of the total water requirement

Chirayath (1988) estimated the various forms of water loss that occurs in Kole lands of Trichur district with lysimeter and evaporimeter Water loss by evaporation transpiration and percolation were 12 34 per cent 17 32 per cent and 70 34 per cent respectively of the total water loss The total water requirement of the crop was 2134 22 mm measured by using a field hook gauge

Joseph and Havanagi (1988) observed that the percolation losses varied from 52 27 cm to 72 54 cm in different seasons On an average over the seasons the percolation loss worked out to 56 53 per cent of the total water requirement Percolation losses in the rice field were measured by using the drum culture technique

Eapen (1990) conducted an experiment to quantify the percolation loss of water and to assess the nutrient losses in the percolated water The loss due to vertical percolation was estimated using percolation meter which was designed and fabricated for the study Estimations of evaporation, transpiration and percolation were also made on the basis of measurements using evaporimeter evapotranspirimeter and field hook gauge Lateral percolation was obtained by subtracting vertical percolation from total percolation The study revealed that the total water requirement was 1270 25 mm The percentages of water lost by evaporation transpiration and total percolation were 13 69 31 0 and 55 3 respectively 55 4 per cent and 40 6 per cent of the total percolation was lost by vertical and lateral percolation respectively

2 3 Measures to reduce percolation loss of water and to increase yield from rice fields

Sinha (1964) had conducted an experiment using desi plough melur plough rotary type rectangular bladed puddler and voltas puddler and reported that there was no significant difference in grain yield obtained by using different puddling implements

Bandyopadhya et al (1966) studied the effect of different methods of puddling using country plough mould board plough disc harrow power tiller and their combinations and operating them two to five times He observed that the treatment two ploughings followed by running a puddler appeared to be optimal as inferred from the data on moisture holding capacity and pore space

Reddy and Rao (1971) reported that the APAU 750 mm puddler was superior to voltas and swastik puddlers in reducing the time and cost of puddling and increasing the grain yield

Dakshinamurti (1973) reported that bentonite bed technique was effective in reducing infiltration in rice fields Extperiments carried out at I A R I indicated that the bentonite field required 250 cm of water while 350 cm of water had to be used in the controlled field without bentonite This technique could also be perfected with the addition of black cotton soil which contains about 50 per cent of this type of clay in it

Experiments conducted at C R R I by Asthana and Vamadevan (1974) showed that the rate of percolation was reduced by one-third by practicing soil compaction The use of clay and tank silt (about 150 m^3/ha) resulted in reduction of percolation losses (20 to 25 per cent) Bentonite mixed with upper top soils remarkably suppressed the percolation loss (33 per cent) Percolation was greatly suppressed where vinyl film laid out at a depth of 30-40 cm below the field surface

Pande et al (1974) found that under acid-lateritic-sandy loam soil the loss due to percolation alone amounted to as high as 40 to 50 per cent of the total water loss during rainless months and about one third during rainy season They made efforts to reduce this loss of water from the submerged rice fields through a series of field experiments

Treatments of surface soil manipulation and subsurface layering created a soil barrier to reduce or check the downward movement of water Surface soil manipulation treatments included depths and degree of puddling and compaction whereas subsurface layering was done by placing 0 3 to 0 5 cm thick layer of bitumen at 20 and 40 cm depths The water requirement of 388 cm was decreased by 298 202 and 184 cm through subsurface bitumen layering puddling and compaction respectively Though bitumen layering effects maximum saving of water the information on the accumulation of toxin in successive years had yet to be obtained

Sivanappan *et al* (1974) conducted an experiment to estimate the percolation loss in rice fields and control measures were suggested Experimental results had shown that the percolation loss was between 30 to 35 per cent The soil in the field was puddled both with country plough and sheep foot roller for a specified time The percolation rate was reduced by 0 4 mm/hr by using the sheep foot roller

Experiments were conducted by Yadav (1974) on black clay soil with IR-8 rice during Kharif at Siruguppa in Mysore state and with Jaya rice during Kharif at Hyderabad in Andra Pradesh to study the comparative efficiency of different puddling implements and of the artificial impervious subsoil layers to reduce the percolation loss

1 The following implements were used for puddling

1 Country plough (control)

2 Krishi power tiller

3 Angular block puddler at Siruguppa and ARI puddler at Hyderabad

4 Disc harrow at Siruguppa and ADS harrow at Hyderabad

5 Tractor with cage wheels at Siruguppa

6 Manual labour at Siruguppa

Submergence of 5 cm water was maintained throughout the crop growth period Depth of puddling cost of puddling water loss and crop yield under each treatment were recorded

At Siruguppa the greatest depth of puddling was achieved by tractor with cage wheels, followed by disc harrow, whereas the lowest depth of puddling was obtained by manual labour followed by country plough The total water loss (including percolation and that used by the crop) was somewhat higher in case of power tiller and angular block puddler The highest grain yield of IR-8 rice was recorded in the treatment in which puddling was done by tractor cage wheels and lowest in case of manual labour and country plough The tractor with cage wheels saved about 6 cm water as compared to the country plough and manual labour and 21 cm water as compared to angular block puddler Considering the various factors the tractor with cage wheels appeared to be most effective as a puddling implement

At Hyderabad the maximum grain yield of Jaya rice was achieved with ARI puddler followed by power tiller ADS disc harrow and country plough The percolation loss of water was lowest in the case of puddling done with power tiller and maximum with country plough and ARI puddler On the whole puddling with power tiller was preferable as the operation was done quickly and there was minimum percolation loss amongst the implements tried

2 Artificial impervious layers in subsoil to reduce percolation loss

Experiments were conducted in lateritic sandy loam soil at Kharagpur and in black clay soil at Siruguppa in which artificial impervious layers were created in the subsoil to reduce the percolation loss The treatments included the following

At Kharagpur

1 Control (no subsoil impervious layer)

2 Bitumen layer placed at 20 cm depth

3 Bitumen layer placed at 40 cm depth

4 Cement layer placed at 30 cm depth

At Siruguppa

1 Control (no subsoil impervious layer)

2 Polyethylene sheet placed at 60 cm depth

3 Bitumen layer (2 cm thick) placed at 60 cm depth

4 Cement + sand + gravel (1 3 4) layer placed at 60 cm depth

The experiment at Kharagpur was conducted in two seasons

The data on water requirement and grain yield of rice under different treatments revealed that the use of impervious layers brought about significant reduction in total water requirement of rice under flooded condition by decreasing the percolation loss The reduction in the boro season was about 4 times (from 317 3 cm to 85 4 cm) and less than 2 times in aman season (from 76 6 cm to 47 2 cm) as compared to control

At Siruguppa the measurement of total water loss 24 h after ponding showed highest percolation loss in the control plot, followed by the treatment of polyethylene sheet layer The maximum saving (50 per cent) in water use was recorded in the bitumen layer followed by cement + sand + gravel layer

Rao and Sirohi (1975) made a study to compare the performance of the newly developed APAU 750 mm puddler with that of country plough disc harrow and power tiller He found that the percolation loss in rice fields was less with the power tiller It was also reported that with APAU 750 mm puddler the depth of puddling and grain yield were more

Tyagi et al (1975) conducted field experiments at Chiplima in Orissa to study the effect of different puddling implements on the percolation losses and water use efficiency in the rice field The implements used were local plough mould board plough disc harrow power tiller with rotavator and tractor with cage wheel The efficiency of puddling implements was judged in terms of percolation losses water use efficiency and cost of puddling Power tiller with rotavator was found to be the most efficient in terms of percolation losses and water use efficiency followed by tractor with cage wheel and disc harrow But the cost was least when puddling was done with disc harrow followed by power tiller and tractor

Prihar et al (1976) compared the effectiveness of puddling with different implements and soil compaction in respect of water requirement and grain yield of rice on a sandy loam soil Compared with the unpuddled control compaction and puddling treatments reduced the mean water expense by 40 cm and 80 cm respectively Puddling with a disc harrow angular puddler and rotavator was as effective as puddling with a country plough

In another field study by Singh et al (1981) increase in compaction of loamy sand soil as indexed by bulk density of 0 5 cm layer progressively reduced irrigation need of the crop The highest saving in water occurred when the loamy-sand soil was compacted to a bulk density of 1 84 g/cm^3 On the whole compaction tended to increase the yield

A field experiment was conducted by George et al (1983) in sandy loam soil to study the efficiency of puddling with different implements (power tiller country plough and wet land puddler) soil dressing with lateritic loam and subsoil compaction at 30 cm depth in reducing percolation loss in rice fields The results showed that these methods neither effectively reduced the water loss nor influenced the grain yield

Awadhwal and Thierstein (1984) evaluated the performance of four tillage methods using various bullock drawn tillage tools The influence of tillage methods on soil physical conditions soil moisture weed control root growth grain yield were studied It was noted that deep tillage was favourable for better grain yield and weed control but it aggrevates the problems of soil and moisture loss during a dry spell The changes in the physical conditions of the soil induced by tillage were visible soon after the tillage operations but these differences reduced with passage of time and almost vanished by the end of crop growing season

The four tillage tools tested were

T_1 Bed splitting followed by two strip ploughing with MB plough

T_2 - Strip ploughing with MB plough

T_3 Chiseling at crop rows followed by blade harrow

T_4 - Shallow tillage with duck foot shovels

Awadhwal and Singh (1985) developed a methodology to evaluate the comparative performance of puddling equipment According to him a comparative performance of puddling implements could be evaluated by measuring their specific energy consumption for puddling and shear strength ratio of the puddled soils and then computing the performance ratio

Mathan et al (1985) reported that the strength of the fluffy paddy soils could be improved by compaction This technology involved passing of 400 kg stone roller eight times over the soil at proctor moisture level By this method the bulk density of the soil was increased from 1 11 g/cc to 1 33 g/cc and paddy yield was increased by 17 8 per cent over control Once compacted, the effect on bulk density remained for three successive crops The cost of compaction was only Rs 250 per hectare while the net profit was Rs 1200 per hectare

Rodriguez and Lal (1985) carried out a study to evaluate the effect of different tillage systems on the growth and yield of rice grain yield response to N applications and weed control The experiments were conducted at the I I T A Ibadon comparing the effects of zero tillage (without dry tillage and puddling) and conventional tillage (dry tillage and puddling) at two or more N levels In two of the above experiments the effects of either two moisture regimes or chemical versus manual weed control were also evaluated He found that there were no significant difference in grain yield between zero tillage plots and conventional tillage plots The continuous flooding treatment gave better weed control and higher grain yield than the saturation moisture regime

Ogunremi _et al_ (1986) conducted field experiments on a sandy loam soil to assess the effects of compaction puddling and no till systems on soil physical properties and on rice growth and yield with and without supplementary irrigation Soil compaction decreased macro and micro pores more than puddling or no-till treatments The equilibrium infiltration rates were 0 12, 0 15 and 1 05 ms^{-1} in compacted, puddled and no-till treatments respectively The mean grain yield for 4 consecutive crops were 6 4 5 1 and 4 9 Mg ha^{-1}, the compacted being significantly greater than the puddled and no-till treatments Compared to both puddling and no-till treatments, soil compaction resulted in significant yield increase of about 20 per cent under the rainfed regime and from 34 to 40 per cent in the flooded moisture regimes

Walker and Rushton (1986) reported that where rice was grown under continuous flow and with ground water at depth of 1 m or greater field water use efficiency of only 25 to 30 per cent were measured The principal loss was caused by lateral percolation the movement of water from the flooded fields laterally into the bunds and from there vertically down to the water table The results showed that field water use efficiencies could be greatly increased by scaling the bunds or by maintaining the shallowest possible water layer in the rice fields

Razzaq (1987) carried out a study to compare the performance of cultivator tillage and rotary tillage each carried out independently and in combination for puddling fine textured soil Puddling carried out with the use of cultivator twice plus rotary cultivator once followed by one planking recorded significant increase in paddy yield as compared with their individual combination

Kumar and Singh (1988) conducted an experiment to study the efficacy of Carboxymithyl Cellulose (CMC) polymer in reducing the percolation losses in paddy fields under ponded conditions and observed that the reduction in percolation losses as compared to the puddled conditions was found to be 35 62 per cent and 61 0 per cent respectively for two soil samples with 0 10 per cent polymer concentrations after 1500 minutes of polymer treatment With 0 05 per cent polymer concentration the reduction in percolation were 16 25 and 31 92 per cent for two soil samples compared to puddled conditions The efficacy of CMC treatment to reduce percolation losses increased with concentration upto the limit of 0 10 per cent

Manian and Jivaraj (1989) in an experiment with different combinations of four bullock drawn implements namely country plough victory plough helical bladed puddler and sheep foot roller in black clay soil found no significant difference in percolation loss for the different stages of growth and even all stage combined With respect to yield there was no significant difference in yield among treatements

Sharma (1990) conducted an experiment on calcareous sandy loam soil to evaluate the puddling efficiency of animal drawn implements in terms of puddling index yield of rice and cost of operation Puddling treatments consisted of two or four ploughing by local or mould board plough followed by planking and an additional treatment consisting of two ploughings by local plough followed by one operation of bullock drawn puddler and then planking He found that two ploughings either by local or mould board plough followed by planking were sufficient to give the same yield and puddling index as four ploughings

Sarma et al (1991) conducted a study to evaluate the performance of different bullock drawn puddling equipment The implements used for the study were rotary blade puddler disc harrow and harrow-cum-puddler in comparison with desi plough The performance of rotary blade puddler was found very effective in reducing percolation loss as it provided good puddle with puddling index of 49 10 to 57 02 per cent in clay loam soil Significantly higher yield was obtained with rotary blade puddler for the three years studied, followed by disc harrow The energy required and cost of operation of bullock drawn disc harrow and desi plough was 1 35 and 4 64 times the requirements of bullock drawn rotary puddler

Materials and Methods

MATERIALS AND METHODS

The materials used and methodology adopted for conducting the experiment are described in this chapter. A field experiment to estimate the percolation loss of water and grain yield under different tillage methods was conducted during December 1991 to March 1992.

