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MODELLING OF INFILTRATION IN PUDDLED ACIDIC SOILS

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ABSTRACT

Infiltration characteristics of *Acid alfisols* under lowland paddy cultivation at Umiam, Meghalaya were studied to examine the feasibility and adoptability of alternate puddling methods to check the exessive rate of water losses during cropping season. The effects of various puddling options viz., manual puddling, mechanical compaction of the subsoil, mechanical compaction of the subsoil plus incorporation of paddy straw/weeds on loss of water through infiltration from paddy fields and yield of transplanted paddy in lowland condition at Umiam (Meghalaya) were studied. Infiltration behaviour under unpuddled field and manual puddling matched closely whereas, the infiltration behaviour under compeaction of subsoil layer and compaction of subsoil plus paddy straw / weed incorporation matched each other closely. It was observed that these treatments follow two distinct groups. the instantaneous infiltration and infiltration capacities in the treatments with mechanical compaction were observed to be 0.75 and 0.02 cm/min respectively. For rest of the two treatments these were observed to be 0.95 and 0.4 cm/min respectively. The result showed that there were significant differences in rice grain and straw yields among various treatments over control at five per cent level. the mechanical compaction of subsoil proved to be the best treatment (puddling option) to check the rate of infiltration from paddy fields whereas incorporation of paddy straw/weed@10t/ha along with the subsoil compaction yielded maximum in terms of grain.

INTRODUCTION

Although the North Eastern Region (NER) of India experiences high to very high rainfall during the monsoon season yet due to the excessive loses of water due to infiltration influences the crop yields especially if the short spells of rainless periods coincide with the most sensitive growth stages of crop which is quite possible. In order to avoid this, it is highly desirable that the appropriate level of standing water is always maintained so as to provided sufficient moisture to crop when water is required most. Checking the infiltration by the way of puddling is the most common method of achieving this.

Rice is one of the main crops of NER of India. In the region the altitude varies from 500 to > 3000 m above mean sea level. the topography of the region is highly rugged. The climate of the region ranges from subtropical plains to temperate hills with average annual rainfall varying form 1000 to 4000 mm and temperature ranges from below 0 °C to above 38°C. The various soil groups are Alfisols, Entisols, Inseptisols, Moillisols and Ultisols. These factors have been listed to substantiate the claim that the region has very good potential for rice production.The region has got rich diversity of local germ plasm. But the productivity and production of the rice is quite low resulting into a lower per capita consumption as well.

Many workers in the past have already emphasised the effectiveness of puddling in reducing the infiltration losses from the paddy fields vis-a-vis the increase in the production (Aggarwal, *et al* (1997), Ringrose-Voase *et al* (1996), Sanchez (1973), Saroch and Thakur (1991), Singh *et al* (1991) and Wopereis *et al* (1992). The present study was therefore, conducted with a view to compare and quantify the effect of various puddling options viz., manual puddling, mechanical compaction of the subsoil, mechanical compaction of the subsoil plus incorporation of paddy straw / weeds on the infiltration behaviour and the yield of lowland transplanted rice.

MATERIAL AND METHODS

The experiment was initiated at the experimental farm of ICAR Research Complex, Umiam (Meghalaya) in the year 1998 and continued for three rice growing seasons. The soil of the experimental plots is Acid Alfisols with soil pH of 5.3, Organic carbon 0.93, available P 9.6 mg P/kg of soil, available K 50.0 mg K/kg and sandy loam in texture. The usual crop rotation followed was Rice-Fallow-Rice. The Completely Randomised Design (CRD) in 20 sq. m plot size was adopted and 21 days old nursery of rice crop variety IET-1512 was transplanted. Treatments were replicated thrice. The normal doses of fertilizers (80 Kg N, 40 Kg P_2O_5 and 40 Kg K_2O/ha) were applied as Ammonium sulphate, SSP and MOP respectively. the plant spacing was kept as 20x20 cm.

