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SURFACE DRAINAGE REQUIREMENT OF DWARF HYV RICE (IR-36) DURING WET SEASON

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INTRODUCTION

In order to design multiple cropping systems in eastern India it is essential to introduce short and medium duration rice varieties in wet (monsoon) season. The cultivation of dwarf high yielding varieties (HYV's) in wet season will help in increasing cropping intensity and crop production per unit area. However, the short and medium duration HYV's give poor yield in medium lands and shallow lowlands due to almost continuous standing water of varying depths on these lands. It has been established that the provision of surface drainage helped the adoption of improved technology in Kushabhadra-Bhargavi Doab of Orissa (Panda, Nanda, and Singh, 1994). But the question of adequacy of surface drainage in terms of optimum allowable ponded depth of water is yet to be answered. Knowledge of surface drainage needs of different rice cultivars will help the farmers in selecting varieties in accordance to land physiography that determines the depth and duration of ponding. This study aims to answer some of the questions pertaining to surface drainage needs of HYV's rice. Thus the purpose of the study is to quantify (i) the ponded depth-rice yield relationship and thereby determine the surface drainage needs of dwarf HYV rice (IR-36), and (ii) components of water balance under different depths of continuous ponding.

MATERIALS AND METHODS

In order to study the effect of different depths of ponding on yield of IR-36, a high yielding semi-dwarf variety, experiments were conducted at the Water Technology Centre for Eastern Region (WTCER) during monsoon seasons of 1992, 1993 and 1994 by maintaining water level depths at 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30 cm throughout the growing season after establishment of the transplanted seedlings. A weir was constructed in each experimental plot (9.85 m x 6.15 m) for removal of excess water (Fig.1, Photo-1). In 1992 the 30 cm ponding was not there. Lysimeters (Photo 2, 3 and 4) were fitted in the fields to determine the components of water balance. Plant spacing of 20 cm x 15 cm and a fertiliser dose of 60:30:30::N:P2O5:K2O (kg/ha) was maintained for all the three years. The rice crop were transplanted on 14th September in 1992 (60 days old seedling); 22nd and 24th July on 1993 and 1994 (30-35 days old seedlings). The bund around each field was lined with polythene sheet upto 60 cm depth to check lateral seepage. The soil of the experimental plots is acidic in nature (pH = 5.10) with bulk density of 1.53 g/cc. Experiment was laid out in randomised block design with three replications.

EFFECT OF CONTINUOUS PONDING ON YIELD OR RICE

Significant rice yield decline due to increased ponding has been recorded during all the three years (Table 1a). Pooled data showed that yields were at par upto 12 cm ponding. It is similar to the findings of Yadav (1972) who reported at par yield of rice upto 10 cm ponding. In the all India coordinated research project (AICRP) experiments maximum rice yields were recorded at

3 cm continuous ponding during all the years of experiments. Bhatia and Dastane (1971) reported 0 - 4 cm submergence as optimum for dwarf HYV's. Nephade and Ghildayal (1971) reported rice yield at 3 cm ponding were better than 15 cm ponding at Kharagpur. Chandramohan (1970) reported 5 cm submergence better for higher yield of rice. The analysis of three years data results the following relationships:

$$Z(1992) = 1.0097 - 0.975\,X,\ R^2 = 0.92^{**} \quad (1)$$

$$Z(1993) = 1.009 - 0.555\,X,\ R^2 = 0.98^{**} \quad (2)$$

$$Z(1994) = 0.9575 - 0.71\,X,\ R^2 = 0.75^{**} \quad (3)$$

$$Z(Pooled) = 0.995 - 0.755\,X,\ R^2 = 0.96^{**} \quad (4)$$

in which Z is dimensionless relative grain yield, Y/Y_{max} (Table 1b); Y is the yield of paddy in kg/ha corresponding to the depth of ponding d, in cm; Y_{max} is the maximum yield of paddy in Kg/ha; X is dimensionless ponding ratio, d/h_{mat}; and h_{mat} is average height of rice plants at maturity. The graphical representation of the pooled data is shown in Fig.2. An extrapolation in the neighbourhood of experimental data represented by equation (1) to (4) results maximum relative grain yield, Z, at dimensionless ponding, X = 0, during all the three years of experimentation. The extrapolation values at X = 0 are 1.007, 1.009, 0.9575, and 0.995 during 1992, 1993 and 1994 and pooled years respectively. It may be taken as unity, the maximum plausible yield.

While designing surface drainage system one is interested to know the reduction in yield due to higher depth of water in rice fields. It is obtained by substracting Z, given by equation(4) from its maximum plausible value of unity. Let Z_R is reduction in yield due to ponding, then

$$Z_R = 0.0051 + 0.7554\,X \quad (5)$$

Equation (5) indicates that at 6 % ponding depth the yield reduction is 5.06 %, at 12 % it is 9.62 %, at 20 % it is 15.69 %, at 25 % it is 19.49 %, at 30 % it is 23.29 % and at 50 % it is 38.47 %. Beyond 15 % of submergence the yield reduction is about 0.76 % for every one percent increase in ponding. The pooled analysis also confirms that yields were at par upto 12 cm ponding i.e. 15.6 % of plant height at maturity. The dimensionless relative yield - ponding depth relationship shows 9.62 % reduction in grain yield when the rice plant is submerged upto 15% of its height at maturity. It is in agreement with the observations of Bhuiyan and Undan (1986) where they have recommended that water depth in field should generally not exceed 15 to 20 percent of the crop height. Even though each rice variety would respond differently to different degrees and duration of ponding, aforesaid result may serve as a general guideline in understanding the drainage needs of rice crop.

The relation between harvest index (grain yield/(grain yield + straw yield))and dimensionless ponding ratio were also developed and are reported below.

$$Z_{HI}\ (1993) = 0.3738 - 0.2537\ X,\ R^2 = 0.58 \tag{6}$$

$$Z_{HI}\ (1994) = 0.3986 - 0.2359\ X,\ R^2 = 0.26 \tag{7}$$

$$Z_{HI}\ (\text{Mean}) = 0.3822 - 0.2540\ X,\ R^2 = 0.61 \tag{8}$$

where Z_{HI} is the harvest index and X is the dimensionless ponding ratio (Table 1c). Equation (8) reveals 0.25 percent decrease in harvest index for every one percent increase in ponding. The graphical plot of expression (8) is shown in Fig.3. The harvest index can be estimated from the relative grain yield (eq.(4)) in the following way:

$$\left(\frac{Y}{BM}\right) = \left(\frac{Y}{Y_{max}}\right)\left(\frac{Y_{max}}{BM}\right) \tag{9}$$

Here Y/BM is the harvest index; Y is paddy yield in Kg/ha, and BM is total biomass (grain + straw) production in Kg/ha. In order to develop prediction equation, the BM in the right hand side of equation (9) is replaced by the arithmatic mean, BM_m, of all the BM values.
Thus

$$BM_m = \frac{1}{N}\sum_{i=1}^{N} BM_i \tag{10}$$

For the given data in Table 1c, BM_m = 8293.5 kg/ha and

Y_{max}/BM_m = 0.3855. Hence

$$\left(\frac{Y}{BM}\right)_{estimated} = 0.3836 - 0.2911\ X \tag{11}$$

The maximum error in the estimated value of the harvest index by equation (8) and (11) have been computed to be 13.95 and 17.90 percents, respectively, at maximum dimensionless ponding ratio of 0.390. The other errors in equations (8) and (11) range from 0.19% to 8.53% and 0.25% to 8.55%, respectively. Thus, equation (11) is acceptable and could be used in place of equation (8) to estimate harvest index.

ROLE OF CONTINUOUS PONDING ON THE YIELD COMPONENTS OF RICE

Effective Tillers and Total Tillers

The effective tillers were adversely affected by the increased ponding depth of water. In 1992 and 1994 the effective tillers were not affected significantly due to different ponding depths

(Table 2a). The effective tillers were statistically at par upto 15 cm ponding depth of water in 1993. A reducing tendency of total tillers were also found due to excess ponding (Table 2b). Pande and Singh (1972) reported the reduction in effective tillers due to submergence at 10 ± 2 cm with respect to submergence at 5 ± 2 cm.Chatterjee and Maity (1983) reported inverse relation between tillers and the ponding depths. Bhatia and Dastane (1971) reported reduction in tillers per hill due to higher depth of submergence. Declining trend in mean effective tillers are shown in Table 2a. The relationship between dimensionless relative effective tillers and dimensionless ponding ratio are shown below.

$$Z_T\,(1993) = 0.98196 - 0.9224\,X,\ R^2 = 0.744 \quad (12)$$

$$Z_T\,(1994) = 0.9502 - 0.8304\,X,\ R^2 = 0.47 \quad (13)$$

$$Z_T\,(\text{Mean}) = 0.9669 - 0.8771\,X,\ R^2 = 0.79 \quad (14)$$

where Z_T is dimensionless relative effective tillers, T/T_m at Y_{max} (Table 2c); T is the effective tillers/m^2 corresponding to the depth of ponding d in cm; T_m at Y_{max} is the effective tillers where rice yield was maximum; X is dimensionless ponding ratio, d/h_{mat}; and h_{mat} is the average plant height at maturity. The graphical form of mean data is shown in Fig.4.

Though extrapolation is not permissible, careful interpretation arises from the equations that maximum dimensionless effective tillers Z_T is achieved at a dimensionless ponding ratio of $X = 0$ in all the years of experimentations.

While designing surface drainage one is interested to know the reduction in effectiive tillers due to excessive ponding of water in rice fields. It is obtained by substracting Z_T from its maximum plausible value unity. Let Z_{TR} is reduction in effective tillers due to ponding, then

$$Z_{TR} = 0.0332 + 0.8771\,X \quad (15)$$

Equation (15) explains that the reduction in effective tillers is 0.87 percent for every one percent increase in ponding depth.

Number of Grains Per Panicle, Chaffs Per Panicle and Length of Panicle

The grains per panicle due to different ponding depth were not significantly different in all the years of experiment (Table 3a). The length of panicles were unaffected due to excess ponding. But a tendency to produce more chaffs/panicle were observed due to excess ponding depth of water. The regression equation for dimensionless relative chaffs/panicle and ponding ratio are shown below. The trend for mean of 1992, 1993 and 1994 is shown in Fig.5.

$$Z_{Ch}\ (1992) = 0.9437 + 0.3194\ X,\quad R^2 = 0.03 \qquad (16)$$

$$Z_{Ch}\ (1993) = 0.796 + 0.1005\ X,\quad R^2 = 0.34 \qquad (17)$$

$$Z_{Ch}\ (1994) = 1.173 + 0.455\ X,\quad R^2 = 0.32 \qquad (18)$$

$$Z_{Ch}\ (\text{Mean}) = 0.8995 + 1.0278\ X,\ R^2 = 0.74 \qquad (19)$$

where Z_{Ch} is the dimensionless relative rice chaffs/panicle; Ch/Ch_m at Y_{max} (Table 3b); Ch is the chaffs/panicle corresponding to the depth of ponding d in cm; Ch_m at Y_{max} is the chaffy grains/panicle where rice yield was maximum; X is demensionless ponding ratio, d/h_{mat}; and h_{mat} is the average plant height at maturity. Though the data of 1992, 93 and 94 are not represented by straightline, the mean may be considered to fit the straight line well. From equation (19) it is clear that for every one percent increase in ponding there results one percent increase in chaffy grains/panicle.