3.1 Location

The experimental field was located in the paddy field of the instructional farm of K.C.A.E.T, Tavanur. The experimental field was typical wetlands of the region. It is situated at 10° 53' 30" north latitude and 76° east longitude. The total area of K.C.A.E.T is 40.99 ha of which total cropped area is 29.65 ha.

3.2 Soil

The surface soil is sandy loam in texture comprising of 10 per cent gravel, 65 per cent sand, 12.5 per cent silt and 12.5 per cent clay.

3.3 Climate

Agro climatically, the area falls within the border line of northern zone and central zone. Most part of the rainfall received in this region is from south-west monsoon The average annual rainfall varies from 2500 mm to 2900 mm

3 4 Season and weather conditions

The experiment was conducted during December 1991 to March 1992 The meteorological observations recorded at the instructional farm of K C A E T , Tavanur during the crop growing period are presented in Appendix-I No rainfall occurred during the periof of crop growth

3 5 Experimental procedure

The procedure employed for conducting the field experiment to estimate the percolation loss of water in rice fields under different tillage methods is described here

The following five treatments were chosen for the study

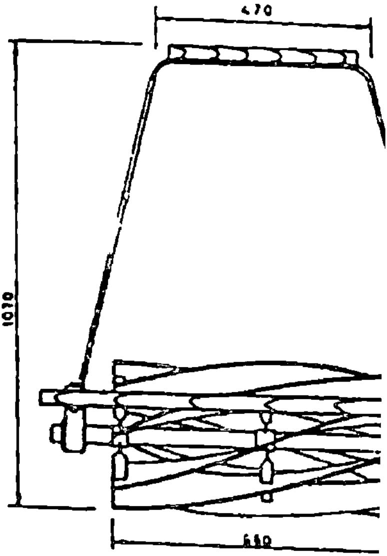
T_1 - Puddling with power tiller

T_2 - Puddling with tractor cage wheel

T_3 - Puddling with bullock drawn puddler (T N A U helical bladed type)

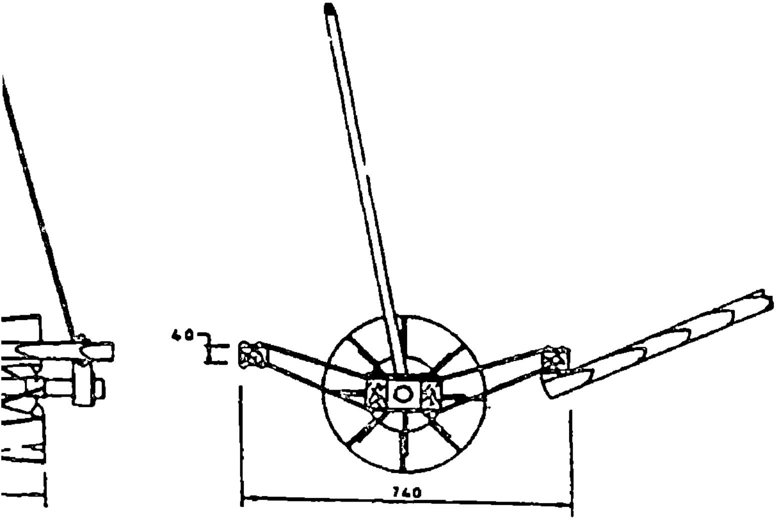
T_4 - Soil compaction using roller

T_5 - Country ploughing along with planking (control)



ELEVATION

FIG.2 T.N



END VIEW

.A.U. HELICAL BLADE PUDDLER

Country plough is still used by the majority of the farmers having small size land holding So it was used as a control practice in comparing the effectiveness of other implements and roller in reducing percolation loss of water in rice fields and in increasing crop yield

The experimental field was thoroughly ploughed with tractor and levelled after the harvesting of preceding crops Then all the plots to be puddled were irrigated and the treatments were carried out one by one Each treatment was replicated five times Treatments in each replication were arranged in blocks and these blocks were labelled as R_1 R_2, R_3 R_4 and R_5 The experiment was laid out in randomised block design Treatments within a block were located at random The size of each plot was 8 m x 5 m

The plots to be compacted were puddled with tractor cage wheel first Two passes of roller were then made on these plots Twenty centimetre high bunds were made around each plot The width of the bund was about 30 cm at the bottom and 20 cm at the top Facilities were provided for irrigating each plot separately The total area of the experimental field was 1120 m^2 The sources of irrigation water were an open well and ponds situated near the experimental field The layout of the plot is shown in Fig 3 and also in Plate I

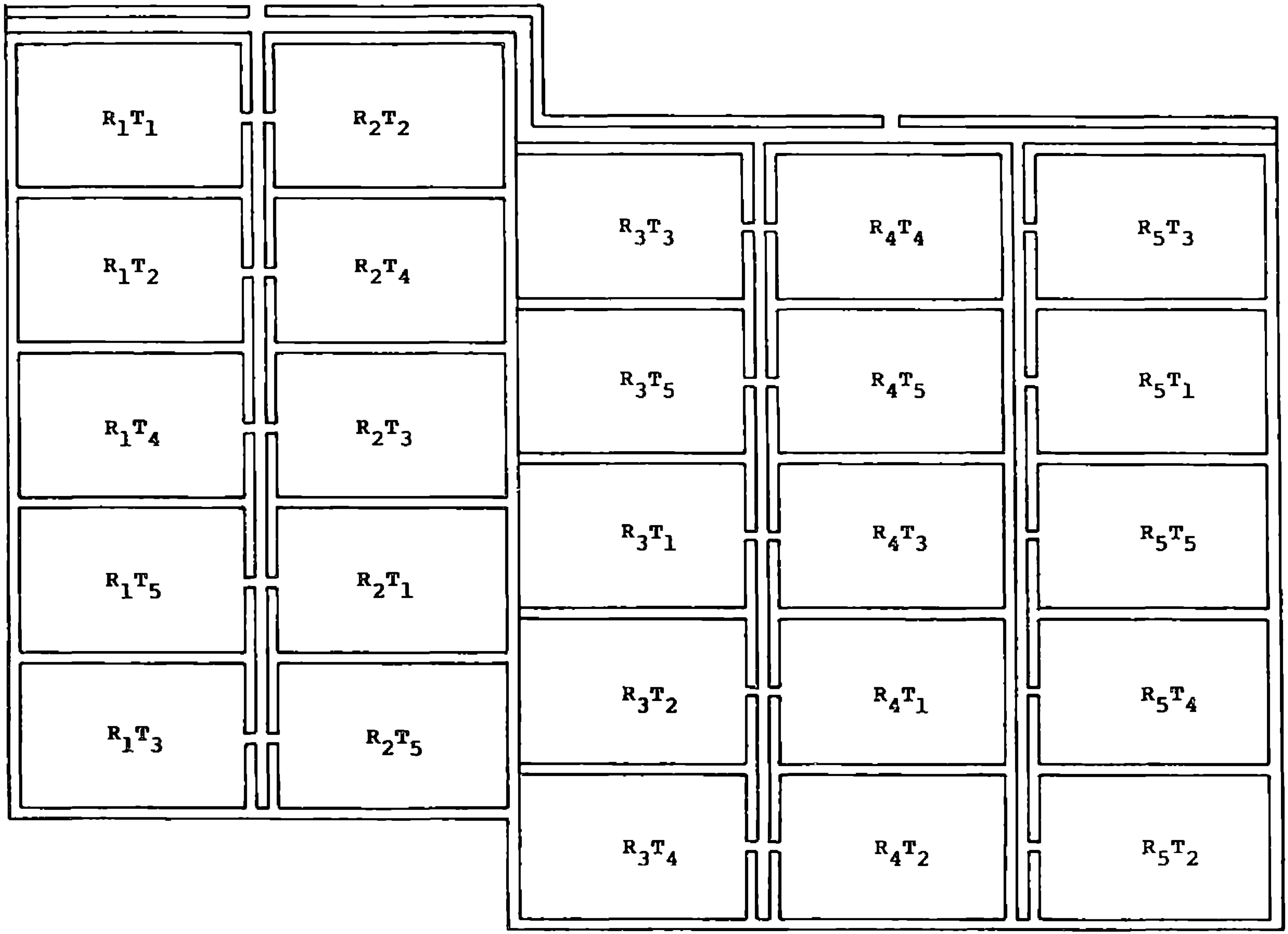


FIG.3 LAYOUT OF THE EXPERIMENTAL PLOTS

Plate I Experimental field

3.6 Crop cultural practices

Twenty five days old seedlings of short duration rice variety 'triveni' were used for transplanting Seedlings were transplanted in the puddled soil on 27-28 December, 1991 Fertilizer was applied at the rate of 75:35:35 kg N, P_2O_5 and K_2O respectively per hectare Half of the nitrogen was applied at the time of transplanting and the remaining half in two split dozes during the crop growth period Phosphorus and potassium were applied in full doze at the time of transplanting Weeding and other plant protection measures were done as per the recommendations in the package of practices and is given in Appendix-II

3.7 Measurement of total water loss and evaporation from the experimental field

Field hook gauge were fabricated and used for the measurement of daily water loss from the field

3.7.1 Field hook gauge

Field hook gauge consisted of a pointer bent upwards, which was sliding over a 6 mm iron rod to which a graduated scale was fitted Least count of the scale was 1 mm The height of the hook gauge was designed so as to read the scale without parallax error by squatting on the bund A frame made of angle iron was provided at the bottom for giving perfect seating to the equipment in the field The diagram of the hook gauge is given in Fig 4 Field hook gauge was firmly installed in the field to avoid movement due to wind or any other reason Hook gauges were installed in all the 25 plots

Hook gauge was installed in the field at a distance of about 45 cm from the bund so as to enable one to take the reading without entering into the field Water level of 5 cm was maintained in the field throughout the crop growth period For this a pointer 5 cm high fixed on a flat plate was kept in all the plots near to the hook gauge Each day the plots were irrigated till the water level coincided with the tip of the pointer fixed to the flat plate This made the depth of water in the field exactly 5 cm After making the water level in the field 5 cm high the screw of the hook gauge was loosened and the pointer of the hook gauge was brought in level with the water in the field Then the screw was tightened and the corresponding scale reading was taken After 24 h the water level must have lowered For measuring the drop in water level, the hook gauge was adjusted such that the pointer was just in contact with the water level and the corresponding reading in the scale was taken The difference in the two scale readings gives the total water loss from the plot during 24 h which included the losses due to percolation and evapotranspiration All the plots were again irrigated

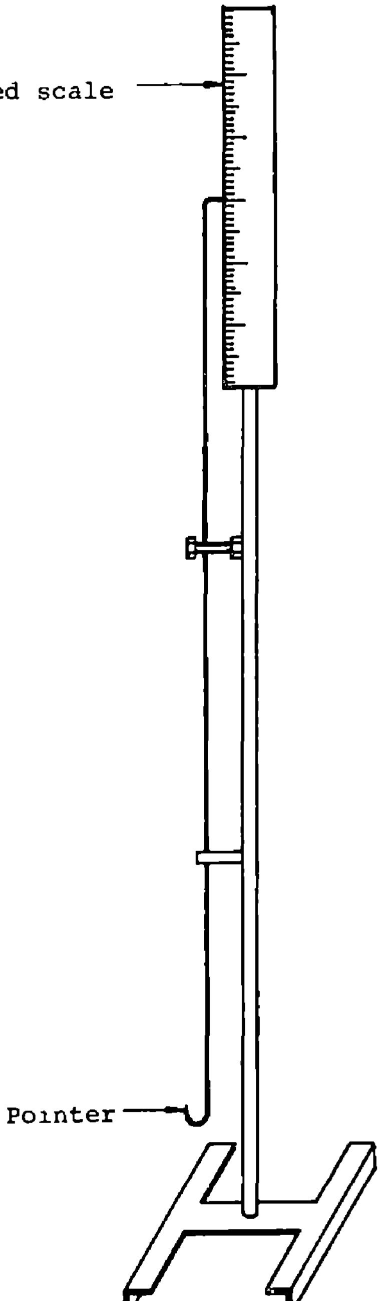


FIG.4 FIELD HOOK GAUGE

Plate II   Field hook gauge

till the water level coincided with the tip of the pointer fixed on the flat plate Thus the water level was brought back to 5 cm The hook gauges in all the plots were reset so that the pointer of the hook gauge was brought in level with the water in the field Hook gauge measurements were continued till irrigation was stopped and crop reached maturity All the observations were made at a particular time daily By adding up the daily water loss the total water loss from the plots during the crop growth period was obtained

3 7 2 Evapotranspiration

Uniform evapotranspiration was assumed to occur from all the plots To determine the evapotranspiration from the field evaporation was measured using U S W B class A pan evaporimeter installed in the observatory

3 7 2 1 U S W B class A pan evaporimeter

Evaporimeter measurements were made by the pan evaporimeter The standard U S W B class A pan evaporimeter was used for this purpose It is made of 22 gauge galvanized iron 120 cm in diameter and 25 cm in depth, and is painted white and exposed on a wooden frame in order that air may circulate beneath the pan It is filled to a depth of about 20 cm The water surface level was measured daily by means of a hook gauge in a stilling well, and evaporation computed as the difference between observed levels Water was added each day to bring the level to a fixed point in the stilling well