There were four treatments viz, no puddling or unpuddled (T1), manual puddling (T2), mechanical compaction of the subsoil (T3) and mechanical compaction of the subsoil plus incorporation of paddy straw/weeds@ 10 t/ha (T4). Manual puddling was done by pressing the soil in the plots by feet. The soil layer of upper 15 cm was excavated and piled at a corner of the field while compacting the subsoil by ramming in the treatment T3 followed with spreading the top soil again before transplanting. In treatment T4 the subsoil was compacted in the same manner as in T3, then the paddy straw/weed@ 10 t/ha were also spread over the compacted soil layer before spreading the topsoil again.

A double ring infiltrometer with constant head of 15 cm was used to record the infiltration behaviour. The infiltration characteristics were recorded in the beginning of the season before transplanting and after the harvest. The average figures of these two were considered for further analysis and reported in the present study. The crop yields were recorded in terms of grain and straw yields and analysed.

RESULTS AND DISCUSSION

Infiltration behaviour as affected by various puddling methods

The infiltration behaviour of the soils as influenced by different puddling options was studied by observing the instantaneous infiltration rate (i), infiltration capacity or basic infiltration rate (ic) and the cumulative infiltration in theelapsed time of 80 min (I) (Fig. 1 and 2). The best fit curves were also drawn using theMicrosoft Excel worksheet. The infiltration behaviours under unpuddled field and manual puddling matched closely whereas, the infiltration behaviour under compaction of subsoil layer and compaction of subsoil plus paddy straw/weed incorporation @ 10 t/ha matched each other closely.

The instantaneous infiltration rate (i) in treatments T1, T2, T3, and T4 were observed to be 0.95, 0.845, 0.6 and 0.75 cm/.min. respectively. It is evident from the initial infiltration values that the infiltration losses were maximum in the unpudled fields followed by manual puddling, mechanical compaction of subsoilplus weed/ straw incorporation @ 10t/ha and mechanical compaction of subsoil. Incorporation of straw/weed over compacted subsoil resulted in slightly increased infiltration. This may be attributed to the possibility of water losses through porous spaces between biomass and soil.

The infiltration capacity or basic infiltration rate (ic) in T1, T2, T3, and T4 were observed to be 0.35, 0.34, 0.035 and 0.02 cm/min respectively. The basic infiltration rate was least in treatment with mechanical compaction of subsoil plus paddy straw/ weed incorporation followed by only mechanical compaction of subsoil followed by manual puddling and no puddling. The paddy straw/weed might have acted as a filter for fine soil particles over the elapsed time by the way of blocking all the finer pores through which the water would have infiltrated rapidly in the beginning. (Table 1).

Table 1 Fitted equations for infiltration rate

Treatments	Equations	R^2
Unpuddled (B.T.)	$i = 1.2354t^{-0.2773}$	0.9830
Unpuddled (A.H.)	$i = 1.1209t^{-0.2636}$	0.9698
Manual puddling (B.T.)	$i = 6.0094t^{-0.4733}$	0.9224
Manual puddling (A.H.)	$i = 0.8282t^{-0.0065}$	0.9803
Mechanical compaction of sub-soil (B.T.)	$i = 0.6775t^{-0.2052}$	0.9496
Mechanical compactionof sub-soil (A.H.)	$i = 0.6526t^{-0.1958}$	0.9628
Mechanical compactionof sub-soil & weed/paddy Straw incorporation (B.T.)	$i = 2.3627t^{-1.0549}$	0.9126
Mechanical compaction of sub-soil & weed/paddy straw incorporation (A.H.)	$i = 2.3627t^{1.0549}$	0.9126

Note : B. T. = Before Transplant, A. H. = After Harvest

The cumulative infiltration losses in 80 min elapsed time were 31.74, 30.655, 7.05 and 7.125 cm in T1, T2, T3, and T4 respectively. It is noticeable that in the first two treatments the cumulative infiltration was approximately four times to that of other two treatments. Also, the cumulative infiltration from the paddy straw/weed incorporated and mechanical compaction of subsoil was slightly higher than only the mechanically compacted subsoil layer.