Role of Ponding Depth on Plant Height

The plant height increased significantly in most of the observations in 1993 and 1994 due to increase in depths of ponding (Table 4a and 4b). At 60 DAT, the plant height increased sharply due to increased ponding during 1993 and 1994. At maturity the plant heights were significantly different due to different ponding depths in 1993 and 1994. Chatterjee and Maity (1983) reported that plant height is directly proportional to the ponding depth. Fig. 6 shows the relationship between dimensionless relative plant height at maturity and ponding ratio relationship. The relation between dimensionless relative plant height and dimensionless ponding ratio are shown below.

30 days after transplanting

$$Z_H\ (1993) = 0.9888 + 0.1099\ X,\ R^2 = 0.31 \qquad (20)$$

$$Z_H\ (1994) = 0.9647 + 0.4788\ X,\ R^2 = 0.92^{**} \qquad (21)$$

$$Z_H\ (\text{Mean}) = 0.9767 + 0.2966\ X,\ R^2 = 0.86^{**} \qquad (22)$$

60 days after transplanting

$$Z_H\ (1993) = 0.944 + 0.516\ X,\quad R^2 = 0.81^{**} \qquad (23)$$

$$Z_H\ (1994) = 0.9489 + 0.619\ X,\ R^2 = 0.89^{**} \qquad (24)$$

$$Z_H\ (\text{Mean}) = 0.951 + 0.55\ X,\quad R^2 = 0.88^{**} \qquad (25)$$

Maturity

$$Z_H \text{ (1993)} = 0.9945 + 0.633\ X,\ R^2 = 0.86^{**} \quad (26)$$

$$Z_H \text{ (1994)} = 0.952 + 0.603\ X,\ R^2 = 0.95^{**} \quad (27)$$

$$Z_H \text{ (Mean)} = 0.974 + 0.601\ X,\ R^2 = 0.93^{**} \quad (28)$$

where Z_H is dimensionless relative plant height; h/h_m at Y_{max} (Table 4c, 4d and 4e); h is the plant height in cm at different growth stages corresponding to the depth of ponding d in cm;

h_m at Y_{max} is the height of plants where rice yield was maximum; X is dimensionless ponding ratio, $d/h_{30.60\ \&\ mat}$; and $h_{30.60\ \&\ mat}$ is the average plant height at 30 DAT, 60 DAT and at maturity, respectively. Equation (28) reveals an increase of 0.6% plant height for every one percent increase in ponding at maturity.

Depth of Ponding Vs Leaf Area Index

The leaf area index (LAI) was measured with a Licor digital area meter (LI-3100, Licor, USA). The leaf area index showed a declining trend with increasing ponding depth of water (Table 5a). The LAI were not significantly different on different dates and years of observations due to excess ponding. The relation between dimensionless relative leaf area index and dimensionless ponding ratio are shown below.

30 days after transplanting

$$Z_L \text{ (1993)} = 1.0947 - 1.149\ X,\ R^2 = 0.77 \quad (29)$$

$$Z_L \text{ (1994)} = 0.8344 - 0.52\ X,\ R^2 = 0.31 \quad (30)$$

$$Z_L \text{ (Mean)} = 0.9709 - 0.837\ X,\ R^2 = 0.77^{**} \quad (31)$$

$$Z_{LR} = 0.0292 + 0.8367\ X \quad (32)$$

60 days after transplanting

$$Z_L \text{ (1993)} = 0.8347 - 0.155\ X,\ R^2 = 0.04 \quad (33)$$

$$Z_L \text{ (1994)} = 0.6225 - 0.458\ X,\ R^2 = 0.10 \quad (34)$$

$$Z_L \text{ (Mean)} = 0.734 - 0.378\ X,\ R^2 = 0.10 \quad (35)$$

$$Z_{LR} = 0.2656 + 0.3873\ X \quad (36)$$

Maturity

Z_L (1993) = 0.817 + 1.829 X, R^2 = 0.73** (37)

Z_L (1994) = 0.776 + 0.834 X, R^2 = 0.09 (38)

Z_L (Mean) = 0.782 + 1.197 X, R^2 = 0.28 (39)

where Z_L is dimensionless relative leaf area index; A/A_m at Y_{max} (Table 5b-5d); A is the leaf area index at different growth stages corresponding to the depth of ponding d in cm; A_m at Y_{max} is the leaf area index where rice yield was maximum;

X is dimensionless ponding ratio, $d/h_{30.60 \& mat}$; and $h_{30.60 \& mat}$ is the average plant height at 30 DAT, 60 DAT and at maturity respectively. Z_{LR} is the reduction in LAI due to ponding.

From the mean data it is clear that the reduction of LAI were upto 60 days after transplantation. At maturity the opposite trend were found due to delayed senescence of rice leaves under deeper submergence. The LAI at 60 DAT and maturity (except 1993) may not be considered to be represented well by a first degree polynomial due to the low R^2 values. Equation (32) reveals a reduction of 0.84 percent LAI at 30 due to every one percent increase in ponding depth. The graphical representation of mean data is depicted in Fig.7 (30 DAT).

Dry Matter Versus Depth of Water

The dry matter accumulation did not show any clear trend (Table 6). On most of the days of observations the dry matter accumulations were not significantly different in all the years of experiments.

Electrical Conductivity

The electrical conductivity (μ mhos/cm at 25 ^{0} C) of water due to different ponding depth is shown in Table 7. The electrical conductivity of water increased with declining ponding depth of water. The best fit regression equation is given below.

Z_{EC} (1993) = 68.843 - 1.242 X, R^2 = 0.78** (40)

where Z_{EC} is electrical conductivity of water in μ mhos/cm at 25 ^{0}C.

WATER BALANCE COMPONENTS

The detailed graphical manifestation for water balance components of 1993 and 1994 are shown in Fig.8 and 9. The detailed discussion follows.

Water Requirement

The total water requirement were recorded during 1993 and 1994 only. It increased with increased ponding depth (Table 8). In the experiment the total water requirement varied from 318 to 1036 cm under different ponding condition. Mitra and Sabris (1945) reported 916 cm water requirement for early maturing varieties. It increased with increasing ponding depth of water, (Fig 10). The functional relations are shown below. The daily water requirement (Table 10) varied from 4.47 - 15.6 mm/day and 5.52 - 18.3 mm/day during 1993 and 1994 respectively.

$$WR\ (1993) = 2.80 + 0.39\ X,\ R^2 = 0.84^{**} \quad (41)$$

$$WR\ (1994) = 6.10 + 0.3656\ X,\ R^2 = 0.81^{**} \quad (42)$$

where WR is daily water requirement of rice crop in mm and X is depth of ponding in cm.

Evapotranspiration (ET)

The total seasonal ET (Table 8) and the seasonal average evapotranspiration (Table 9) of rice crops under different ponding depths were almost stationary with increased ponding (Fig.3 and 9). This may be due to increased evaporation with increased depth of ponding water and decreasing transpiration with increased depth of ponding which have almost equalised the ET under different ponding depths. (These were mainly due to the indirect effect of reduced LAI with increased ponding depth). The average monsoon ET has been found to be 4.71, 3.66 and 4.77 mm/day during 1991, 1992 and 1993, respectively. For the three years the average comes to be 4.38 mm/day.

The evapotranspiration were low at initial stages of growth but increased towards the later growth stages (Table 11a and Table 11b). The characteristiics curve of ET with progressivie development of rice crop is shown in Fig.11.

Evaporation (E, mm/day)

The average weekly evaporation from rice field is shown in Table 12 (a) and 12 (b) for 1993 and 1994 respectively. The evaporation from rice field declined as the crop grew progressively (Fig.12). It is clear from Table 10 that the mean daily evaporation varied from 1.6 to 2.9; 1.4 to 2.1 and 1.3 to 3.6 mm/day in 1992, 1993 and 1994, respectively.

The evaporation from rice fields declined with increased ponding depth of water due to less leaf area index with increasing ponding depth (Fig.8 and 9). The regression equation between evaporation and ponding depth are shown below.

$$E\ (1992) = 1.51 + 0.0488\ X, \quad R^2 = 0.91^{**} \quad (43)$$

$$E\ (1993) = 1.472 + 0.0361\ X, \quad R^2 = 0.72^{**} \tag{44}$$

$$E\ (1994) = 1.3279 + 0.06387\ X, \quad R^2 = 0.75^{**} \tag{45}$$

where E is mean daily evaporation (mm) and X is depth of ponding water (cm).

Transpiration (T, mm/day)

The mean daily rate of transpiration and the detailed average weekly transpiration are shown in Table 10 and Table 13a respectively. The average transpiration rate was declining with increasing ponding depth which may be due to poor leaf area index. The regression equations between rate of transpiration and ponding depth are shown below.

$$T\ (1992) = 6.53 + 0.94\ X + 0.063\ X^2 - 0.0013\ X^3, \quad R^2 = 0.78^{*} \tag{46}$$

$$T\ (1993) = 2.735 - 0.0507\ X + 0.0004\ X^2, \quad R^2 = 0.53 \tag{47}$$

$$T\ (1994) = 3.64 - 0.0588\ X, \quad R^2 = 0.22 \tag{48}$$

where T is the rate of transpiration in mm/day and X is the depth of ponding.

The transpiration rates varied from 1.7 to 4.2; 1.2 to 2.7 and 0.4 to 3.4 mm/day on 1992; 1993 and 1994, respectively (Fig.13).

Deep Percolation (mm/day)

The deep percolation rate increased with the increased ponding depth of water. The daily deep percolation rate varied from 0.78 to 13.8 mm/day due to ponding from 3 to 30 cm, (Fig. 8. and Fig. 9). Vamadevan (1971) reported greater depth of flooding increased the percolation rate than shallow flooding.

$$DP\ (1993) = -\ 0.1134 + 0.4158\ X, \quad R^2 = 0.86 \tag{49}$$

$$DP\ (1994) = 2.078 + 3376\ X, \quad R^2 = 0.75 \tag{50}$$

where DP is the deep percolation rate in mm/day and X is the ponding depth in cm.

Water Production Function

The water production function (yield in Kg/ha Vs. total seasonal ET at different ponding depths in mm) are presented here.

$$Y\ (1992) = 16637.25 - 137.82\ X + 0.319\ X^2,\ R^2 = 0.37 \quad (51)$$

$$Y\ (1993) = 1380.06 + 29.5139\ X - 0.0467\ X^2,\ R^2 = 0.24 \quad (52)$$

$$Y\ (1994) = 5474 - 31.14\ X + 0.0705\ X^2,\ R^2 = 0.58^* \quad (53)$$

where Y is the yield of rice in kg/ha and X is the total seasonal ET in mm.

CONCLUSIONS

1. Three to 12 cm continuous ponding recorded rice yields which were statistically at par, after which the rice yield sharply declined. Twelve cm continuous submergence equal to 15 percent of the plant height reduced the crop yield by 9.62 percent. There was 0.76 percent reduction in grain yield due to every one percent increase in ponding. Fifteen percent of the plant height at maturity is the critical depth of allowable ponding in rice fields. The drainage system should not allow the water level to rise above this level. The effect of excess ponding on rice crop were manifested in the reduction of grain yield, effective tillers, leaf area index.

2. For every one percent increase in ponding, the decrease in effective tillers, harvest index and leaf area index were 0.87, 0.25 and 0.84 (30 DAT) percent, respectively.

3. Chaffy grains per panicle increased by 1.0 per cent for every one percent increase in ponding height.

4. The height of the rice plant were increased by 0.6 percent for every one percent increase in ponding height.

5. The total water requirement varied from 318 to 1253 mm and total evapotranspiration from 230 mm to 313 mm, respectively depending on the depth of ponding. However, the total evapotranspiration was unaffected by the submergence level. The average ET for the three years was 4.38 mm/day.