The evapotranspiration/pan evaporation ratio also known as the crop factor was used for converting pan evaporation data into evapotranspiration For this the crop factor for rice computed on a weekly basis during an experiment conducted earlier was used The evapotranspiration was then subtracted from the total water loss from all the plots to obtain the water loss due to percolation

3.8 Yield

As the crop reached maturity, irrigation was stopped one week before harvest so as to enable the field to dry during harvest Crop from each plot was harvested separately by manual labour and collected for threshing After threshing winnowing and drying operations the quantity of cleaned grain was weighed for each plot separately

Results and Discussion

RESULTS AND DISCUSSION

Tillage of agricultural soil is the manipulation of soil properties to modify soil conditions for crop production Tillage produces changes in soil conditions which interact with physical chemical and biological crop growth factors The suitability of a tillage system in achieving the objective of crop production is judged by its effectiveness in soil and water conservation Puddling is a widely accepted practice in lowland rice growing fields to reduce the loss of irrigation water by percolation The results of the field experiment conducted for estimating the percolation loss of water and yield under different tillage methods in rice fields with a short duration rice are presented in this chapter

The daily water loss from the plots which were subjected to different tillage practices were measured using field hook gauge The evapotranspiration data were subtracted from the total water loss to obtain the quantity of water lost through percolation The data are given in Tables 1 to 9 The results are presented diagramatically in Figures 5 to 11 Tables showing the analysis of variance are given in Appendices V to X

The evapotranspiration obtained by multiplying the pan evaporation data by crop factor amounted to 573 88 mm for the crop growth period (Table 1) Uniform evapotranspiration was

Table 1 Pan evaporation, crop factor and evapotranspiration on a weekly basis

Week	Pan evaporation (mm)	Crop factor (mm)	Evapotranspiration (mm)
1	29 40	0 52	17 42
2	37 10	0 78	28 08
3	37 70	1 05	40 95
4	25 30	1 70	61 20
5	29 30	1.85	66 60
6	29 70	2 05	65 60
7	34 30	2 16	64 80
8	35 40	1 82	66 79
9	30 60	1 96	64 48
10	31 90	1 77	52 04
11	25 80	1 64	45 72
	346 50		573 88

assumed to take place from all the plots Table 2 shows the mean total water loss under different tillage practices and evapotranspiration on a weekly basis The mean water requirement was highest in the plots puddled with country plough (1609 3 mm) which was the control practice It was followed by animal drawn puddler compaction using roller power tiller and tractor cage wheel The lowest quantity of water requirement obtained in the case of puddling with tractor cage wheel was 1510 3 mm The percolated water constitute 62 per cent of the water requirement in the case of plots puddled with tractor cage wheel and 64 34 per cent in the case of country plough (control)

The mean total water loss under different treatments and the evapotranspiration during the crop growth period on a weekly basis are represented graphically in Fig 5 From the graph it can be seen that the water requirement increased steadily after transplanting and reached a maximum value between 7th and 8th weeks Then it decreased till the crop reached maturity The same trend is observed for all the treatments The increase in the water requirement upto the eighth week after transplanting is due to the increase in the evapotranspiration of the crop After that evapotranspiration decreased as the crop entered the ripening stage of growth Thus there is a corresponding decrease in the total water loss also

Table 2 Mean total water loss under different tillage treatments and evapotranspiration from rice field

Week	Total water loss (mm) Treatments					ET (mm)
	T_1	T_2	T_3	T_4	T_5	
1	73 6	73 5	80 1	79 1	81 3	17 42
2	87 3	84 5	103 9	92 9	95 5	28 08
3	103 6	104 2	119 5	111 3	119 4	40 95
4	126 2	125 1	137 1	125 4	142 5	61 20
5	145 4	144 4	160 0	147 6	162 7	66 60
6	175 2	169 9	182 5	173 6	182 8	65 60
7	217 8	203 9	220 3	213 7	219 0	64 80
8	215 0	212 3	217 5	213 9	219 4	66 79
9	174 1	179 3	180 3	175 8	177 4	64 18
10	136 3	139 4	132 3	131 5	137 3	52 04
11	69 4	73 8	68 8	70 7	72 0	45 92
Total	1523 9	1510 3	1602 3	1535 5	1609 3	573 88

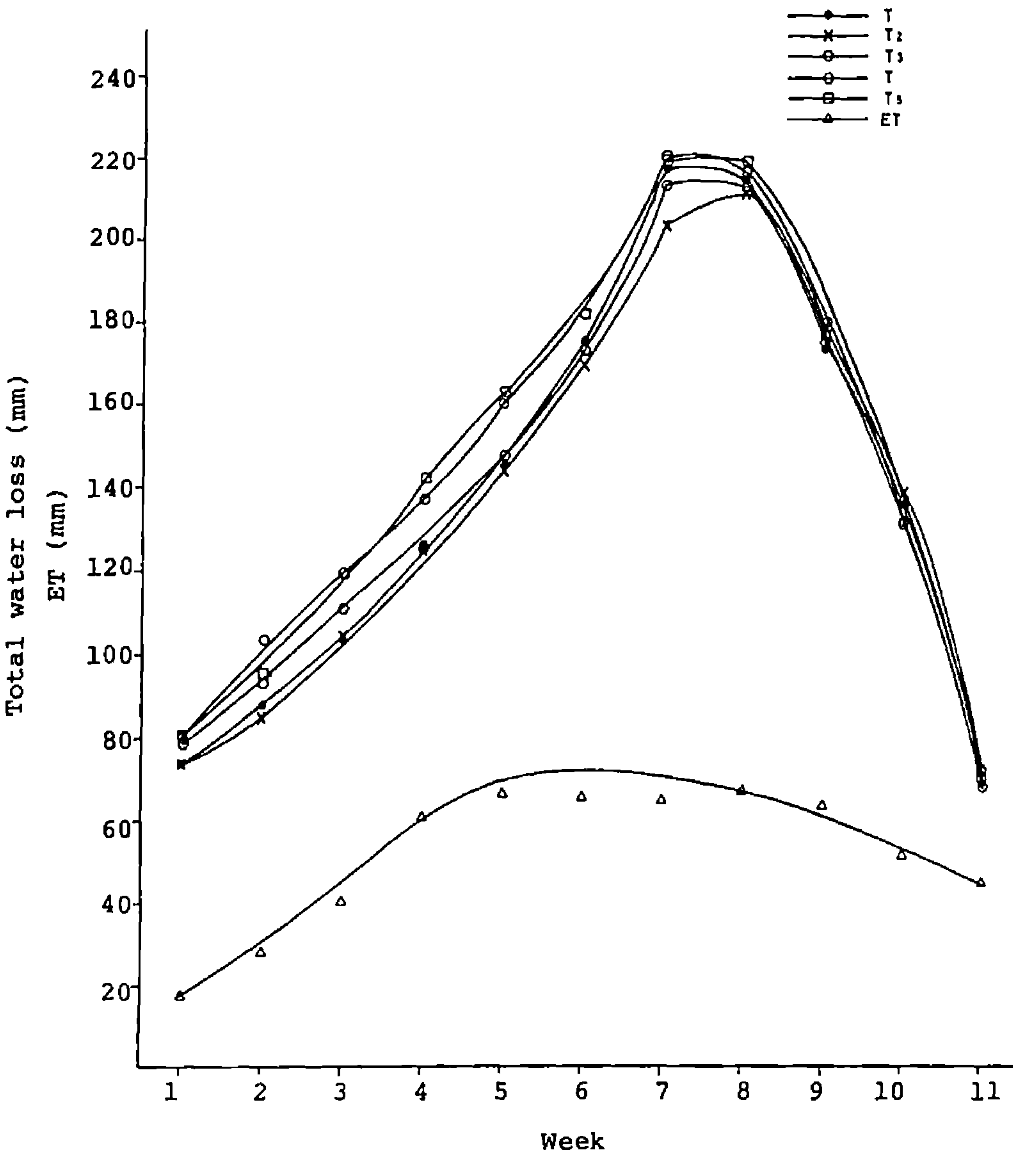


FIG.5 MEAN TOTAL WATER LOSS UNDER DIFFERENT TILLAGE TREATMENTS AND EVAPOTRANSPIRATION

The total water loss from all the individual plots were calculated for each seven days interval and are given in Table 3 The daily water loss from all the individual plot s for the entire growing season are given in Appendix-III

4 1 Effect of different tillage practices on percolation of water from rice field

The total quantity of percolated water from the plots as influenced by the different treatments are given in Table 4 The statistical analysis carried out for the data shows that there is no significant difference among the treatments regarding the quantity of water percolated from the plots However the lowest mean percolation of 936 12 mm was recorded in T_2 (puddling with tractor cage wheel) followed by T_1 T_4 T_3 and T_5 The highest mean percolation observed in T_5 was 1035 12 mm The percentage decreases in percolation over the control (T_5 - puddling with tractor cage wheel) were 9 56 8 32 6 68 and 0 69 in T_2 T_1 T_4 and T_3 respectively The diagramatic representation of the data is shown in Fig 6

The growth of rice plant can be divided into three main phases They are

Vegetative phase 50 days		from seed germination to panicle initiation
Reproductive phase 50 days	-	from panicle initiation to flowering
Ripening phase 30 days	-	from flowering to full maturity

Table 3 Total water loss under different tillage treatments and evapotranspiration from the plots for each seven days interval

Plot	Total water loss (mm)											Total
	Week											
	1	2	3	4	5	6	7	8	9	10	11	
R_1T_1	79 0	94 0	118 5	138 5	162 5	195 5	225 0	214 0	169 5	134 5	74 0	1605 0
R_1T_2	73 0	81 0	91 5	106 0	122 0	156 5	207 5	209 5	178 5	144 0	77 0	1446 5
R_1T_3	85 0	109 0	122 0	146 0	181 0	201 0	225 0	226 0	192 0	131 5	63 0	1681 5
R_1T_4	79 0	94 0	117 5	133 0	160 0	182 0	213 0	211 5	162 5	132 0	76 5	1562 0
R_1T_5	90 5	110 0	129 5	153 5	171 5	192 5	216 5	219 0	181 0	136 5	77 0	1677 5
R_2T_1	72 0	88 0	98 5	122 0	138 5	165 0	200 0	210 5	166 5	133 5	78 5	1473 0
R_2T_2	75 5	85 5	99 0	116 0	131 0	160 0	203 5	213 5	183 5	148 5	81 5	1493 5
R_2T_3	78 5	103 5	115 5	133 0	162 0	188 0	223 0	214 0	172 5	128 5	70 0	1588 5
R_2T_4	86 0	103 5	122 0	142 0	162 0	189 5	226 5	212 5	175 5	132 5	66 0	1618 0
R_2T_5	75 5	90 0	104 5	125 5	143 0	167 0	218 5	223 5	169 5	159 0	81 5	1577 5
R_3T_1	69 0	80 5	91 5	114 5	136 0	164 0	215 5	210 0	175 5	131 5	61 5	1449 5
R_3T_2	72 0	88 0	125 0	153 5	183 5	198 0	214 5	204 0	175 0	139 0	73 5	1626 0

Contd

Table 3 (Contd)

Plot	Total water loss (mm)											Total
	Week											
	1	2	3	4	5	6	7	8	9	10	11	
R_3T_3	74 5	101 5	115 5	133 5	153 0	178 5	222 5	225 0	184 5	130 5	67 5	1587 0
R_3T_4	76 0	84 0	98 5	109 5	130 5	155 0	201 0	214 5	175 5	134 5	70 5	1449 0
R_3T_5	86 5	97 0	128 5	159 5	190 0	207 5	225 0	214 0	166 5	118 5	59 0	1652 0
R_4T_1	71 0	83 5	95 5	117 0	138 0	166 0	215 5	218 5	175 0	140 5	68 5	1489 0
R_4T_2	72 5	79 5	89 5	106 5	126 0	158 0	194 0	212 0	188 0	141 5	75 5	1443 0
R_4T_3	77 5	96 0	122 5	131 0	149 0	170 0	211 5	214 5	174 5	135 5	70 0	1548 0
R_4T_4	75 5	90 0	108 5	122 0	141 5	170 5	216 5	223 0	178 5	129 5	70 5	1526 0
R_4T_5	76 5	94 5	119 5	138 0	153 5	172 5	218 0	211 5	179 0	140 5	73 5	1577 0
R_5T_1	77 0	90 5	114 0	139 0	152 0	185 0	233 0	222 0	184 0	141 5	64 5	1603 0
R_5T_2	74 5	88 5	116 0	143 5	159 5	177 0	200 0	222 5	171 5	124 0	61 5	1537 0
R_5T_3	85 0	109 5	223 0	142 0	155 0	175 0	219 5	208 0	178 0	135 5	73 5	1604 5
R_5T_4	79 0	98 0	110 0	120 5	144 0	171 0	211 5	208 0	187 0	129 0	70 0	1544 5
R_5T_5	77 5	86 0	115 0	136 0	155 5	174 5	217 0	229 0	171 0	132 0	69 0	1561 0
ET	17 42	28 08	40 95	61 20	66 60	65 60	64 80	66 79	64 48	52 04	44 92	578 88

Table 4 Effect of tillage treatments on percolation loss of water

Treatment	Percolation loss (mm) Replications					Treatment mean	Percentage decrease over control
	R_1	R_2	R_3	R_4	R_5		
T_1	1030 62	899 12	875 62	915 12	1029 12	949 92	8 32
T_2	872 62	923 62	1052 12	869 12	963 12	936 12	9 56
T_3	1107 62	1014 62	1013 12	974 12	1030 62	1028 02	0 69
T_4	988 12	1044 12	875 12	952 12	970 62	966 02	6 68
T_5	1103 62	1003 62	1078 12	1003 12	987 12	1035 12	-