It was observed that these treatments followed two distinct groups where the instantaneous infiltration rates and infiltration capacities varied from 0.845 to 0.95 cm/min and 0.35 to 0.34 cm/min respectively for group one comprising of treatment T1 and T2; and from 0.6 to 0.75 cm/min and 0.035 to 0.02 cm/min respectivley for second group consisting the treatment T3 and T4. Thus, the treatment in which only mechanical compaction of the subsoil layer was done emerged as the best puddling option compared to other three as for as the effectiveness to check the infiltration losses is concerned. An impervious layer might have been formed by depositionof finer soil particles over the biomass incorporated resulting in minimal basic infiltration rate as compared to the other treatments. (Table 2).

Table 2 Fitted equations for cumulative infiltration

Treatments	Equations	R^2
unpuddled (B.T.)	$I = 1.3551\ t^{0.7645}$	0.9984
Unpuddled (A.H.)	$I = 1.1603\ t^{0.7896}$	0.9971
Manual puddling (B.T.)	$I = 6.0684\ t^{0.6636}$	0.9836
Manual puddling (A.H.)	$I = 0.8627\ t^{0.4102}$	0.9473
Mechanical compaction of sub-soil (B.T.)	$I = 0.7602\ t^{0.7868}$	0.9977
Mechanical compaction of sub-soil (A.H.)	$I = 0.7468t^{0.7909}$	0.9983
Mechanical compaction of sub-soil & weed/paddy straw incorporation (B.T.)	$I = 0.6992\ t^{0.5598}$	0.9486
Mechanical compaction of sub-soil & weed/paddy straw incorporation (A.H.)	$I = 1.4738t^{0.4833}$	0.8991

where,

i = Infiltration rate, cm/min
t = Elapse time, minutes
I = Cumulative infiltration, cm
B.T. = Before Transplanting
A.H. = After Harvesting

Rice yield as influenced by varius puddling methods

The plot wise rice grain and straw yield as affected by different puddling methods have been presented in Tables 3 and 4. The mean effect of various puddling methods on rice grain as well as straw yield following the analysis of variance study has been presented in Table 3. The results showed that there were significant differences in the rice grain and straw yield of different treatments.The mechanical compaction of subsoil resulted into more straw yield followed by mechanical compaction of subsoil plus paddy straw/weed incorporation and manual puddling. But the grain yield was maximum when paddy straw/weed incorporated over compacted subsoil (Table 3).