6. The average daily water requirement varied from 4.47 to 18 mm/day depending on the depth of ponding.

7. The average daily evaporation, transpiration and deep percolation varied from 1.3 to 3.6 mm/day; 1.6 to 4.2 mm/day and 0.78 to 14 mm/day, respectively depending on depth of ponding.

8. Gallmidge and leaf eating caterpillars were common in excess ponded fields.

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Table 1a : Grain yield of rice (IR-36) under different continuous ponding depths in Kharif season on successive years

Treatments	Years of experiments			
Depth of ponding (cm)	1992	1993	1994	Pooled
3	2567	3554	2839	2987
6	2202	3442	2409	2684
9	2127	3337	2508	2673
12	2285	3359	2316	2653
15	2063	3233	2211	2502
18	1944	3142	2302	2463
21	1696	3089	2299	2361
24	1528	3045	2309	2294
27	1594	2954	2031	2193
30	1405	2934	1878	2072
S.Em ±	287.14	193	211.98	165.6
C.D. at 5 %	608.76	405	445.38	348
C.V. %	21.32	9.26	14.65	—

Table 1b : Dimensionless relative yield and dimensionless ponding ratio for IR-36 in Kharif season

Ponding (cm)	1992		1993		1994		Mean	
	$Z=y/y_{max}$	$X = d/h_{mat}$	$Z=Y/y_{max}$	$X=d/h_{mat}$	$Z=y/y_{max}$	$X=d/t\ h_{mat}$	$Z=y/y_{max}$	$X=d/h_{mat}$
3	1.00	0.047	1.00	0.035	1.000	0.037	1.00	0.039
6	0.86	0.094	0.968	0.070	0.848	0.074	0.899	0.078
9	0.83	0.142	0.939	0.105	0.883	0.111	0.895	0.117
12	0.89	0.189	0.945	0.140	0.816	0.147	0.888	0.156
15	0.80	0.236	0.910	0.175	0.779	0.184	0.838	0.195
18	0.76	0.283	0.884	0.209	0.811	0.221	0.824	0.234
21	0.66	0.331	0.869	0.244	0.809	0.258	0.790	0.273
24	0.60	0.338	0.857	0.279	0.813	0.295	0.768	0.312
27	0.62	0.425	0.831	0.314	0.715	0.332	0.734	0.351
30	0.54	0.477	0.825	0.349	0.661	0.368	0.693	0.390

Table 1c : Harvest index and dimensionless ponding ratio for IR-36 in Kharif season

Ponding (cm)	1993		1994		Mean	
	Z=G/G+S	X=d/h_{mat}	Z=G/G+S	X=d/h_{mat}	Z=G/G+S	X=d/h_{mat}
3	0.390	0.035	0.430	0.037	0.407	0.039
6	0.321	0.070	0.446	0.074	0.363	0.078
9	0.367	0.105	0.358	0.111	0.363	0.117
12	0.325	0.140	0.313	0:147	0.320	0.156
15	0.350	0.175	0.296	0.184	0.326	0.195
18	0.293	0.209	0.313	0.221	0.301	0.234
21	0.324	0.244	0.316	0.258	0.303	0.273
24	0.300	0.279	0.330	0.295	0.312	0.312
27	0.274	0.314	0.335	0.332	0.296	0.351
30	0.307	0.349	0.370	0.368	0.329	0.390

Table 2a : Effective tillers/m^2 of rice (IR-36) under different ponding depths in Kharif season

Treatments	Year of experiments		
Depth of ponding (cm)	1992	1993	1994
3	440	364	339
6	439	336	262
9	480	333	283
12	493	313	271
15	460	284	290
18	461	256	272
21	485	262	272
24	473	238	261
27	448	272	155
30	—	272	246
S.Em ±	76.77	47.01	45.63
C.D. at 5 %	NS	—	NS
C.V. %	18.99	21.59	23.55

Table 2b : Progressive tillers development of rice under different ponding depths

Ponding depth (cm)	Total tillers/m²						
	30 DAT			60 DAT		Maturity	
	1992	1993	1994	1993	1994	1993	1994
3	608	573	404	468	356	392	339
6	669	459	362	383	279	354	262
9	702	379	354	341	290	367	283
12	567	374	310	314	264	340	271
15	563	303	310	311	287	310	290
18	557	351	310	342	285	271	272
21	514	280	308	274	271	278	272
24	600	223	285	276	267	254	261
27	544	272	245	295	258	308	155
30	—	242	241	271	248	280	244
S.Em ± 155	56.2	39.1	50.3	38.5	—	38.5	
C.D. 5 % NS	118	82.2	NS	NS	—	NS	
C.V. %	22.1	33.6	20.0	106	17.5	—	17.2

Table 2c : Dimensionless relative effective tiller and dimensionless ponding ratio for IR-36

Ponding (cm)	1993		1994		Mean	
	$Z=T/T$ at y_{max}	$X=d/h_{mat}$	$Z=T/T$ at y_{max}	$X=d/h_{mat}$	$Z=T/T$ at y_{max}	$X=d/h_{mat}$
3	1.00	0.035	1.00	0.037	1.00	0.036
6	0.923	0.067	0.773	0.074	0.851	0.072
9	0.915	0.105	0.835	0.111	0.876	0.107
12	0.860	0.140	0.799	0.147	0.831	0.143
15	0.780	0.174	0.955	0.184	0.817	0.179
18	0.703	0.209	0.802	0.221	0.751	0.215
21	0.720	0.244	0.802	0.258	0.760	0.251
24	0.654	0.279	0.770	0.295	0.710	0.287
27	0.747	0.314	0.457	0.332	0.607	0.323
30	0.747	0.349	0.726	0.368	0.737	0.358

Table 3a : Number of grains/panicle, length of panicle, number of chaffs/panicle of rice plants as affected ponding depths.

Ponding depth(cm)	Number of grains/panicle			Length of panicle (cm)			Number of chaffs/panicle		
	1992	1993	1994	1992	1993	1994	1992	1993	1994
3	45	59	67	16.8	20.3	20	6	19	15
6	50	65	67	17.4	20.5	19.9	7	17	17
9	51	68	58	17.2	21.1	19.3	6	15	16
12	44	68	73	16.7	20.9	21.4	4	19	21
15	45	76	58	16.8	21.9	20.2	7	16	20
18	45	81	60	16.7	21.9	20.1	4	16	24
21	48	78	64	17.1	21.7	20.0	8	16	18
24	51	83	59	17.0	22.4	20.4	6	25	19
27	45	74	72	16.6	22.1	21.1	7	23	22
30	—	80	61	—	22.3	19.9	—	22	26
S.Em	5.12	9.48	8.62	—		0.95	1.20	4.5	3.56
C.D.(5%)	NS	NS	NS	—	NS	NS	NS	NS	NS
C.V. (%)	12.5	17.3	17.6	—	6.05	5.85	30.5	29.1	24.7

Table 3b : Dimensionless relative chaffy grains and dimensionless ponding ratio for IR-36 in Kharif season

Ponding (cm)	1992		1993		1994		Mean	
	Z= Ch/Ch at y_{max}	X= d/ h_{mat}	Z= Ch/Ch at y_{max}	X= d/ h_{mat}	Z= Ch/Ch at y_{max}	X= d/ h_{mat}	Z= Ch/Ch at y_{max}	X= d/ h_{mat}
3	1.00	0.047	1.00	0.035	1.000	0.037	1.00	0.039
6.	1.17	0.094	0.895	0.070	1.028	0.074	1.028	0.078
9	1.00	0.142	0.789	0.105	0.927	0.111	0.927	0.117
12	0.67	0.189	1.00	0.140	1.103	0.147	1.103	0.156
15	1.17	0.236	0.842	0.175	1.077	0.184	1.077	0.195
18	0.67	0.283	0.842	0.209	1.103	0.221	1.103	0.234
21	1.33	0.331	0.842	0.244	1.053	0.258	1.053	0.273
24	1.00	0.338	1.316	0.279	1.253	0.295	1.253	0.312
27	1.17	0.425	1.210	0.314	1.300	0.332	1.300	0.351
30	1.10	0.477	1.158	0.349	1.356	0.368	1.356	0.390

Table 4a : Progressive height of plants as influenced by different ponding depths.

Ponding depth (cm)	Progressive plant height (cm)							
	30 DAT			60 DAT		Maturity		
	1992	1993	1994	1993	1994	1992	1993	1994
3	59.2	60.3	51.2	82.3	78.6	62.6	77.0	75.8
6	57.6	60.6	49.7	79.8	75.4	64.0	82.2	74.4
9	63.6	59.1	54.3	82.6	81.0	65.1	82.2	76.6
12	58.4	60.9	54.5	82.2	82.9	65.3	83.0	77.8
15	60.8	60.2	56.2	81.7	83.6	61.6	83.5	82.0
18	60.8	62.4	57.3	84.7	84.6	65.0	84.7	81.7
21	56.4	64.9	60.1	89.4	84.0	63.7	88.5	82.6
24	60.3	62.3	60.6	90.1	88.5	63.0	94.2	85.9
27	58.7	63.7	60.8	94.5	93.2	62.0	93.2	88.5
30	—	61.6	60.9	91.2	90.8	—	91.0	89.0
S.Em±	3.22	2.42	2.04	2.85	1.90	4.05	2.32	2.61
C.D.(5%)	NS	NS	4.29	5.99	4.00	NS	4.9	5.49
C.D.(1%)	NS	NS	5.86	8.46	5.47	NS	6.89	7.52
C.V. (%)	5.99	4.05	7.85	6.62	6.70	6.37	6.90	7.01

Table 4b : Weekly record of plant height (cm) of rice as affected by different ponding depths for 1994

Depth of water, cm	Progressive plant heights (cm)				
	30-8-94	6-9-94	21-9-94	28-9-94	4-10-94
3	60	63	73	79	79
6	57	62	73	75	75
9	59	64	75	81	80
12	64	69	78	83	83
15	66	72	79	84	84
18	65	67	77	80	80
21	67	71	79	86	88
24	64	74	82	86	88
27	74	78	88	95	93
30	68	81	81	90	89
S.Em±	3.90	5.89	3.48	2.11	2.64
C.D. 5%	8.20	NS	7.32	6.07	7.62
C.V. (%)		9.67	6.99	7.05	6.90%

Table 4c : Dimensionless relative plant height and dimensionless ponding ratio at 30 days after transplanting

Ponding (cm)	1993		1994		Mean	
	$Z=h/h$ at y_{max}	$X=d/h_{30\ DAT}$	$Z=h/h$ at y_{max}	$X=d/h_{30\ DAT}$	$Z=h/h$ at y_{max}	$X=d/h_{30\ DAT}$
3	1.00	0.045	1.00	0.053	1.00	0.051
6	1.005	0.097	0.970	0.106	0.989	0.102
9	0.98	0.145	1.06	0.159	1.017	0.153
12	1.009	0.195	1.064	0.212	1.035	0.203
15	0.998	0.244	1.097	0.265	1.044	0.254
18	1.035	0.292	1.119	0.318	1.074	0.305
21	1.076	0.341	1.174	0.371	1.121	0.355
24	1.033	0.391	1.183	0.424	1.102	0.406
27	1.056	0.438	1.187	0.477	1.116	0.457
30	1.02	0.487	1.189	0.530	1.098	0.508

Table 4d : Dimensionless relative plant height and dimensionless ponding ratio at 60 days after transplanting