T_1 - Puddling with power tiller

T_2 - Puddling with tractor cage wheel

T_3 - Puddling with bullock drawn puddler (T N A U helical blade type)

T_4 Compaction using roller

T_5 - Puddling with country plough along with planking (control)

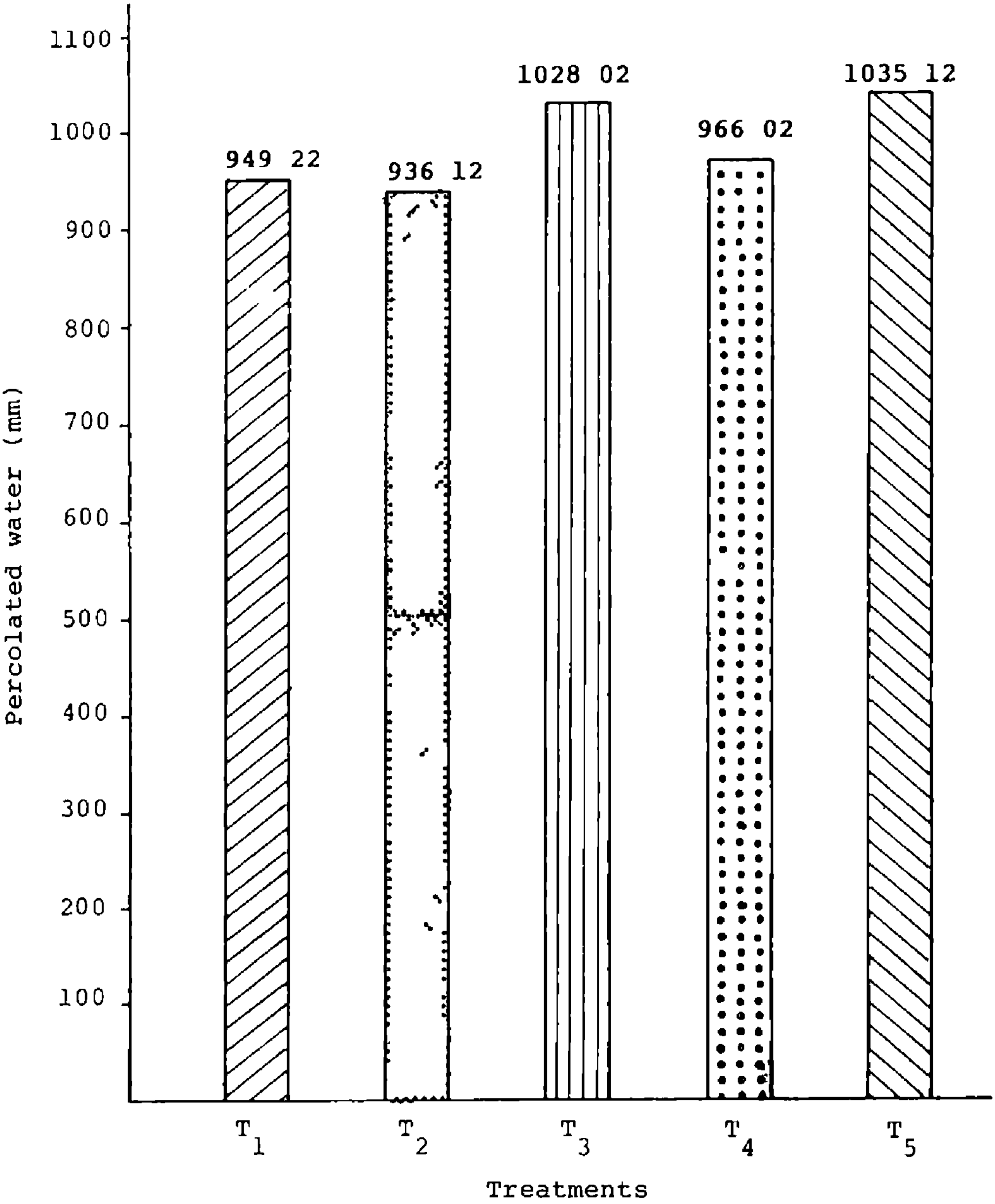


FIG 6 INFLUENCE OF TILLAGE TREATMENTS ON PERCOLATION LOSS

The statistical analyses were carried out for the water loss through percolation during different stages of crop growth to get a comprehensive picture of the variation in the percolation loss of water between the treatments

4.1 1 Effect of different tillage methods on percolation loss of water during the vegetative phase

Table 5 shows the water loss through percolation under different treatments during the vegetative phase of the crop growth period

Table 5 Effect of tillage treatments on percolation loss during vegetative phase

Treatment	Percolation loss (mm) Replications					Treatment mean	Percentage increase/ decrease over control
	R_1	R_2	R_3	R_4	R_5		
T_1	282 4	232 8	207 9	219 4	272 9	243 08	-16 49
T_2	203 8	228 4	290 9	200 4	274 9	239 68	17 66
T_3	314 4	282 9	277 4	269 4	311 9	291 20	+0 04
T_4	275 8	305 9	220 4	248 4	254 9	261 08	10 31
T_5	335 8	247 9	323 9	280 9	266 9	291 08	--

The treatments T_3 and T_5 (control) registered highest quantity of percolated water (291 2 mm and 291 08 mm

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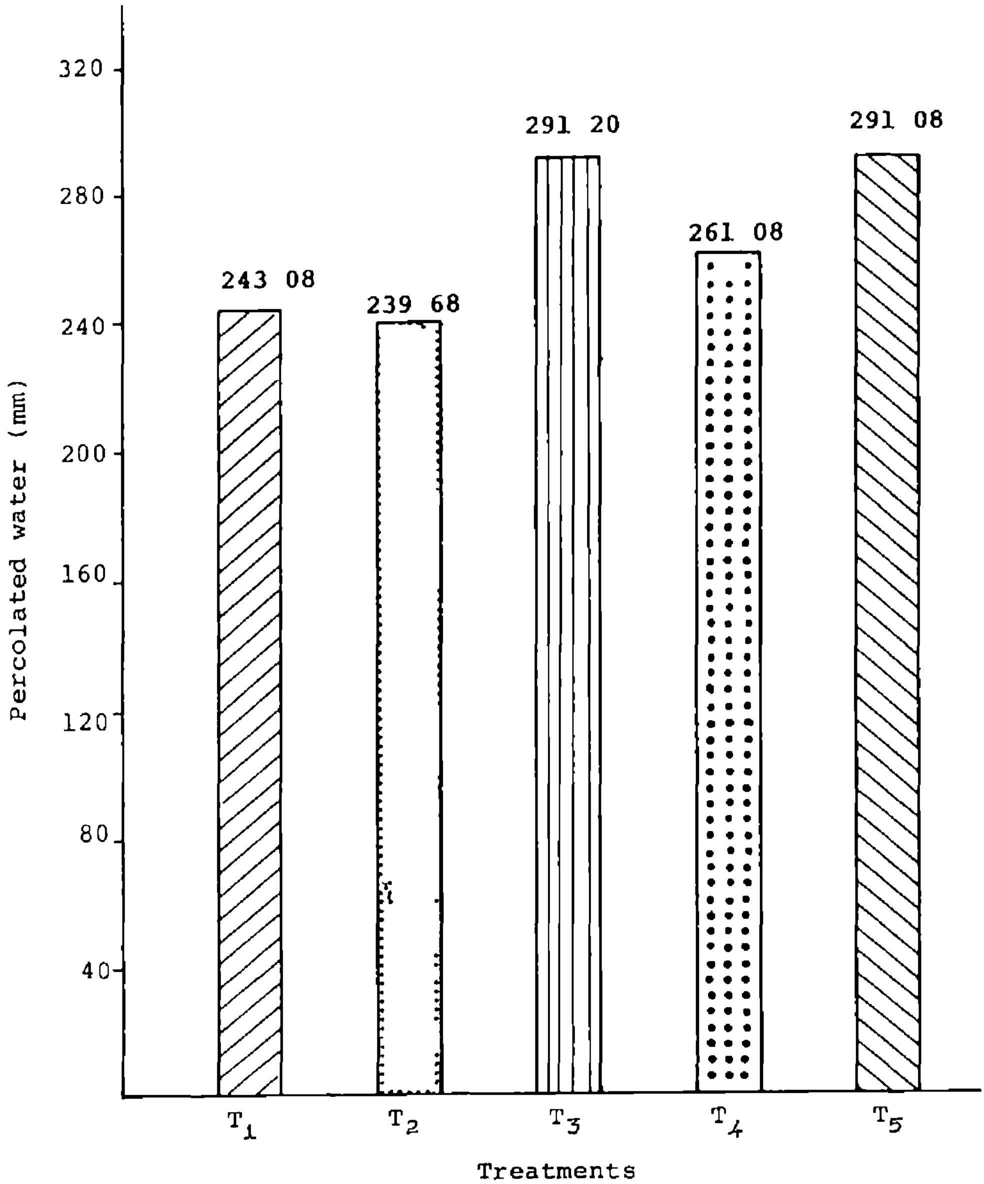

FIG 7 INFLUENCE OF TILLAGE TREATMENTS ON PERCOLATION LOSS (VEGETATIVE PHASE)

respectively) This was followed by treatments T_4 T_1 and T_2 The treatments T_4 T_1 and T_2 decreased the percolation of water by 10 31 per cent 16 49 per cent and 17 66 per cent respectively over the control practice T_5 i e puddling with country plough The diagramatic representation of the data is shown in Fig 7

4 1 2 Effect of different tillage methods on percolation loss during the reproductive phase

Percolation loss of water during the reproductive stage of crop growth under different tillage treatments are given in Table 6 The minimum percolation loss of 470 mm was recorded in the plots puddled with tractor cage wheel and the maximum percolation of 518 mm was observed in the plots puddled with bullock drawn puddler The treatment T_2 showed the lowest percentage decrease over control (7 69 per cent) The treatment T_3 recorded an increase of 1 73 per cent over the control practice The differences in percolation loss of water during reproductive stage were not statistically significant (Appendix-VII) The mean percolated water under the different tillage methods during reproductive stage is also shown in Fig 8

Table 6 Effect of tillage treatments on percolation loss during reproductive phase

Treatment	Percolation loss (mm) Replications R_1	R_2	R_3	T_4	T_5	Treatment mean	Percentage increase/ decrease over control
T_1	533 2	450 2	461 7	515 7	515 7	495 3	-2 73
T_2	431 7	444 2	536 2	434 2	503 7	470 0	-7 69
T_3	569 2	523 2	534 7	469 2	493 7	518 0	+1 73
T_4	502 7	526 7	460 7	487 2	470 7	489 6	-3 85
T_5	535 7	488 2	520 2	489 7	512 2	509 2	-

4 1 3 Effect of different tillage methods on percolation loss during ripening phase of crop growth

Table 7 shows the effect of tillage practices on the percolation of water in the rice growing plots during the ripening phase of crop growth The plots under treatment T_4 registered the lowest percolation of 215 5 mm, followed by T_1 (217 3 mm) T_3 (218 9 mm) T_5 (224 2 mm) and T_2 (230 0 mm) The percentage variations over the control are also given in Table 7 Statistical analysis shows that there is no significant differences among treatments (Appendix-VIII) Figure 9 shows the diagramatic representation of the data

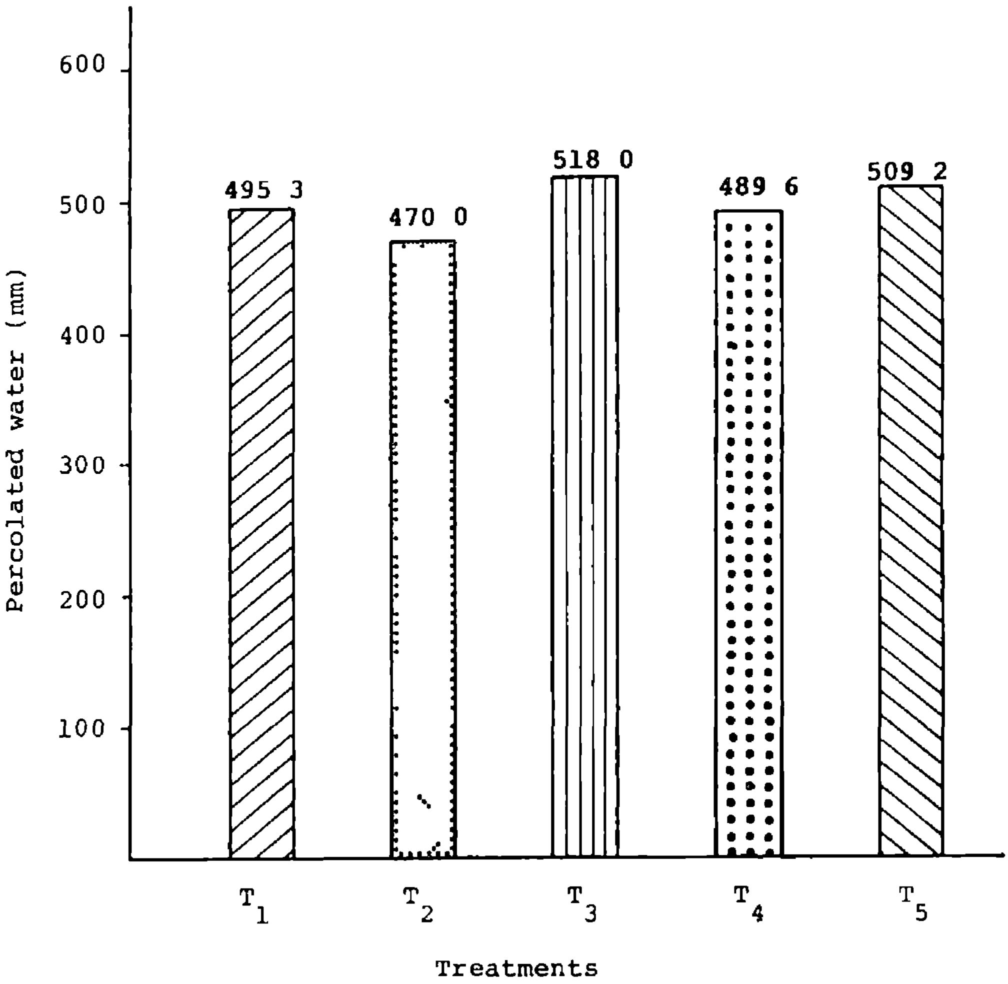

FIG 8 INFLUENCE OF TILLAGE TREATMENTS ON PERCOLATION LOSS (REPRODUCTIVE PHASE)