Fig. 1: Effect of various puddling methods on Infiltration rates

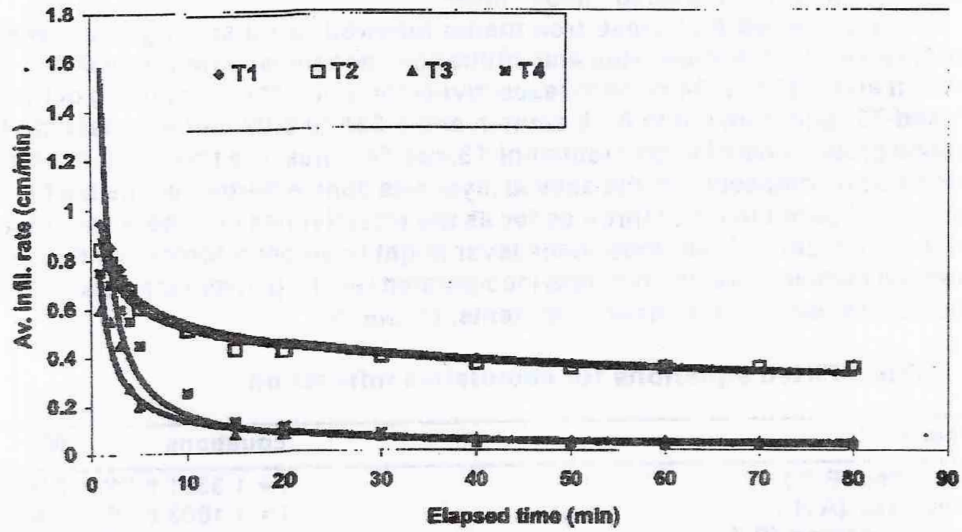

Fig. 2: Effect of various puddling methods on Cumulative infiltration

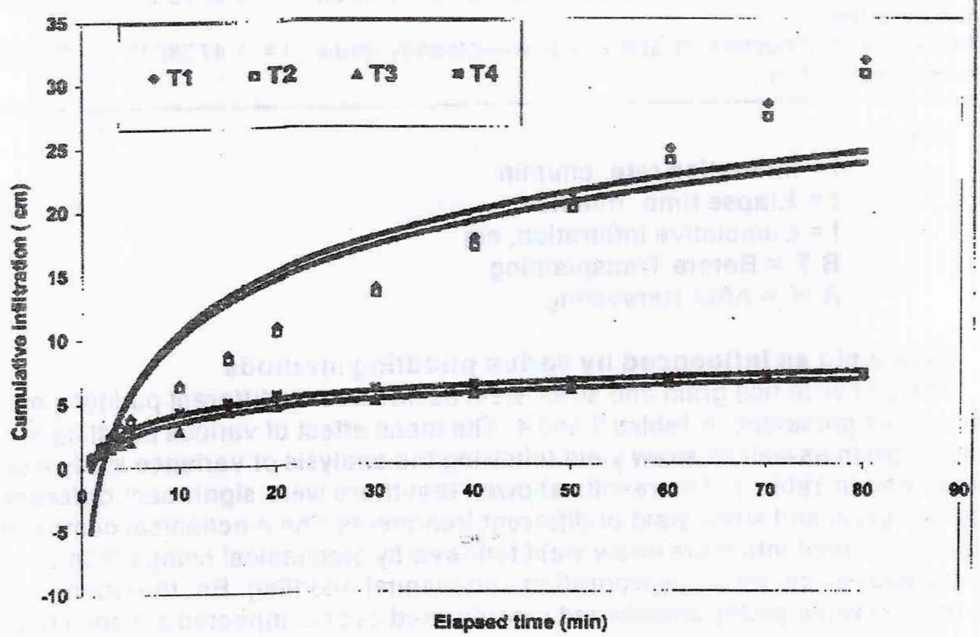

Table 3. Mean effect of various puddling methods on paddy grain/straw yield (Q/ha)

Treatments	Grain yield	Straw Yield
T1: Control	19.5	58.8
T2: Mannual Puddling	23.3	69.6
T3: Mechanical Compaction of Subsoil	31.7	78.3
T4: Mechanical Compaction of Subsoil plus incorporation of paddy straw/weed @ 10 t/ha	33.1	77.3
SEm+/-	0.5333	0.4468
C.D. 0.05	1.85	1.55

It can be inferred on the basis of the above results that the transpanted paddy, if grown using the above option of puddling may result in achieving a net increase in the productivity of about 70% of the unpuddled and approximately 40% of the manual puddling/conventional puddling. Nevertheless, it is necessary to mention here that already a hard pan develops below the normal working depth of the soil i.e. 45 cm which do restrict the infiltration downward but due to the moderate to steep gradient of narrow valley lands in hilly areas, where majority of lowland paddy is grown, the seepage losses resulting from high infiltrability of soils are rarely checked. Although, it is not possible to compact larger areas by ramming but some mechanical measures must be emplyed before transplanting the paddy in the fields other than the established methods of puddling. The small machinery for compacting the subsoil may also be employed to achieve the above purpose. By following the above procedure it is not only possible to increase the production and productivity of rice in rainfed areas but the judicious utilization of harvested rainwater can also be ensured. This will also check the ground water flow to nearby streams as well as to arest the soil erosion and other evils.

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