Pondinh (cm)	1993	1994	Mean			
	Z=h/h at y_{max}	X=d/ $h_{60\ DAT}$	Z=h/h at y_{max}	X=d/ $h_{60\ DAT}$	Z=h/h at y_{max}	X=d/ $h_{60\ DAT}$
3	1.00	0.035	1.00	0.036	1.00	0.035
6	0.970	0.069	0.959	0.071	0.964	0.070
9	1.004	0.105	1.031	0.107	1.017	0.106
12	0.999	0.140	1.046	0.142	1.026	0.141
15	0.993	0.175	1.039	0.178	1.027	0.176
18	1.029	0.210	1.078	0.214	1.052	0.212
21	1.086	0.245	1.076	0.249	1.078	0.247
24	1.095	0.279	1.126	0.285	1.110	0.282
27	1.148	0.315	1.186	0.320	1.166	0.31
30	1.108	0.349	1.160	0.356	1.131	0.353

Table 4e : Dimensionlless relative plant height and dimensionless ponding ratio at maturity

Ponding (cm)	1993	1994	Mean			
	Z=h/h at y_{max}	X=d/ h_{mat}	Z=h/h at y_{max}	X=d/ h_{mat}	Z=h/h at y_{max}	X=d/ h_{mat}
3	1.00	0.035	1.00	0.036	1.00	0.036
6	1.067	0.069	0.981	0.074	1.025	0.072
9	1.067	0.105	0.010	0.110	1.039	0.107
12	1.078	0.140	1.026	0.147	1.052	0.143
15	1.084	0.174	1.082	0.184	1.083	0.179
18	1.100	0.209	1.078	0.221	1.089	0.251
21	1.149	0.244	1.089	0.258	1.119	0.251
24	1.223	0.279	1.133	0.294	1.178	0.288
27	1.210	0.314	1.167	0.331	1.189	0.323
30	1.182	0.349	1.174	0.368	1.178	0.358

Table 5a : Progressive leaf area index of rice under different ponding depths.

Ponding depth (cm)	Leaf area index					
	30 DAT		60 DAT		Maturity	
	1993	1994	1993	1994	1993	1994
3	3.02	2.80	2.48	2.75	0.74	1.39
6	3.10	1.51	1.84	1.06	0.67	0.98
9	2.51	2.24	1.86	1.08	0.62	0.66
12	2.79	2.07	1.93	1.22	0.78	1.38
15	2.35	1.54	1.84	1.45	0.97	1.24
18	2.74	1.99	1.94	1.92	0.87	1.66
21	2.31	1.89	2.17	0.98	0.92	2.07
24	1.51	2.00	1.85	1.44	0.86	0.84
27	2.07	1.70	2.13	1.31	1.13	1.66
30	1.38	1.38	1.92	1.32	1.08	1.26
S.Em±	0.56	0.52	0.55	0.65	0.23	0.11
C.D.(5%)	NS	NS	NS	NS	NS	0.23
C.V. (%)	34.6	34.7	30.5	25.9	22.4	41.5

Table 5b : Dimensionless relative leaf area index and dimensionless ponding ratio at 30 days after transplanting

Ponding (cm)	1993		1994		Mean	
	Z=A/ A at y_{max}	X=d/ $h_{30\ DAT}$	Z=A/ A at y_{max}	X=d/ $h_{30\ DAT}$	Z=A/ A at y_{max}	X=d/ $h_{30\ DAT}$
3	1.00	0.045	1.00	0.053	1.00	0.051
6	1.026	0.097	0.539	0.106	0.792	0.102
9	0.831	0.145	0.800	0.159	0.816	0.153
12	0.924	0.195	0.739	0.212	0.835	0.203
15	0.778	0.244	0.550	0.265	0.668	0.254
18	0.907	0.292	0.711	0.318	0.813	0.305
21	0.765	0.341	0.675	0.371	0.722	0.355
24	0.500	0.391	0.714	0.424	0.603	0.406
27	0.685	0.438	0.607	0.477	0.648	0.457
30	0.457	0.487	0.493	0.530	0.474	0.508

Table 5c : Dimensionless relative leaf area index and dimensionless ponding ratio at 60 days transplanting

Ponding (cm)	1993		1994		Mean	
	Z=A/ A at y_{max}	X=d/ $h_{60\ DAT}$	Z=A/ A at y_{max}	X=d/ $h_{60\ DAT}$	Z=A/ A at y_{max}	X=d/ $h_{60\ DAT}$
3	1.00	0.035	1.00	0.036	1.00	0.035
6	0.742	0.069	0.385	0.071	0.554	0.070
9	0.750	0.105	0.393	0.107	0.562	0.106
12	0.778	0.140	0.444	0.142	0.602	0.141
15	0.742	0.175	0.527	0.178	0.629	0.176
18	0.782	0.210	0.698	0.214	0.738	0.212
21	0.875	0.245	0.356	0.249	0.602	0.247
24	0.746	0.279	0.524	0.285	0.629	0.282
27	0.859	0.315	0.476	0.320	0.658	0.3
30	0.774	0.349	0.480	0.356	0.619	0.353

Table 5d : Dimensionless relative leaf area index and dimensionless ponding ratio at maturity

Ponding (cm)	1993		1994		Mean	
	Z=A/ A at y_{max}	X=d/ h_{mat}	Z=A/ A at y_{max}	X=d/ h_{mat}	Z=A/ A at y_{max}	X=d/ h_{mat}
3	1.00	0.035	1.00	0.036	1.00	0.036
6	0.905	0.069	0.705	0.074	0.775	0.072
9	0.838	0.105	0.475	0.110	0.601	0.107
12	1.054	0.140	0.993	0.147	1.014	0.143
15	1.311	0.174	0.892	0.184	1.037	0.179
18	1.176	0.209	1.194	0.221	1.187	0.251
21	1.243	0.244	1.489	0.258	1.404	0.251
24	1.162	0.279	0.604	0.294	0.798	0.288
27	1.527	0.314	1.194	0.331	1.310	0.323
30	1.459	0.349	0.906	0.368	1.098	0.358

Table 6 : Progressive dry matter accumulation of rice under different ponding depths

Ponding depth (cm)	Dry matter accumulation / m^2						
	30 DAT			60 DAT		Maturity	
	1992	1993	1994	1993	1994	1993	1994
3	350	279	193	754	580	911	660
6	262	298	247	789	633	1072	540
9	343	233	220	793	467	910	700
12	303	253	213	747	447	1033	740
15	261	246	213	663	593	923	747
18	320	227	253	793	520	1072	735
21	237	143	287	591	502	955	727
24	318	175	260	682	567	1014	700
27	281	233	187	851	533	1079	607
30	—	194	220	650	587	955	507
S.Em ±	50	32	63	74	94	162	121
C.D. 5%	NS	67.5	NS	NS	NS	NS	NS
C.V.%	20.5	25.3	37.9	—	20.8	18.7	21.6

Table 7 : Electrical conductivity of water as influenced by different ponding depths at (μ mhos/cm at 25 ^{0}C)

Depth of water (cm)	Electrical conductivity at 25 ^{0}C (μ mhos/cm) 5-10-93	Electrical conductivity at 25 ^{0}C (μ mhos/cm) 10-10-93
3	67.02	94.30
6	63.05	67.71
9	53.83	74.18
12	56.35	61.82
15	50.48	51.98
18	52.38	46.36
21	28.51	37.09
24	36.22	42.14
27	40.73	25.60
30	34.92	30.06
S.Em ±	9.07	6.90
C.D. at 5%	NS	20.50
C.V. %	38.90	43.04

Table 8 : Total water requirement and total evapotranspiration as affected by different ponding depth of water

Treatments	Total water requirement (mm)		Total evapotranspiration (mm)		
Depth of Water (cm)	1993	1994	1992	1993	1994
3	352	359	256	292	307
6	493	638	196	309	239
9	318	643	198	306	311
12	500	569	173	277	284
15	524	810	183	290	296
18	1014	888	208	274	268
21	835	852	247	313	293
24	1036	1006	214	269	280
27	925	1190	193	230	261
30	1253	945	—	293	231

Table 9 : Average daily evapotranspiration, evaporation and transpiration as governed by different ponding depth of water (mm)

Ponding depth (cm)	Different forms of water loss								
	Evapotranspiration (mm/day)			Evaporation (mm/day)			Transpiration (mm/day)		
	1992	1993	1994	1992	1993	1994	1992	1993	1994
3	5.8	3.6	5.3	1.6	1.5	1.9	4.2	2.3	3.4
6	4.5	3.9	4.1	1.8	1.5	2.0	2.7	2.7	2.1
9	4.5	4.1	5.4	1.9	1.4	1.3	2.6	2.6	4.1
12	3.9	3.5	4.9	2.2	1.6	2.2	1.7	1.9	2.7
15	4.2	3.7	5.1	2.2	1.7	1.9	2.0	2.3	3.2
18	4.7	3.5	4.6	2.5	1.9	2.5	2.2	1.6	2.1
21	5.6	3.9	5.0	2.5	2.1	2.4	3.5	2.2	2.6
24	4.8	3.7	4.8	2.9	2.1	2.9	1.8	1.6	1.9
27	4.4	2.9	4.5	2.6	1.7	3.2	1.8	1.2	1.3
30	—	3.8	4.0	—	1.8	3.6	—	1.9	0.4

Table 10 : Daily water requirement and deep percolation under different ponding depths in Kharif season.

Treatments	Daily water requirement (mm/day)		Deep percolation loss (mm/day)	
Depth of ponding (cm)	1993	1994	1993	1994
3	4.47	5.52	0.78	0.22
6	6.25	9.82	2.33	5.70
9	5.57	9.90	1.70	4.54
12	6.33	8.75	2.82	3.86
15	6.64	12.5	2.97	7.37
18	12.8	13.7	9.36	9.05
21	10.6	13.1	6.60	8.06
24	13.1	15.5	9.72	10.6
27	11.7	18.3	8.79	13.8
30	15.6	14.4	12.2	10.4

Table 11(a) : Evapotranspiration from rice field due to different ponding depth of water (mm), 1993

Depth cm	Weekly average evapotranspiration (mm)										Mean
	August				September-October				September-October		
—	1-7	8-14	15-21	22-28	29-4	5-11	12-18	19-25	26-02	03-10	—
3 cm	1.7	3.02	1.26	4.57	3.78	4.48	3.53	4.0	4.80	5	3.64
6 cm	1.86	4.40	3.20	4.71	3.93	4.22	3.83	4.2	4.5	4.33	3.92
9 cm	2.45	4.36	2.20	5.28	4.50	4.94	3.83	3.68	4.83	4.66	4.07
12 cm	2.20	5.53	1.86	4.57	3.60	4.68	3.67	3.87	3.83	3.66	3.53
15 cm	1.95	3.53	2.20	5.14	3.78	4.26	4.17	4.17	4.17	3.66	3.70
18 cm	2.20	4.0	2.53	4.29	3.78	4.0	3.67	3.67	3.87	3.33	3.53
21 cm	1.70	3.20	2.90	5.14	3.93	4.66	4.0	4.0	5.17	5.0	3.97
24 cm	2.20	4.40	3.20	5.00	3.64	3.80	3.17	3.17	4.17	4.0	3.67
27 cm	1.53	4.05	2.87	4.14	2.78	3.33	2.67	2.67	2.83	2.0	2.88
30 cm	2.53	3.70	3.20	4.88	4.50	4.08	3.67	3.67	4.0	3.33	3.75