Table 7 Effect of tillage treatments on percolation loss during ripening phase

Treatment	Percolation loss (mm) Replications R_1	R_2	R_3	R_4	R_5	Treatment mean	Percentage increase/ decrease over control
T_1	215 5	216 1	206 1	221 5	227 5	217 3	-3 08
T_2	237 0	251 1	225 1	242.5	194 5	230 0	+2 59
T_3	224 1	208 6	220 1	217 5	224 5	218 9	-2 36
T_4	208 5	211 6	218 1	216 0	223 5	215 5	-3 89
T_5	232 1	267 6	181 5	230.5	209.5	224 2	--

The statistical analysis of the percolated water from the plots under different tillage treatments showed that the differences in the percolation of water among the treatments were not significant for the different stages of growth and even all stages combined The reason for this could be attributed to the sandy loam nature of the soil in which creation of a good puddle is not possible When the submerged paddy field is puddled a muddy suspension is created The larger particles in the suspension settle first and the finer ones later These finer particles block the pores in the top soil surface and reduce the percolation Since the clay content of the soil in the experimental field is only 12 5 per cent, the amount of finer particles available for clogging of

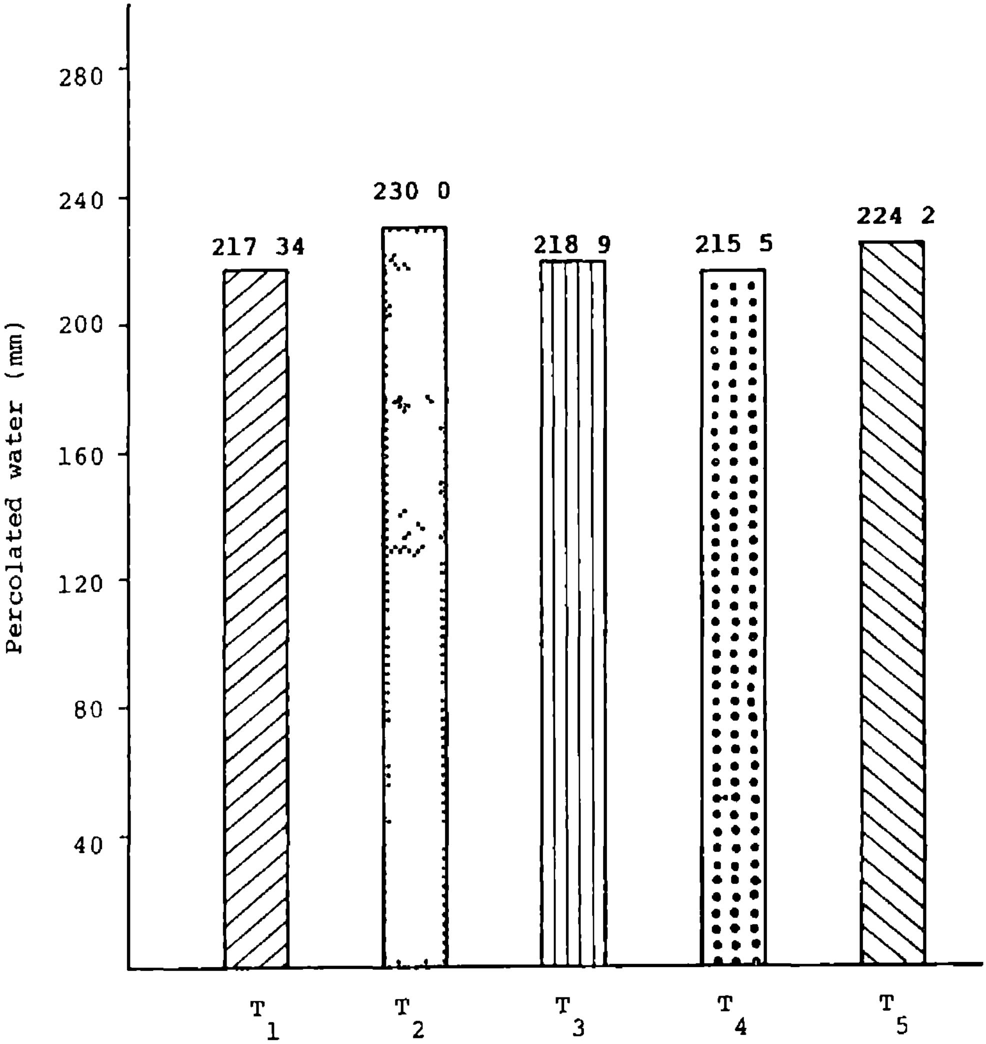

FIG 9 INFLUENCE OF TILLAGE TREATMENTS ON PERCOLATION LOSS (RIPENING PHASE)

pores and surface seal development are less So the implements were not found effective in reducing the percolation loss of water George et al (1983) also reported that puddling with different implements soil dressing with lateritic loam and subsoil compaction at 30 cm depth were not effective in reducing the percolation loss in sandy loam soil

Puddling is the process of manipulation of the soil at high moisture content by mechanical device so as to form a homogeneous mixture such that the soil particles remain in suspension during the course of transplanting of paddy The deformation of the soil during puddling operation results from the combined effects of shear and compression with respect to moisture content and clay composition It is known that rice response to various puddling methods depends on soil physical properties especially the soil texture Surface soil aggregates have a major impact on water infiltration Aggregates <0 25 mm in diameter play a major role in decreasing infiltration rates through clogging of pores and surface seal development The soil in the experimental field is sandy loam in texture comprising of 10 per cent gravel 65 per cent sand 12 5 per cent silt and 12 5 per cent clay Aggregates <0 25 mm in diameter are less in this type of soil The reason for the insignificant difference among the treatments in reducing the percolation loss of water could be attributed to the above aspect of the soil in the experimental field

The plots which were subjected to compaction also did not show any significant change in the percolation loss compared to other treatments This may be due to the high moisture content of the soil in the field Since compaction was carried out after puddling, the moisture content was high Akram _et al_ (1979) determined the infiltration rate and bulk density of soil as a function of compacting pressure and water content at the time of compaction and found that maximum compaction occurred when the moisture content was near field capacity Compaction of the field at field capacity in sandy loam soil reduced infiltration rates by only less than 0 1 per cent of the value at no compaction condition This implies that the effect of compaction can be expected to be more pronounced in the case of heavy soil than in light soils with corresponding alteration in the infiltration rate

From the results obtained it can also be seen that the percentage variation of the percolated water for different treatments over the control was maximum (17 66 per cent) during the vegetative phase The variation from the control decreased during the latter two stages and was minimum during the ripening stage (3 89 per cent) This indicate that the changes in the physical condition of the soil induced by tillage are visible soon after the tillage operations but these differences reduce with the passage of time

4 2 Effect of different tillage methods on grain yield

The grain yield as influenced by the treatments are given in Table 8 Puddling with tractor cage wheel recorded the highest yield i e 11 26 kg/plot Yield increase of 11 71 per cent was obtained over the control in treatment (T_2) The treatment T_2 was followed by T_3 (11 22 kg/plot), T_4 (11 08 kg/plot) T_1 (10 76 kg/plot) and T_5 (10 08 kg/plot) However the statistical analysis showed that the yield did not differ significantly among the treatments (Appendix-IX) The data is represented diagramatically in Fig 10

Table 8 Grain yield as influenced by various tillage treatments

Treatment	Yield (kg/plot) Replications R_1	R_2	R_3	R_4	R_5	Treatment mean	Percentage increase/ decrease over control
T_1	11 3	11 0	10 8	9 7	11 0	10 76	+6 75
T_2	11 5	12 5	12 6	10 0	9 7	11 26	+11 71
T_3	12 0	11 2	11 5	11 5	9 9	11 22	+11 31
R_4	12 2	9 5	11 2	11 2	11 3	11 08	+9 92
T_5	9 4	9 7	10 0	11 7	9 6	10 08	-

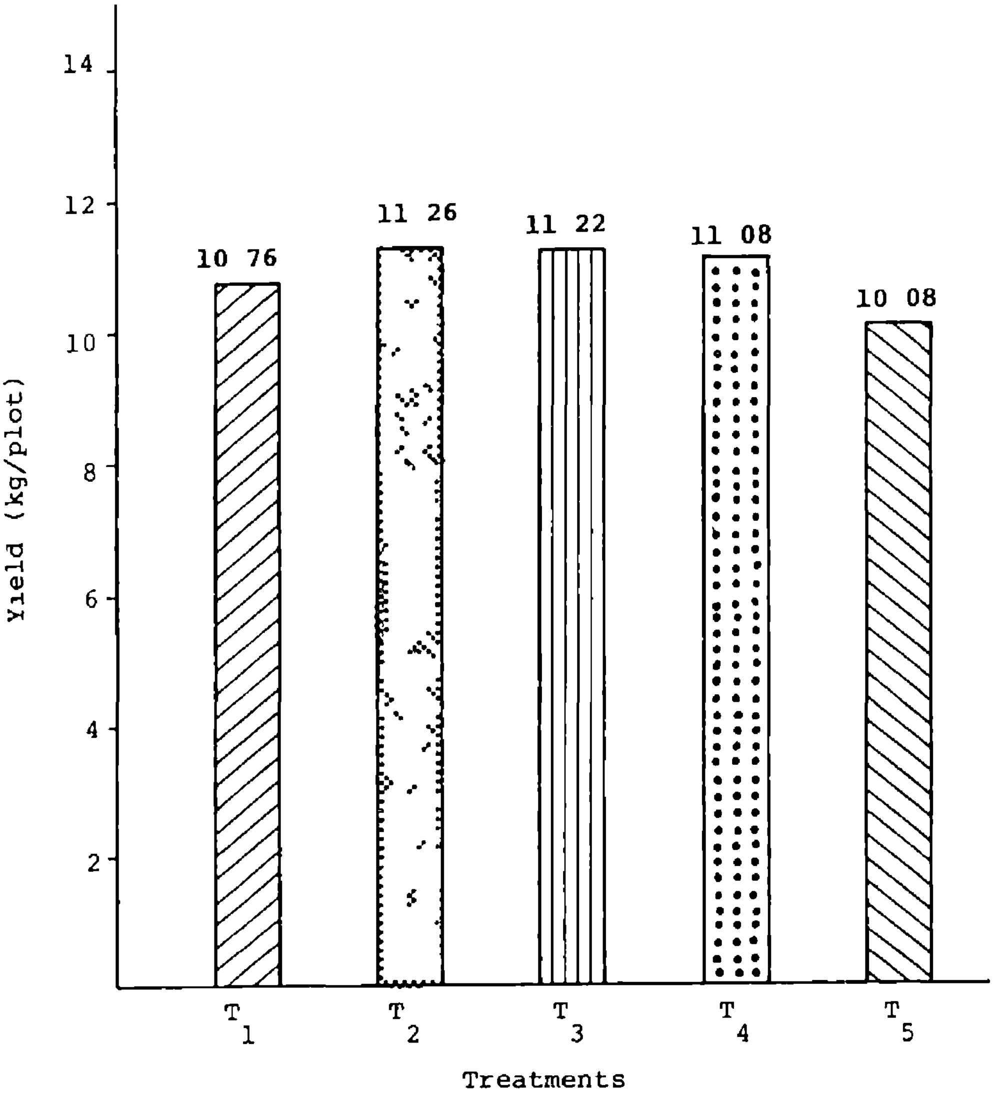

FIG 10 EFFECT OF TILLAGE TREATMENTS ON GRAIN YIELD

In the puddled soil the separate particle structure develops in the lower part of puddled layer, while the finer particles are held in suspension forming a thin platy or laminar horizon at the soil surface It is possible that the laminar structure provides a suitable environment for the finer roots of the rice plant and for the development of nitrifying organisms such as blue green alage which ultimately helps in increasing the yield Since the differences in yield observed among the treatments were statistically insignificant it may be possible to infer that such differentiation is seldom seen in sandy loam soils

4 3 Effect of different tillage methods on water use efficiency

The efficiency of any puddling implement is judged in terms of the reduction it effects in percolation losses The ultimate objective of puddling is to get more yield from a unit area per unit of water applied The expression of yield per unit area per unit of water applied is termed as water use efficiency and its value depends on the crop yield and total water requirement Since the percolation loss form a major part of the water requirement of rice crop it has a direct influence on the water use efficiency

The mean water use efficiency under different tillage treatments varied from 15 68 kg/ha-cm of water to

18 64 kg/ha cm of water (Table 9), the lowest being under T_5 and highest under T_2

Table 9 Field water use efficiency as influenced by various tillage methods

Treatment	Field water use efficiency (kg/ha cm) Replications					Treatment mean kg/ha-cm of water	Percentage increase/ decrease over control
	R_1	R_2	R_3	R_4	R_5		
T_1	17 6	18 63	18 63	16 29	17 16	17 668	12 68
T_2	19 87	20 86	19 37	17 32	15 78	18 640	18 88
T_3	17 84	17 63	18 12	18 57	15 43	17 52	11 73
T_4	19 50	14 68	19 32	18 35	18 29	18 03	14 99
T_5	14 00	15 37	15 13	18 55	15 37	15 68	-