Table 11 (b) : Weekly average evapotranspiration, 1994

Depth of water	August-September					September-October				Mean
	1-7	8-14	15-21	22-28	29-04	05-11	12-18	19-25	26-02	—
3	7.3	4.4	4.9	5.0	4.4	3.9	5.1	6.1	5.3	5.16
6	5.0	4.2	4.2	4.4	4.3	4.2	4.1	5.0	4.7	4.46
9	8.3	6.2	5.4	4.7	5.3	4.4	6.2	6.2	5.7	5.82
12	5.3	4.7	4.7	3.7	4.2	4.7	5.1	7.2	6.3	5.1
15	8.8	5.0	5.4	4.4	4.7	4.8	4.9	6.7	6.1	5.64
18	5.3	4.9	4.8	3.8	4.2	4.9	4.9	6.5	6.0	5.03
21	6.3	4.2	4.2	4.3	4.5	5.1	5.4	6.7	7.1	5.31
24	7.8	4.4	4.2	3.3	3.6	3.9	4.4	5.8	5.7	4.79
27	6.8	4.0	3.5	4.6	3.5	4.1	4.7	6.4	7.0	4.96
30	6.8	4.9	3.7	4.0	4.2	5.1	6.2	8.0	7.3	5.58

Table 12(a) : Evaporation from rice fields as influenced by different ponding depths (mm), weekly average, 1993

Depth cm	Depth of water Average weekly evaporation (mm)										Mean
	August				August - September				October		
	3-7	8-14	15-21	22-28	29-4	5-11	12-18	19-25	26-2	3-9	—
3 cm	0.93	2.8	0.9	1.8	1.25	1.4	1.33	—	1.6	0.7	—
6 cm	1.9	3.05	1.4	1.73	1.20	1.9	1.16	0.95	1.0	1	1.52
9 cm	1.7	2.12	0.86	1.77	1.60	1.5	1.33	1.2	1.0	1	1.40
12 cm	1.6	2.30	0.90	1.77	1.80	2.0	1.33	1.5	1.0	1.5	1.57
15 cm	2.2	2.7	0.90	2.05	1.64	2.0	1.66	1.5	1.16	1	1.68
18 cm	1.86	2.87	1.53	2.48	1.58	2.52	1.62	2.33	1.16	1	1.89
21 cm	2.30	3.0	1.53	2.91	1.93	2.20	1.67	2.45	1.66	1	2.06
24 cm	1.95	3.7	1.86	2.62	1.78	2.35	2.00	1.76	1.66	1	2.07
27 cm	1.2	3.03	2.20	2.20	1.64	2.50	1.10	1.20	1.16	1	1.72
30 cm	1.2	3.36	2.20	2.63	1.91	2.33	1.33	1.45	1.0	1	1.84

Table 12 (b) : Weekly average evaporation (mm), 1994

Depth of water	August-September					September-October				Mean
	1-7	8-14	15-21	22-28	29-04	05-11	12-18	19-25	26-02	—
3	2.2	3.3	2.7	3.4	1.3	1.1	1.7	1.8	1.4	2.1
6	8	3.4	2.7	4.6	1.7	1.4	2.0	1.9	2.4	3.12
9	4.3	3.0	3.0	2.8	2.9	1.6	2.0	2.2	2.0	2.64
12	7	3.5	3.4	3.0	2.5	1.8	1.7	2.5	2.4	3.09
15	4	3.0	2.7	1.9	1.9	1.8	2.6	2.2	2.1	2.47
18	5.3	3.6	3.6	3.8	3.0	1.8	2.6	2.5	2.7	3.21
21	4.8	4.2	3.4	3.4	2.7	1.8	1.7	2.5	2.4	2.99
24	6.8	4.6	3.2	3.6	3.7	1.8	4.1	3.1	2.7	3.73
27	5.8	4.6	4.4	3.8	4.0	2.2	3.7	3.2	2.7	3.82
30	7.3	4.8	3.9	4.1	4.9	2.5	3.1	3.8	3.6	4.22

Table 13 : Daily transpiration from rice field under different ponding depths (cm), 1993

Depth cm	Daily transpiration (mm)										Mean
	August				August - September				October		
	3-7	8-14	15-21	22-28	29-4	5-11	12-18	19-25	26-2	3-9	—
3 cm	0.77	0.4	0.36	3.32	2.53	3.40	2.50	2.00	3.20	4.3	2.28
6 cm	—	1.35	1.8	2.98	2.73	2.32	2.67	3.25	3.5	3.33	2.66
9 cm	0.75	1.24	1.34	3.51	2.9	3.44	2.50	2.48	3.83	3.66	2.56
12 cm	0.60	1.23	0.96	2.80	1.8	2.68	2.34	1.90	2.83	2.16	1.93
15 cm	—	0.83	1.30	3.09	2.14	2.26	2.84	2.33	3.01	2.66	2.27
18 cm	0.34	1.13	1.0	1.81	2.20	1.48	2.05	0.78	2.71	2.33	1.58
21 cm	—	0.2	1.37	2.26	2.00	2.46	2.33	1.52	3.51	4.0	2.18
24 cm	0.25	0.7	1.34	2.38	1.86	1.45	1.17	1.64	3.51	3.0	1.63
27 cm	0.33	1.02	0.67	1.91	1.14	0.83	1.57	1.76	1.67	1.0	1.19
30 cm	1.33	0.34	1.0	2.23	2.59	1.75	2.34	1.86	3.00	3.33	1.98

Table 14 : Average weekly water requirement of rice (mm), 1994

Depth of water	August-September					September-October				Mean
	1-7	8-14	15-21	22-28	29-04	05-11	12-18	19-25	26-02	—
3	-	6.7	5.2	6.8	3.6	6.8	5.7	6.7	3.8	5.66
6	-	7.5	7.6	9.2	4.0	6.5	-	7.1	5.5	6.77
9	6	7.7	7.7	9.9	7.0	9.4	6.0	8.2	5.8	7.52
12	9	8.5	8.1	9.7	4.8	7.3	4.0	8.8	6.1	7.37
15	9	8.8	8.4	9.9	7.0	11.3	4.7	8.8	7.4	8.37
18	16	10	15	11	9.5	11	14	10	9.0	11.72
21	12	12	10	9.6	9.8	11	18	11	9.6	11.44
24	15	10	16	12	9.6	13.3	15	12	10	12.54
27	64	17	18	17	13	16	19	15	13	21.33
30	15	16	16	-	12	13	16	17	12	14.63

Rice crop at 21 cm ponding in initial stage

Rice crop at 30 cm ponding in initial stage (weir shown here)

Rice crop (IR-36) at 3 cm ponding in initial stage

The lysimeter system for measuring water balance components

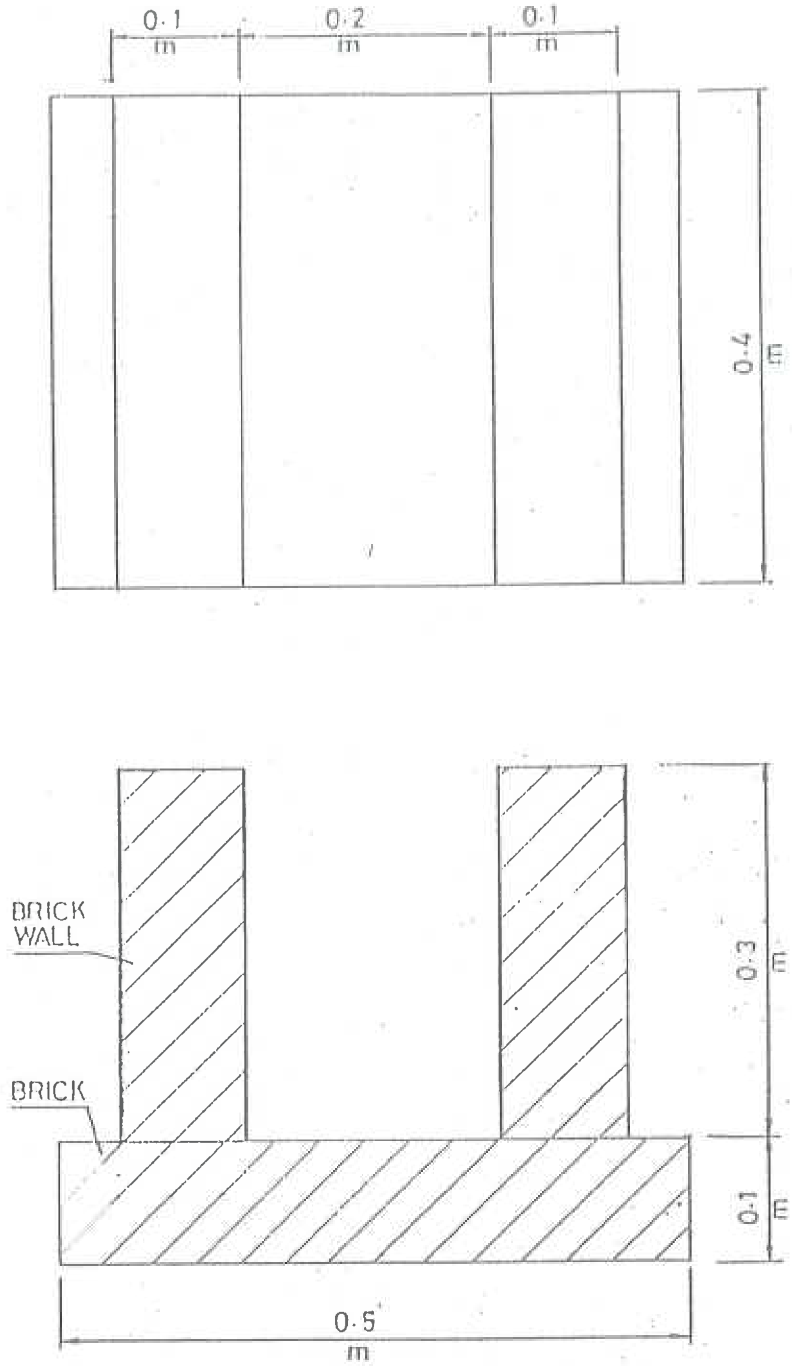


Fig.1. Concrete weir constructed for discharging excess water.

Fig.2.Dimensionless relative grain yield Vs. ponding ratio

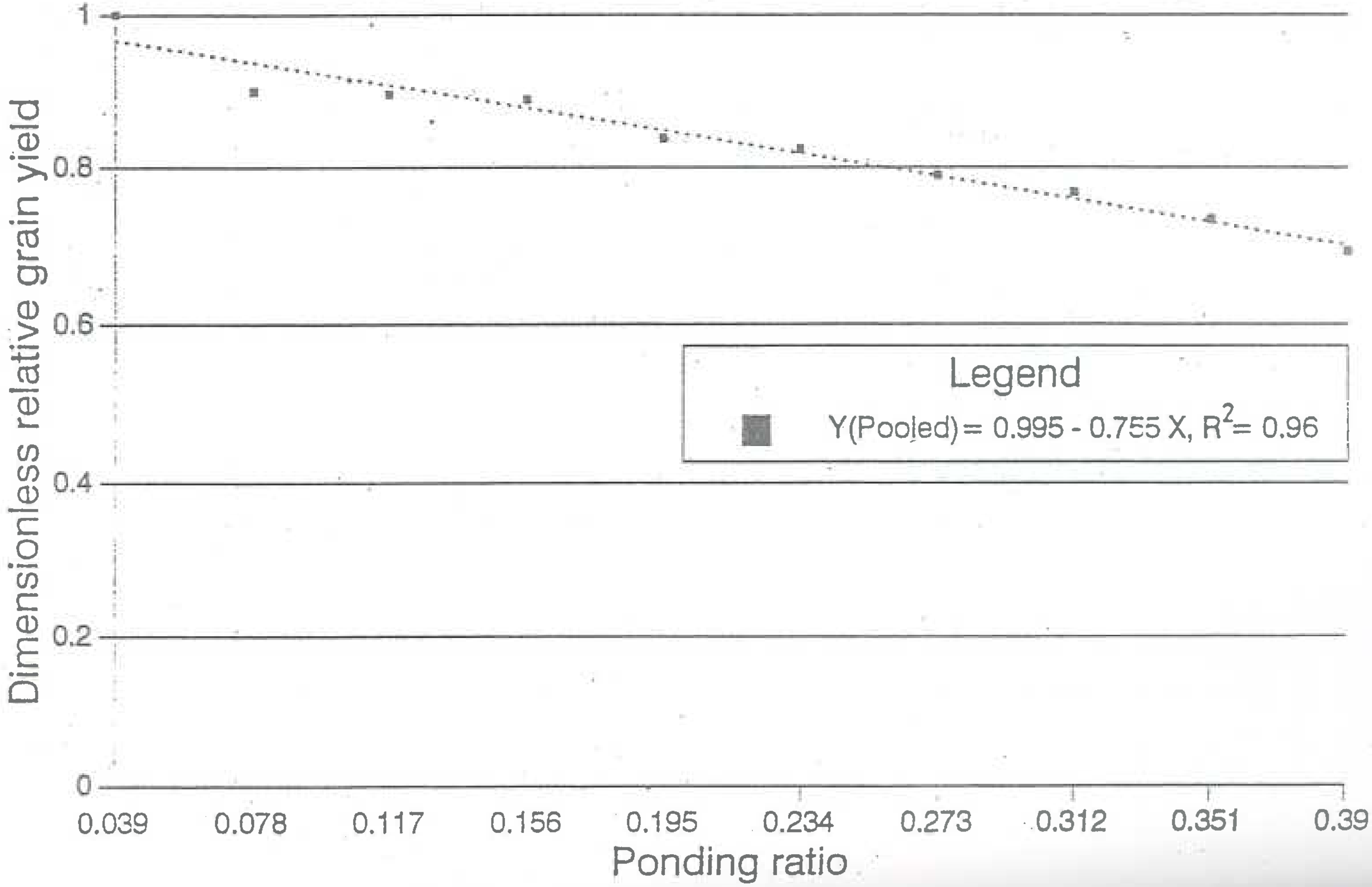


Fig.3.Dimensionless relative harvest index vs. ponding ratio

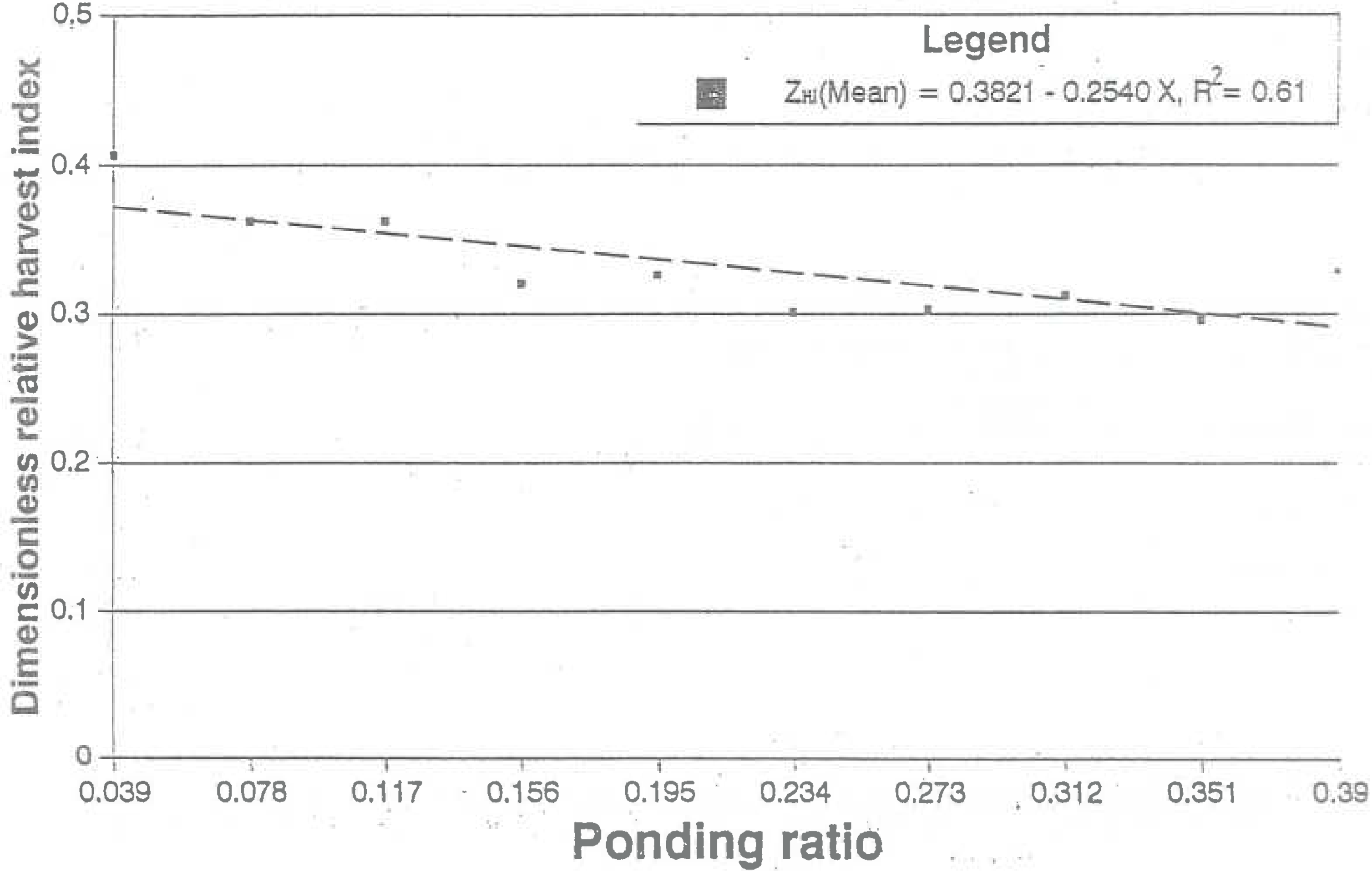


Fig.4. Dimensionless relative effecftive tillers Vs. ponding ratio

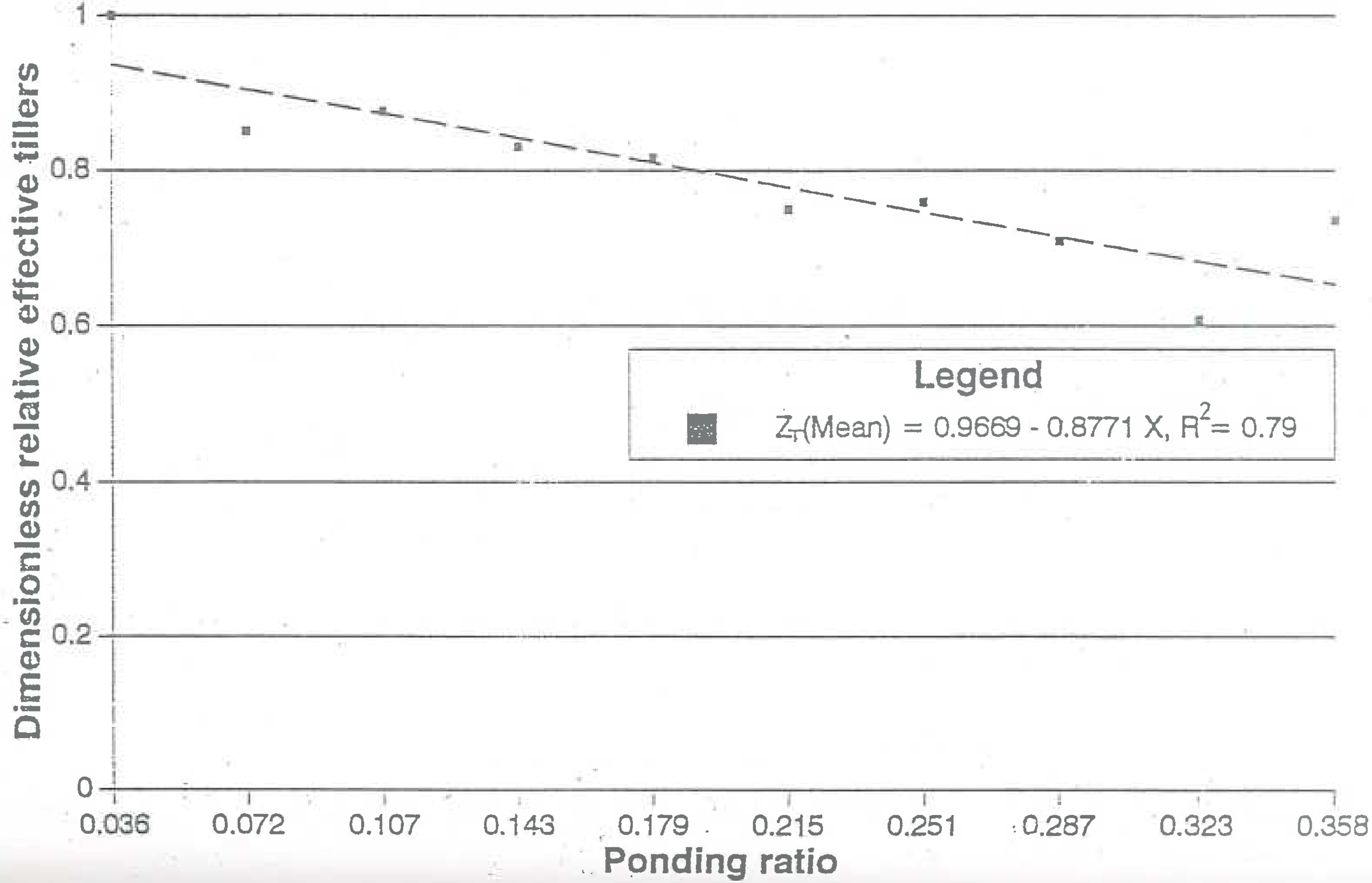


Fig. 5. Dimensionless relative chaffy grains/panicle Vs. ponded ratio

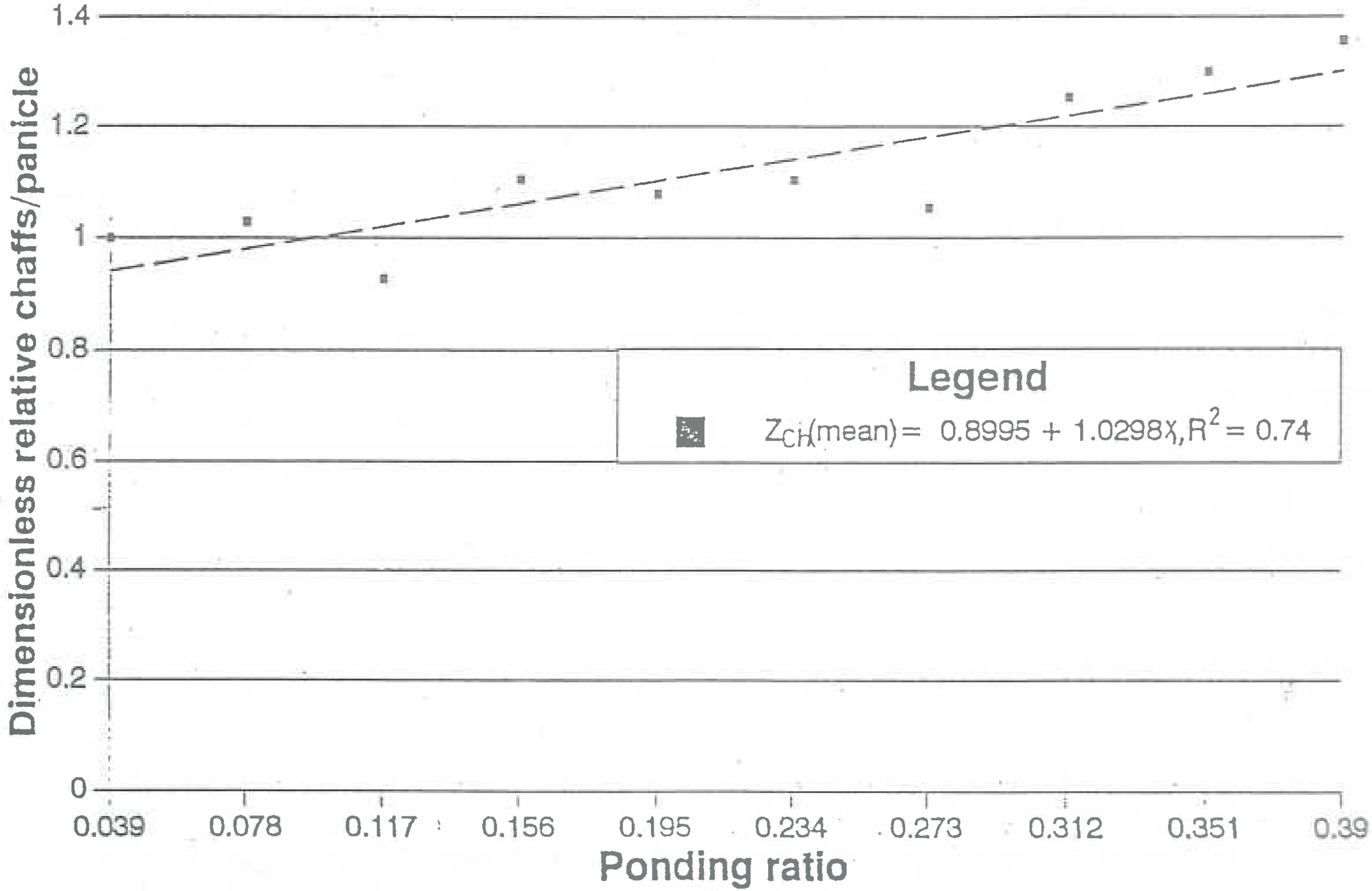


Fig.6.Dimensionless relative plant height Vs.ponding ratio