The highest percentage increase in water use efficiency of 18 88 over the control was obtained under the treatment T_2 puddling with tractor cage wheel However the differences were not statistically significant (Appendix X)

Any change in the soil physical properties resulting from the use of a given implement vary due to implement factors and soil factors like texture water content etc

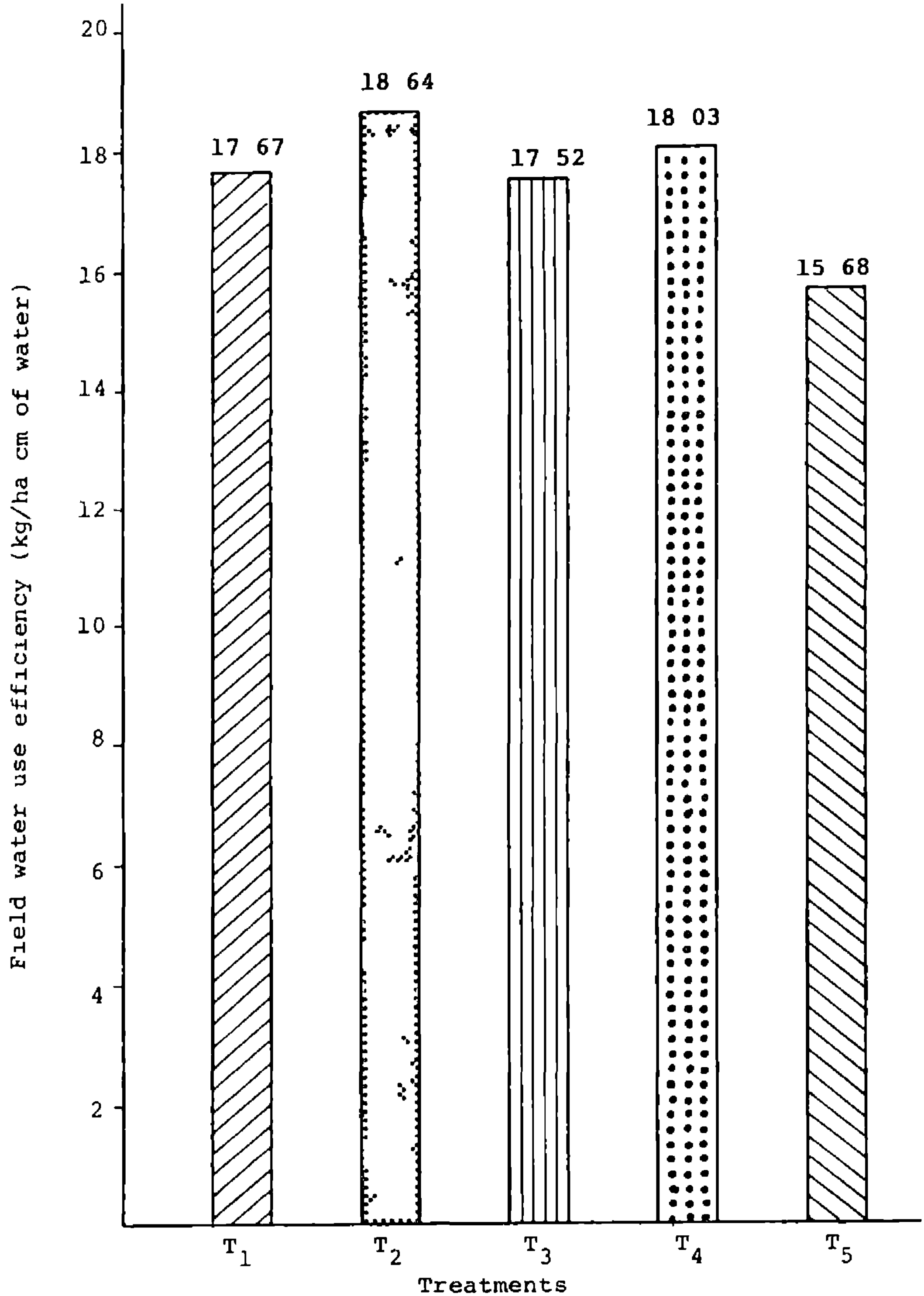

FIG 11 EFFECT OF TILLAGE TREATMENTS ON FIELD WATER USE EFFICIENCY

Since no significant differences were observed among the treatments regarding the loss of water through percolation and grain yield it may be concluded that the number of runs of implement and different types of puddling implements do not have any particular advantage in sandy loam soil Rather the successive puddling by increasing the number of runs of implement will only help to increase the cost of operation So it would be better to go in for minimum tillage in coarse-textured soil so that the cost of operation can be reduced

Summary

SUMMARY

In India, rice is grown in an area of nearly 40 19 million hectares with an annual production of 53 8 million tonnes Rice contribute about 40 per cent of the total grain output in the country A major portion of rice is cultivated under wetland system, in which five or more centimetres of water are retained in the field throughout the greater part of the growing season Submergence of the field results in the loss of water through percolation, which is as much as 50 to 85 per cent of the total water applied depending upon soil type Because of this, at present about 45 50 per cent of the Country s irrigation water has to be diverted to rice field alone Since water is one of the most important inputs in crop production, every drop of it should be utilized with utmost care for bringing more area under cultivation Puddling has been widely accepted in rice cultivation as a method by which a good soil condition favourable to the growth of rice plant can be created Besides, puddling greatly reduce the loss of water through deep percolation Considering these points in view, an experiment was conducted to determine the effect of different tillage methods on percolation loss of water and yield in rice field in a sandy loam soil

The treatments chosen for the study were T_1 - puddling with power tiller, T_2 - puddling with tractor cage

wheel T_3 - puddling with bullock drawn puddler T_4 - compaction using roller and T_5 - country ploughing along with planking (control) The experiment was conducted during December 1991 to March 1992 The experimental field was ploughed and levelled with tractor after the harvesting of preceding crops The design of experiment followed was randomized block design with five replications All plots to be puddled were irrigated and treatments were applied one by one All plots were bounded (about 20 cm high) to provide an efficient water control Facilities were provided for irrigating the experimental plots

After applying the tillage treatments, seedlings of short duration rice variety triveni were transplanted in the experimental plots Field hook gauges were firmly installed in the plots for the measurement of daily water loss Water level of 5 cm was maintained in the plots throughout the growing season A pointer 5 cm high fixed on a flat plate was kept in all the plots near the field hook gauge for this purpose Each day the plots were irrigated till the water level coincided with the tip of the pointer fixed to the flat plate After 24 hours the drop in the level of water in the field was measured by using the field hook gauge Hook gauge readings were taken daily and continued till irrigation was stopped By adding up the daily water loss, the total water loss from the plots during the crop growth period was obtained Uniform evapotranspiration was assumed to occur from all the plots The evaporation measurements were made by the standard U S W B class A pan evaporimeter The evaporation data were converted to evapotranspiration by using crop factor for rice obtained from a previous experiment The evapotranspiration data were subtracted from total water loss to obtain the water lost through percolation At harvest yield from each plot was noted separately

The evapotranspirational requirement of the crop amounted to 573 88 mm during the crop growing period The total water requirement was highest in the plots puddled with country plough (control) (1609 3 mm) and lowest in the plots puddled with tractor cage wheel (1510 3 mm) Losses due to percolation account for 62 per cent and 64 34 per cent of the total water requirement under T_2 and T_5 respectively There was no significant difference among the treatments regarding the quantity of water percolated from the plots The percentage decrease in percolation loss over the control (T_5 - puddling with country plough) were 9 56 8 32 6 68 and 0 69 in T_2 T_1 T_4 and T_3 respectively

The statistical analyses were carried out for water loss through percolation during different stages of crop growth The treatments T_3 and T_5 (control) registered highest quantity of percolated water during vegetative phase (291 2 mm and 291 8 mm respectively) This was followed by treatments T_4, T_1 and T_2 These treatments decreased the percolation of water by 10 31 per cent, 16 49 per cent and 17 66 per cent respectively over the control practice T_5

During the reproductive stage of crop growth, minimum percolation loss of 470 mm was recorded in the plots puddled with tractor cage wheel and the maximum percolation of 518 mm was observed in the plots puddled with bullock drawn puddler

The plots under treatment T_4 registered the lowest mean percolation of 215 5 mm, followed by T_1 (217 3 mm), T_3 (218 9 mm), T_5 (224 2 mm) and T_2 (230 0 mm) during the ripening stage of crop growth

Statistical analysis of the data regarding percolated water from the plots under different treatments showed that the difference among the treatments were not statistically significant for the different stages of growth and even all stages combined This may be due to the sandy loam nature of the soil with very little colloidal material Agrregates $<$0 25 mm in diameter play an important role in decreasing infiltration rates through clogging of pores and surface seal development Since aggregates $<$0 25 mm in diameter are less in sandy loam soil, this explains the insignificant variation in percolation loss of water under different treatments

The highest grain yield of 11 26 kg/plot was recorded under the treatment T_2 (puddling with tractor cage wheel) T_2 was followed by T_3 (11 22 kg/plot), T_4 (11 08 kg/plot), T_1 (10 76 kg/plot) and T_5 (10 08 kg/plot) The statistical analysis showed that the yield did not differ significantly among the treatments

The water utilization by the crop is generally described in terms of water use efficiency The value of water use efficiency depends on the crop yield and total water requirement The mean water use efficiency under different tillage treatments varied from 15 68 kg/ha-cm to 18 64 kg/ha-cm, the lowest being under the plots puddled with country plough and highest in the plots puddled with tractor cage wheel Water use efficiencies of 18 03 kg/ha-cm, 17 668 kg/ha-cm and 17 52 kg/ha-cm were recorded under T_4, T_1 and T_3 respectively However these differences were not statistically significant Since the treatments did not differ significantly with regard to the loss of water through percolation, grain yield and the field water use efficiency, it was concluded that the number of runs of operation the use of different types of puddling implements and compaction using roller do not have any particular advantage in sandy loam soil So a continuation of this study to determine the effect of different puddling implements in reducing the percolation loss of water in heavy soil, where the effect can be expected to be prominent, is suggested

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* Originals not seen

Appendices

Appendix-I

Meteorological observations during the experimental period

Period	Mean maximum temperature (°C)	Mean dry bulb temperature (°C)	Mean wet bulb temperature (°C)	Pan evaporation (mm)
December				
29-4	31 60	23 65	23 07	29 40
January				
5-11	32 14	23 78	21 42	37 10
12 18	32 50	23 07	19 92	37 70
19-25	33 50	24 20	23.20	25 30
26-1	33 70	22 85	22 35	29 30
February				
2-8	32 00	25 70	23 14	29 70
9-15	32 60	25 10	24 20	34 30
16-22	33 80	24 20	23 07	35 40
23-29	35 35	25 20	23 70	30 60
March				
1-7	33 60	26 00	25 07	31 90
8-14	33 07	27 35	16 14	25 80

Appendix-II

Recommendation for rice in the package of practices

(Kerala Agricultural University)

Rice variety	Triveni
Duration (days)	95-105
Bran colour grain quality etc	Tolerant to Brown plant hopper Susceptible to Blast and Sheath diseases
Seed rate for transplanting	60-85 kg to plant one hectare
Age of seedlings	Seedlings are ready to be pulled out when they attain the 4-5 leaf stage, about 18 days after sowing
Transplanting	Transplant 2-3 seedlings per hill in rows at a spacing of 15 cm x 10 cm and at a depth of 3-4 cm
Manures and fertilizers	Apply organic manure in the form of farm yard manure or compost or green leaf at the rate of 5 t/ha and incorporate into the soil while ploughing Fertilizers are to be applied at the rate of 70 kg/ha of N 35 kg/ha of P_2O_5 and 35 kg/ha of K_2
Water management	Maintain water level at about 1 5 cm during transplanting Thereafter increase it to about 5 cm until maximum tillering stage Drain water 13 days before harvest
Weed control	Keep the field free of weeds upto 45 days either by hand weeding and interculture or by use of herbicides
Plant protection	Adopt control measures only if the pest population exceeds the economic threshold levels

Appendix-III

Daily water loss from the individual plots for the entire growing season

(Unit:mm)

Date	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_3T_1	R_3T_2	R_3T_3
29.12.91	10.0	10.0	11.0	11.5	12.0	9.5	10.0	10.5	11.5	10.5	9.0	9.5	10.0
30.12.91	10.5	10.0	11.5	10.5	12.0	9.5	10.0	10.5	11.5	11.0	9.5	10.0	10.5
31.12.91	11.0	10.0	11.5	11.0	12.5	10.0	10.0	10.5	11.5	10.5	9.5	10.5	10.0
01.01.92	11.5	10.5	12.0	10.5	13.0	10.0	11.0	11.0	12.0	10.5	10.0	10.5	10.5
02.01.92	11.5	10.5	12.5	11.5	13.5	10.5	11.5	11.5	12.5	10.0	10.0	10.5	10.5
03.01.92	12.0	11.0	13.0	12.0	13.5	11.0	11.0	12.0	13.0	11.5	10.5	10.0	11.0
04.01.92	12.5	11.0	13.5	12.0	14.0	11.5	12.0	12.5	14.0	11.5	10.5	11.0	12.0
05.01.92	12.0	11.5	14.0	12.0	14.5	11.5	12.0	13.0	14.0	12.0	11.0	11.5	12.5
06.01.92	12.0	11.5	15.0	12.5	14.5	12.0	12.0	14.0	14.0	12.5	11.5	10.5	13.5
07.01.92	13.0	11.0	15.5	13.0	15.0	12.5	10.5	14.5	14.5	12.5	11.0	11.5	14.0
08.01.92	13.5	11.5	16.0	14.0	16.0	12.5	11.5	15.0	15.0	13.0	11.5	12.0	15.0
09.01.92	14.0	11.5	16.0	14.0	16.5	13.0	13.0	15.5	15.5	13.0	12.0	13.0	15.0
10.01.92	14.5	12.0	16.0	14.0	16.5	13.0	13.0	15.5	15.0	13.5	12.0	14.0	15.5

Contd.