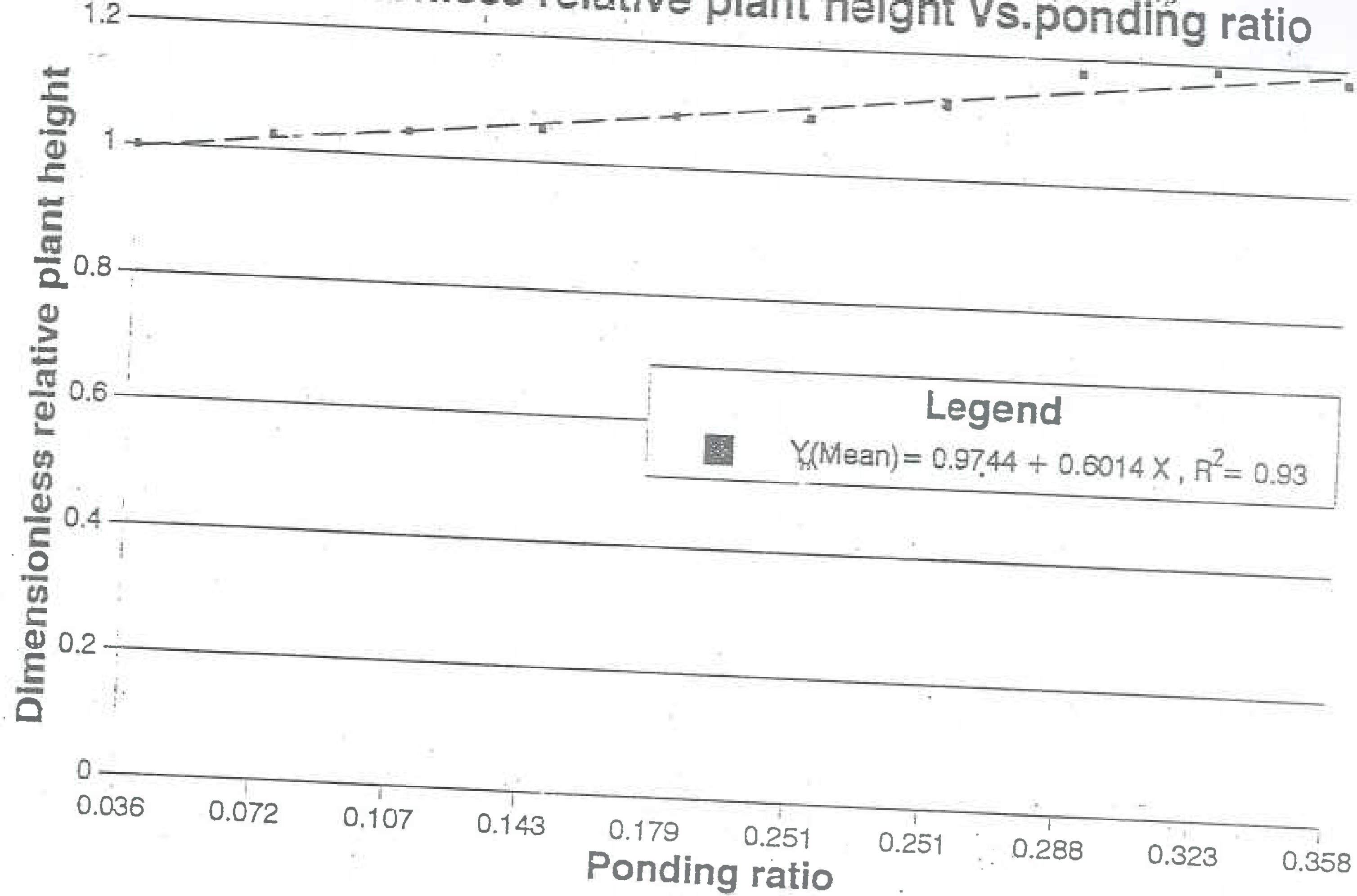


Fig.7. Dimensionless leaf area index Vs. ponding ratio

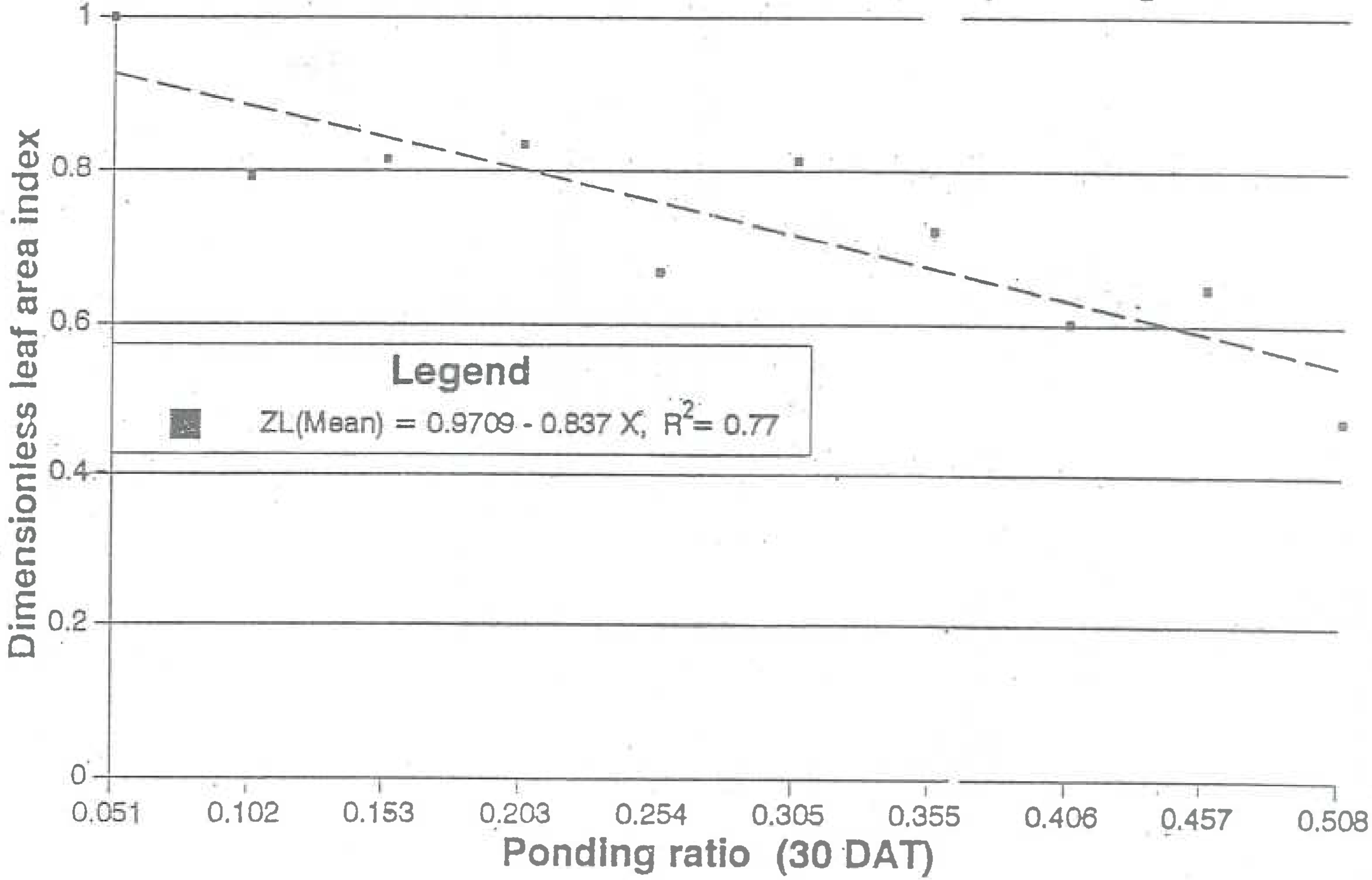


Fig 8. Water balance components of rice mm/day,1993

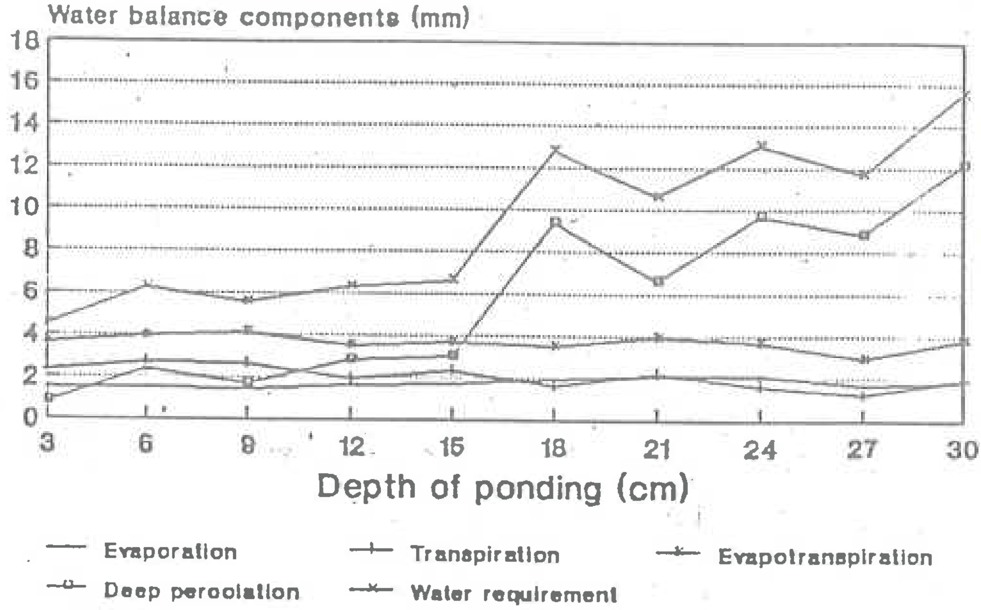


Fig 9.Water balance components of rice (mm/day) 1994

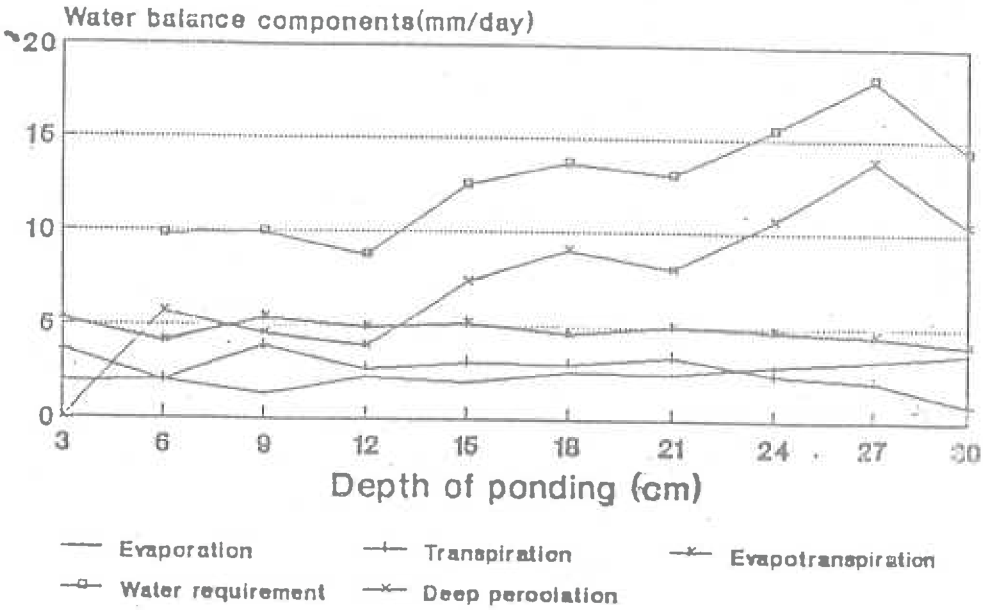
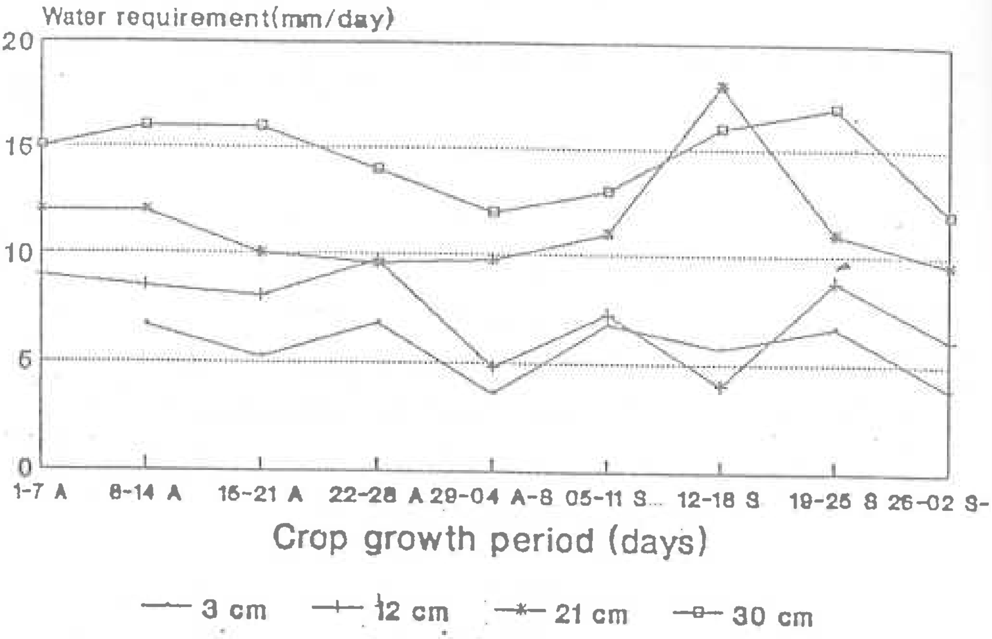
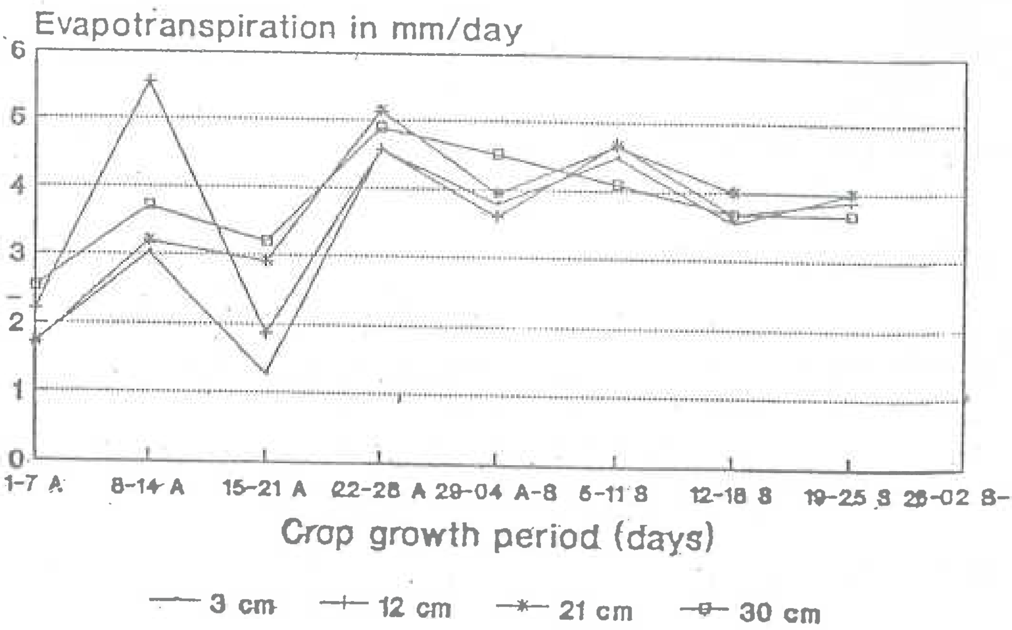