Appendix-III (Contd.)

Date	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_3T_1	R_3T_2	R_3T_3
11.01.92	15.0	12.0	16.5	14.5	17.0	13.5	13.5	16.0	15.5	13.5	11.5	15.5	16.0
12.01.92	15.5	12.5	16.5	15.0	17.0	13.5	14.0	15.5	16.0	13.5	12.0	15.5	16.0
13.01.92	16.0	12.5	17.0	16.0	17.5	12.5	13.5	16.0	16.5	14.0	12.0	15.0	16.5
14.01.92	16.0	12.5	17.5	17.0	18.0	13.5	14.0	16.0	17.5	14.5	12.5	17.5	16.5
15.01.92	17.0	13.0	17.5	17.5	18.5	14.0	13.0	16.5	17.5	15.0	13.0	18.0	16.0
16.01.92	17.5	13.5	17.0	17.0	19.0	14.5	14.5	17.0	18.0	15.0	13.5	18.0	16.5
17.01.92	18.0	13.5	18.0	17.0	19.5	15.0	15.0	17.0	18.0	16.0	14.0	19.0	17.0
18.01.92	18.5	14.0	18.5	18.0	20.0	15.5	15.0	17.5	18.5	16.5	14.5	21.5	17.0
19.01.92	19.0	14.5	19.0	17.5	20.5	16.5	15.0	17.5	19.0	16.5	15.0	20.0	17.5
20.01.92	18.5	14.5	19.5	18.0	21.0	16.5	16.0	18.0	19.5	17.0	15.5	21.0	18.5
21.01.92	19.0	15.5	20.0	18.5	21.5	17.0	15.5	18.5	20.0	18.0	16.0	22.0	19.0
22.01.92	20.0	15.0	21.0	18.5	22.0	17.5	16.5	19.0	20.5	18.0	16.5	21.5	19.5
23.01.92	20.5	15.0	21.5	19.0	22.5	18.0	17.0	19.5	20.5	18.5	17.0	22.5	19.5
24.01.92	21.0	15.5	22.0	20.0	23.0	18.0	17.5	20.0	21.0	19.0	17.0	23.0	19.5
25.01.92	20.5	16.0	23.0	21.5	23.0	18.5	18.5	20.5	21.5	18.5	17.5	23.5	20.0

Appendix-III (Contd.)

Date	R_3T_4	R_3T_5	R_4T_1	R_4T_2	R_4T_3	R_4T_4	R_4T_5	R_5T_1	R_5T_2	R_5T_3	R_5T_4	R_5T_5
11.01.92	13.0	15.0	12.5	12.0	14.5	13.5	14.5	14.0	14.0	16.0	14.0	13.5
12.01.92	13.0	16.0	12.5	12.0	15.0	14.5	15.5	14.5	16.0	16.5	14.5	14.0
13.01.92	13.0	17.5	13.0	12.5	15.0	15.0	16.0	15.0	15.0	17.0	15.0	15.5
14.01.92	14.0	18.0	13.5	13.0	15.5	15.5	17.0	16.0	15.5	17.0	16.0	16.5
15.01.92	14.0	18.5	13.0	13.0	16.0	15.5	17.5	16.5	16.5	17.5	16.0	16.5
16.01.92	15.0	19.0	13.5	13.5	16.5	16.0	17.5	16.5	17.0	18.0	15.5	17.0
17.01.92	15.0	18.5	14.0	12.5	17.0	16.0	18.0	17.5	17.5	18.5	16.0	17.5
18.01.92	14.5	21.0	16.0	13.0	17.5	16.0	18.0	18.0	18.5	18.5	17.0	18.0
19.01.92	14.5	21.0	16.0	14.0	17.5	17.0	18.5	18.5	19.0	19.0	17.0	18.5
20.01.92	15.0	21.0	16.5	14.5	18.0	17.0	18.5	19.0	20.0	19.5	16.5	18.5
21.01.92	15.5	22.5	16.5	15.0	18.0	16.5	19.0	19.5	21.0	20.0	17.0	19.0
22.01.92	16.0	23.5	16.5	14.5	19.0	17.0	20.0	20.0	21.0	20.5	17.0	19.5
23.01.92	16.0	23.0	17.0	16.0	19.5	18.0	20.5	20.5	20.5	21.0	17.5	20.0
24.01.92	16.0	24.0	17.0	16.0	19.5	18.0	20.5	20.5	20.5	21.0	17.5	20.0
25.01.92	16.5	24.5	17.5	16.5	19.5	18.5	21.0	21.0	21.5	21.0	18.0	20.5

Contd.

Appendix-III (Contd.)

Date	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_3T_1	R_3T_2	R_3T_3
26.01.92	21.5	16.0	23.5	21.0	22.5	19.0	18.0	21.0	21.5	19.0	18.0	24.5	20.5
27.01.92	22.0	16.0	24.5	21.5	23.5	18.5	17.5	21.5	22.0	19.0	18.5	25.0	21.0
28.01.92	23.5	16.5	25.0	22.0	24.0	19.5	18.5	22.0	22.5	20.0	19.0	25.5	21.5
29.01.92	23.0	17.0	26.5	23.5	25.0	20.0	19.0	23.5	23.0	20.5	19.5	27.0	22.0
30.01.92	23.5	18.0	26.5	23.5	26.0	19.5	19.0	25.0	23.5	21.0	20.0	26.5	22.5
31.01.92	24.0	19.5	27.5	24.0	25.5	20.5	19.5	24.5	25.0	21.5	20.5	27.0	22.5
01.02.92	25.0	19.0	27.5	24.5	25.0	21.5	19.5	24.5	24.5	22.0	20.5	28.0	23.0
02.02.92	25.5	19.5	28.0	24.0	25.5	22.0	20.0	25.0	25.5	22.5	21.5	27.5	23.5
03.02.92	26.0	20.5	28.5	24.5	26.0	22.5	21.0	26.0	26.0	22.0	22.0	27.5	24.0
04.02.92	27.0	21.0	29.0	25.0	27.5	23.0	22.0	26.5	26.5	22.5	22.0	28.0	24.5
05.02.92	28.5	22.5	29.0	26.0	28.5	23.0	23.5	27.0	27.0	24.0	23.5	29.5	25.5
06.02.92	29.0	23.0	29.0	27.0	28.5	24.0	23.5	27.5	28.0	24.5	24.5	28.0	26.5
07.02.92	29.5	24.0	29.0	27.5	28.0	24.5	24.0	28.0	28.0	25.0	24.5	28.5	26.5
11.02.92	30.0	26.0	28.5	28.0	28.5	26.0	26.0	28.0	28.5	26.5	26.0	29.0	28.0
12.02.92	30.0	26.5	29.0	28.0	29.0	26.5	26.5	29.0	30.0	28.0	26.0	29.5	29.0
13.02.92	30.5	27.5	30.0	29.0	28.5	28.0	27.0	30.0	30.5	29.0	28.0	28.0	30.5

Contd.

Appendix-III (Contd.)

Date	R_3T_4	R_3T_5	R_4T_1	R_4T_2	R_4T_3	R_4T_4	R_4T_5	R_5T_1	R_5T_2	R_5T_3	R_5T_4	R_5T_5
26.01.92	17.0	25.0	18.0	18.0	20.0	18.5	21.0	20.5	22.0	21.5	18.5	21.0
27.01.92	17.4	24.5	18.5	17.5	20.5	19.0	21.5	21.0	22.0	22.0	19.0	21.5
28.01.92	18.5	26.0	19.0	17.0	21.0	19.5	21.0	21.5	22.5	21.5	20.0	22.0
29.01.92	18.5	28.0	19.5	17.5	21.5	20.5	22.0	21.5	23.0	21.5	20.5	22.0
30.01.92	19.0	28.0	20.5	18.5	21.5	21.0	22.5	22.0	23.0	22.0	21.0	22.5
31.01.92	19.5	28.5	21.0	18.5	22.0	21.0	22.5	22.0	23.5	23.0	22.0	23.0
01.02.92	20.5	30.0	21.5	19.0	22.5	22.0	23.0	23.5	23.5	23.5	23.0	23.5
02.02.92	20.5	28.0	22.0	20.5	23.0	23.0	23.0	24.5	23.5	23.5	23.5	23.5
03.02.92	21.0	29.0	22.0	21.0	23.0	23.5	24.0	25.0	24.5	24.0	24.0	24.0
04.02.92	21.5	29.5	24.0	22.0	24.0	23.5	23.5	25.5	25.0	24.5	24.0	25.0
05.02.92	21.5	30.5	23.5	22.0	24.5	24.5	24.5	26.5	25.0	25.0	24.5	25.5
06.02.92	23.0	30.0	24.0	24.0	25.0	24.5	25.0	27.0	26.5	25.0	24.5	25.5
07.02.92	23.0	30.0	24.5	23.5	24.5	25.0	25.5	28.0	25.5	26.0	24.5	25.0
11.02.92	24.5	30.5	26.0	25.0	26.0	26.5	27.0	29.0	27.0	27.0	26.0	26.0
12.02.92	26.0	29.5	28.0	25.0	27.0	28.0	28.0	31.0	26.5	27.5	27.0	28.0
13.02.92	27.0	30.5	29.5	25.5	28.0	29.0	28.5	31.5	27.5	29.0	28.5	30.0

Contd.

Appendix-III (Contd)

Date	R_3T_4	R_3T_5	R_4T_1	R_4T_2	R_4T_3	R_4T_4	R_4T_5	R_5T_1	R_5T_2	R_5T_3	R_5T_4	R_5T_5
11 01 92	13 0	15 0	12 5	12 0	14 5	13 5	14 5	14 0	14 0	16 0	14 0	13 5
12 01 92	13 0	16 0	12 5	12 0	15 0	14 5	15 5	14 5	16 0	16 5	14 5	14 0
13 01 92	13 0	17 5	13 0	12 5	15 0	15 0	16 0	15 0	15 0	17 0	15 0	15 5
14 01 92	14 0	18 0	13 5	13 0	15 5	15 5	17 0	16 0	15 5	17 0	16 0	16 5
15 01 92	14 0	18 5	13 0	13 0	16 0	15 5	17 5	16 5	16 5	17 5	16 0	16 5
16 01 92	15 0	19 0	13 5	13 5	16 5	16 0	17 5	16 5	17 0	18 0	15 5	17 0
17 01 92	15 0	18 5	14 0	12 5	17 0	16 0	18 0	17 5	17 5	18 5	16 0	17 5
18 01 92	14 5	21 0	16 0	13 0	17 5	16 0	18 0	18 0	18 5	18 5	17 0	18 0
19 01 92	14 5	21 0	16 0	14 0	17 5	17 0	18 5	18 5	19 0	19 0	17 0	18 5
20 01 92	15 0	21 0	16 5	14 5	18 0	17 0	18 5	19 0	20 0	19 5	16 5	18 5
21 01 92	15 5	22 5	16 5	15 0	18 0	16 5	19 0	19 5	21 0	20 0	17 0	19 0
22 01 92	16 0	23 5	16 5	14 5	19 0	17 0	20 0	20 0	21 0	20 5	17 0	19 5
23 01 92	16 0	23 0	17 0	16 0	19 5	18 0	20 5	20 5	20 5	21 0	17 5	20 0
24 01 92	16 0	24 0	17 0	16 0	19 5	18 0	20 5	20 5	20 5	21 0	17 5	20 0
25 01 92	16 5	24 5	17 5	16 5	19 5	18 5	21 0	21 0	21 5	21 0	18 0	20 5

Contd

Appendix-III (Contd.)

Date	R_3T_4	R_3T_5	R_4T_1	R_4T_2	R_4T_3	R_4T_4	R_4T_5	R_5T_1	R_5T_2	R_5T_3	R_5T_4	R_5T_5
14.02.92	27.0	31.0	29.0	26.0	28.5	29.5	30.0	32.0	25.5	30.5	28.5	29.0
15.02.92	29.0	32.5	30.5	26.5	29.5	30.5	32.0	33.0	28.0	31.0	30.5	30.0
16.02.92	29.0	33.5	31.0	28.0	31.5	32.0	32.5	34.0	29.5	32.0	31.0	32.0
17.02.92	31.0	34.0	33.0	31.0	33.0	33.0	33.0	36.0	30.0	34.0	32.0	34.0
18.02.92	32.0	34.0	34.5	32.0	34.0	34.5	34.0	35.5	31.0	35.5	34.0	34.0
19.02.92	33.0	33.5	34.5	32.5	33.0	35.0	32.5	35.0	33.0	33.0	36.0	33.0
20.02.92	32.0	33.0	32.0	31.0	33.0	35.0	31.5	33.0	33.5	31.0	34.0	34.5
21.02.92	32.0	31.5	32.0	31.5	31.5	33.5	30.0	32.0	33.5	30.5	34.0	32.0
22.02.92	31.0	31.0	31.0	30.0	30.0	31.0	30.0	31.5	32.0	28.5	32.0	32.0
23.02.92	30.0	29.0	30.5	29.5	29.5	31.0	30.0	31.0	31.0	29.0	32.0	31.5
24.02.92	28.0	28.5	30.5	29.5	29.0	29.5	29.5	30.0	30.0	28.0	31.5	30.0
25.02.92	28.5	27.5	28.0	28.0	28.5	28.0	28.0	29.5	29.5	28.0	30.0	28.0
26.02.92	28.0	25.0	26.0	28.0	28.0	28.0	28.0	29.5	28.0	27.5	29.5	28.0
27.02.92	28.0	23.5	26.0	27.5	26.0	27.5	26.5	27.5	26.0	27.0	28.0	26.0
28.02.92	26.0	24.0	26.0	28.0	26.0	27.0	26.0	27.0	25.5	26.0	28.0	26.0
29.02.92	25.0	24.0	25.5	28.5	24.0	25.0	26.0	26.0	24.0	26.0	27.5	25.5
1.03.92	24.5	24.5	24.5	26.0	24.5	25.0	24.0	25.5	23.0	25.5	26.0	25.5

Contd.

Appendix-III (Contd.)

Date	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_3T_1	R_3T_2	R_3T_3
02.03.92	23.0	23.0	26.0	21.0	24.0	21.0	25.0	21.0	24.0	26.0	23.0	24.0	25.5
03.03.92	21.5	23.0	23.0	21.0	23.0	20.0	23.0	22.0	23.0	25.0	23.0	23.5	24.0
04.03.92	21.0	23.0	21.5	20.5	23.0	20.0	23.0	21.0	22.0	24.0	21.0	22.0	23.5
05.03.92	20.0	22.0	21.0	19.0	21.0	20.0	23.0	20.0	23.0	24.5	20.0	20.0	22.0
06.03.92	18.5	22.0	20.0	19.0	20.0	19.5	22.0	19.0	21.0	24.0	20.0	20.0	19.0
07.03.92	19.0	21.5	19.0	18.5	19.0	19.0	22.0	18.0	19.5	23.0	19.5	21.0	19.0
08.03.92	18.5	19.0	18.0	19.0	19.0	18.5	21.5	18.0	17.0	22.5	18.0	19.5	17.0
09.03.92	19.0	18.0	16.0	19.0	17.0	18.5	19.0	16.0	16.0	21.0	17.0	18.5	15.0
10.03.92	18.5	18.5	16.0	17.0	17.5	18.0	18.0	16.5	14.0	20.0	16.0	18.0	15.0
11.03.92	17.0	17.0	14.0	17.5	17.0	17.0	18.5	16.0	14.5	18.5	13.0	17.5	14.0
12.03.92	16.0	16.0	13.5	16.0	16.0	17.0	17.0	16.5	14.0	17.0	13.0	16.0	14.0
13.03.92	15.0	15.0	12.0	15.0	15.0	16.0	16.0	14.0	13.0	16.0	12.0	15.0	14.0
14.03.92	13.0	15.0	12.0	14.0	15.0	14.5	15.0	12.0	12.0	16.0	12.5	13.0	13.5
15.03.92	13.0	14.0	11.5	14.0	14.0	14.0	15.0	11.5	12.5	14.0	11.0	12.0	12.0
Total	1604.5	144.65	1681.5	1562	1677.5	1473	1497.5	1588.5	1618	1577.5	1449.5	1626	1587

Appendix-III (Contd.)

Date	R_3T_4	R_3T_5	R_4T_1	R_4T_2	R_4T_3	R_4T_4	R_4T_5	R_5T_1	R_5T_2	R_5T_3	R_5T_4	R_5T_5
02.03.92	24.0	22.5	24.0	25.5	24.0	24.0	24.5	24.0	22.5	24.0	24.0	23.0
03.03.92	23.0	23.0	23.0	24.5	22.0	22.0	24.0	24.5	22.5	22.0	24.0	23.0
04.03.92	21.0	21.0	23.5	23.0	22.0	21.0	23.0	24.0	20.0	22.0	22.5	21.5
05.03.92	21.0	19.5	22.0	21.0	21.5	21.5	22.0	23.0	19.0	21.5	20.0	21.0
06.03.92	20.0	18.0	22.0	21.0	19.0	19.0	21.0	21.5	19.0	19.0	18.5	20.0
07.03.92	19.0	17.5	20.0	21.0	19.0	18.5	19.0	21.5	18.0	19.0	18.0	18.0
08.03.92	19.0	15.0	19.0	19.0	19.0	18.0	19.0	19.0	17.5	18.5	17.0	18.5
09.03.92	17.5	14.0	17.0	19.0	18.0	16.5	18.5	17.0	15.5	18.0	17.0	17.0
10.03.92	17.0	13.5	17.0	17.5	17.0	15.0	18.0	15.5	15.0	17.5	16.0	16.0
11.03.92	15.5	12.0	16.5	17.0	15.0	15.0	16.0	14.0	14.5	16.0	15.5	15.5
12.03.92	15.0	11.5	14.0	16.5	15.0	14.5	15.0	13.0	13.0	15.0	14.0	14.0
13.03.92	14.0	11.5	13.0	15.5	13.5	14.0	15.0	13.0	12.0	15.0	14.0	14.0
14.03.92	13.0	12.0	13.0	14.0	13.5	13.5	14.0	12.5	12.0	14.0	13.5	13.5
15.03.92	13.0	12.0	12.0	12.5	13.0	13.5	13.5	12.0	11.0	13.5	13.0	12.0
Total	1449	1652	1489	1443	1548	1526	1577	1603	1537	16045	1544.5	1561

Appendix-III (Contd)

Date	R_1T_1	R_1T_2	R_1T_3	R_1T_4	R_1T_5	R_2T_1	R_2T_2	R_2T_3	R_2T_4	R_2T_5	R_3T_1	R_3T_2	R_3T_3
14 02 92	31 0	28 0	31 5	30 0	30 0	28 0	28 5	31 5	31 0	29 5	29 0	28 0	31 0
15 02 92	33 5	30 0	32 0	30 0	30 0	28 5	28 0	32 0	33 0	31 0	30 5	31 0	32 0
16 02 92	34 0	31 0	33 5	31 0	32 0	29 0	30 0	33 0	33 0	33 5	33 0	32 5	32 0
17 02 92	34 0	32 5	34 0	32 0	33 0	29 0	31 0	34 0	35 0	34 5	34 0	33 0	34 0
18 02 92	32 0	32 0	35 0	33 0	34 0	31 0	32 5	33 5	34 0	33 0	35 0	32 5	34 0
19 02 92	33 0	32 0	34 0	33 5	33 0	32 0	32 0	33 5	34 0	33 0	32 0	32 0	35 0
20 02 92	32 0	31 0	34 0	32 0	33 5	32 0	32 0	32 0	31 0	33 0	32 0	32 0	34 0
21 02 92	32 0	31 5	33 0	31 0	32 0	31 0	31 0	31 0	30 0	32 0	31 0	29 0	33 0
22 02 92	30 0	30 0	32 0	31 0	31 0	31 5	31 5	30 0	30 5	32 0	30 5	29 0	32 0
23 02 92	29 5	29 0	31 0	29 0	30 5	29 0	30 0	30 0	30 0	31 5	29 0	28 5	32 0
24 02 92	29 5	28 0	31 0	28 0	30 0	28 0	29 0	29 5	29 0	32 0	28 5	27 5	31 0
25 02 92	28 0	28 0	31 0	27 0	29 0	27 0	28 0	28 0	28 0	30 0	27 0	26 0	28 0
26 02 92	27 5	28 0	31 5	27 0	29 0	27 0	28 0	27 0	27 5	29 0	27 0	27 0	28 0
27 02 92	25 0	27 0	29 0	24 0	28 0	26 5	28 0	27 0	26 0	28 0	27 0	26 5	28 0
28 02 92	25 0	26 0	28 5	23 0	26 0	25 0	27 0	26 5	25 0	27 0	25 0	25 0	27 0
29 02 92	23 5	26 5	28 0	23 0	26 0	24 0	26 0	25 0	25 0	27 5	25 5	25 0	26 0
1 03 92	24 0	25 0	26 0	23 5	25 0	23 0	26 5	24 0	25 0	27 0	25 0	24 0	26 0

Contd

Appendix-IV

Details of the experiment

1	Location	Instructional Farm of K C A E T Tavanur
2	Crop	Paddy
3	Variety	Triveni
4	Year of study	December 1991 to March 1992

5 Tillage treatments chosen for the study

T_1 Puddling with power tiller
12 hp KUBOTA power tiller
Number of tilling blades - 20
Cage wheel type - lugged type
Diameter 68 5 cm

T_2 Puddling with tractor cage wheel
35 hp HMT tractor
Cage wheel Diameter - 108 cm Width - 74 cm

T_3 - Puddling with bullock drawn puddler
(T N A U helical blade type)
Width 660 mm

T_4 Soil compaction using roller
Diameter 48 cm Width - 84 5 cm
Weight 385 kg

T_5 Puddling with country plough along with planking

6	Number of replications	5
7	Experimental design	Randomized block design

8	Observations taken	1 Daily water loss from the rice field using field hook gauge
		2 Meteorological observations temperature, pan evaporation rainfall
		3 Crop yield from each plot

Appendix-V

Analysis of variance of total percolation loss

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	162 71	40 69	1 013	4 77	3 01
Treatments	4	416 18	104 05	2 59	4 77	3 01
Error	16	642 59	40 16			
Total	24	1221 54				

Appendix-VI

Analysis of variance of percolation loss (vegetative phase)

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	45 773	11 443	1 0175	4 77	3 01
Treatments	4	125 165	31 291	2 782	4 77	3 01
Error	16	179 94	11 246			
Total	24	350 88				

Appendix-VII

Analysis of variance of percolation loss (reproductive phase)

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	38 45	9 612	0 738	4 77	3 01
Treatments	4	68 74	17 185	1 32	4 77	3 01
Error	16	208 176	13 011			
Total	24	315 37				

Appendix-VIII

Analysis of variance of percolation loss (ripening phase)

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	13 48	3 37	1 045	4 77	3 01
Treatments	4	6 97	1 74	0 54	4 77	3 01
Error	16	51 57	3 22			
Total	24	72 02				

Appendix-IX

Analysis of variance of crop yield

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	3 128	0 782	0 801	4 77	3 01
Treatments	4	4 772	I 193	1 22	4 77	3 01
Error	16	15 62	0 976			
Total	24	23 52				

Appendix-X

Analysis of variance of field water use efficiency

Source of variation	d f	S S	M S	F ratio observed	F 1%	F 5%
Blocks	4	8 732	2 183	0 778	4 77	3 01
Treatments	4	24 513	6 128	2 184	4 77	3 01
Error	16	44 89	2 805			
Total	24	78 135				

EFFECT OF DIFFERENT TILLAGE METHODS ON PERCOLATION LOSS IN RICE FIELDS

By

MINI, P. K.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

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ABSTRACT

Water loss by deep percolation constitutes a major part of the total water [illegible] from the rice fields Puddling is widely carried o[illegible] r[illegible]e fields [illegible]o create favourable soil condition for the growth [illegible] [illegible]nt and to reduce the loss of water through per[illegible] An experiment [illegible] conducted [illegible] sand loam soil to determine the [illegible] of different tillage methods on percolation loss of water and to evaluate their effect on grain yield

Th[illegible] treatments [illegible] sen for th[illegible] study were [illegible]uddling [illegible] power t[illegible]e pudd[illegible] [illegible] th tra[illegible]or [illegible] wheel [illegible] dling [illegible] animal d[illegible]awn puddler (KAU [illegible] ca[illegible] made [illegible] compact o[illegible] using [illegible]oller and puddling [illegible]th cou[illegible]y plough along with planking control) The e[illegible]periment [illegible] laid out in randomi[illegible]ed block design with [illegible] [illegible] Seedlings of sho[illegible]t duration rice variety [illegible] we[illegible]e used for transplanting The daily water loss from the experimental plots was measured using field hook gauge The water loss through percolat[illegible]on was obtained by subtracting the evapotranspira[illegible]on from the total water requirement

The mean water requirement was highest in the plo[illegible]s puddled with country plough (1609 3 mm) and was lowest in the p[illegible] puddled with tractor cage [illegible]eel ([illegible]510 3 [illegible]) [illegible]he

percolated water constitute 62 per cent and 64 34 per cent of the total water requirement in the plots puddled with tractor cage wheel and country plough respectively The lowest mean percolation of 936 12 mm was recorded in the plots puddled with tractor cage wheel It was followed by puddling with power tiller (949 92 mm) compaction using roller (966 02 mm) puddling with animal drawn puddler (1025 02 mm) and puddling with country plough (1035 12 mm) However the treatments did not differ significantly regarding the loss of water through percolation The percentage variation of the percolated water for the different treatments over the control was maximum (17 66 per cent) during the vegetative phase The variation from the control decreased during the latter two stages and was minimum during the ripening stage (3 89 per cent) The plots puddled with tractor cage wheel recorded the highest yield (11 26 kg/plot) compared to other treatments The water use efficiency varied from 15 68 kg/ha-cm (puddling with country plough) to 18 64 kg/ha-cm (puddling with tractor cage wheel) The yield and water use efficiency also did not differ significantly among the treatments The reason for the insignificant differences among the treatments regarding the loss of water through percolation yield and water use efficiency could be attributed to the sandy loam nature of the soil since the response of rice plant to various tillage methods depends on soil texture It is known that the surface soil aggregates play a major role in controlling the infiltration rate of soil Since the soil in the experimental field consists of 10 per cent gravel 65 per cent sand 12 5 per cent silt and 12 5 per cent clay the amount of finer particles available for clogging of pores and surface seal development are less in this type of soil which might be the reason for the treatments not showing any significant variation in the water loss through percolation From the study undertaken it was concluded that different tillage methods have no effect in light textured soil in controlling the loss of water through percolation

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