Fig 10 Progressive water requirement at different ponding depths (mm/day),1994



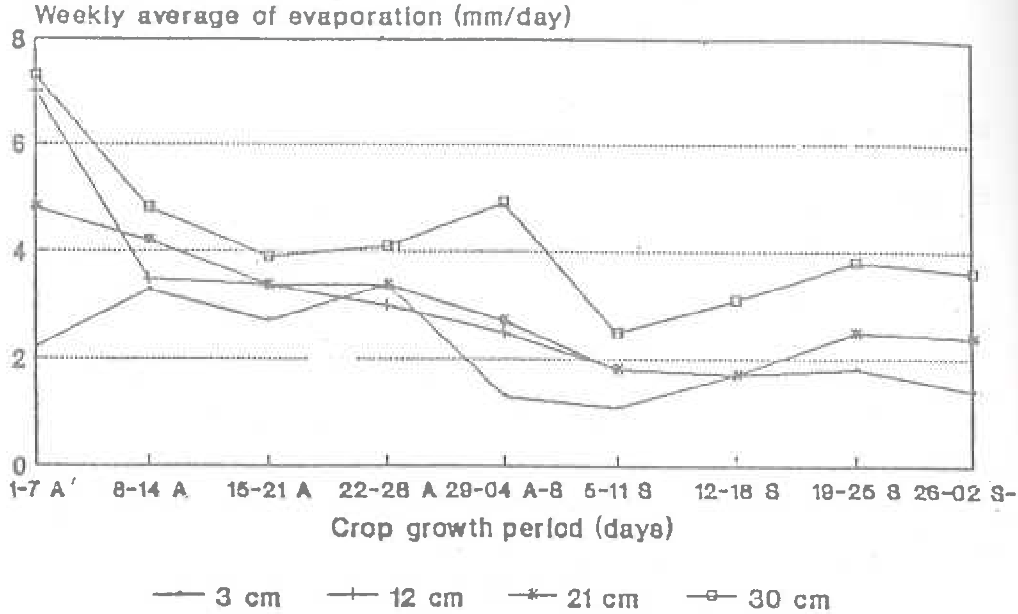
A-August, S-September, O- October

Fig 11. Evapotranspiration of rice (mm/day),1993



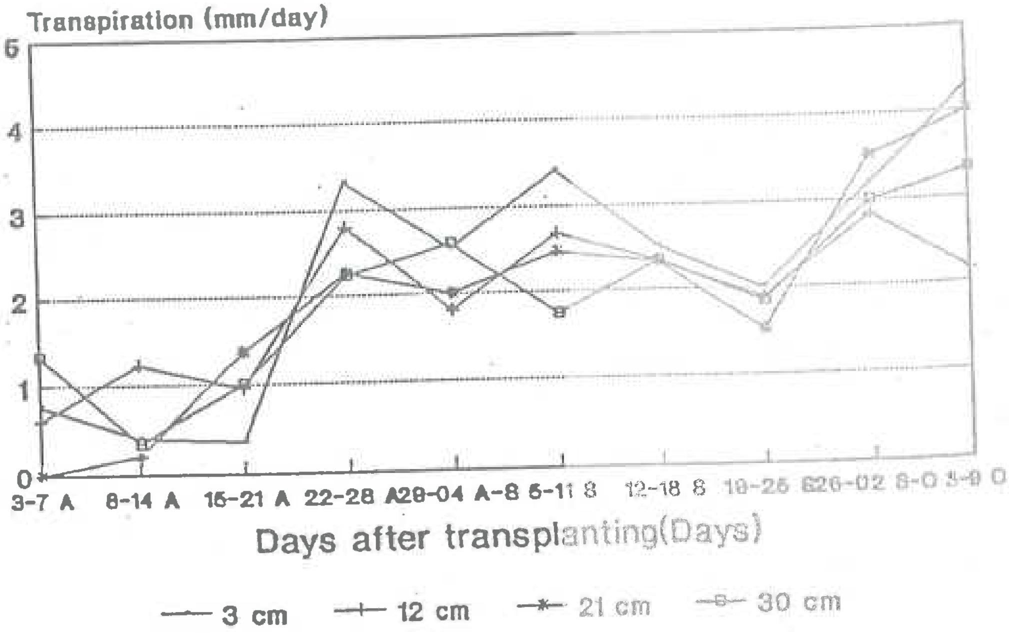
A- August S -September, O - October

Fig 12. Evaporation from rice field mm/day, 1994.



A- August, S- September, O- October

Fig 13 Progressive transpiration of rice at varying ponding depths (mm/day),1994



A- August, B- September, O- October