Effect of Sedimentation Period on Performance of Rice Transplanter

A. K. Goel, D. Behera and S. Swain

Department of Farm Machinery and Power, College of Agricultural Engineering & Technology, OUAT, Bhubaneswar-751003, India.
Email: aswinigoel@yahoo.com

ABSTRACT

Three transplanters namely OUAT, CRRI and Yanji rice transplanter were evaluated in sandy loam soil conditions with four levels of sedimentation period i.e. 24, 32, 48 and 56 hours. Transplanters were evaluated with respect to float sinkage, draft, depth of planting, floating hills, mechanical damage, buried hills, missing hills and hills mortality and the data were analyzed in accordance with split plot design of experiments. It was found that 32 hours of sedimentation period was suitable for operation of manual transplanter while the same was 56 hours for Yanji transplanter.

Keywords: Sedimentation, transplanter, float sinkage, planting depth, floating hills, buried hills, missing hills, hill mortality, India

1. INTRODUCTION

Rice (*Oryza sativa*) is one of the major cereal crop cultivated in more than 110 countries in the world with a total production of 527 million tonnes out of which 78% is contributed by major rice growing countries of Asia. India is the largest grower of rice in the world in terms of area of 44.97 million hectares with an annual production of 89.4 million tonnes at an average yield of 1990 kg./ha (Anon, 1999). However, it ranks second to China in terms of production.

Rice is grown either by direct seeding i.e. broadcasting, drilling and sowing or by transplanting. Many comparative studies have been conducted between transplanting and direct seeding. In India, it was observed that higher and more stable yield was obtained from transplanted rice than direct seeded rice. In most provinces of India, transplanted rice yielded 10 to 20 % higher than broadcast rice (Garg, *et al*, 1997). Besides, transplanting has some added advantages as compared to direct seeding i.e. better water and weed control, uniform ripening and less lodging. Also the transplanted field occupies the field lesser time than the direct seeded rice and facilitates the control of weeds effectively. In Orissa, it is observed that the yield increases by 22.2% over the direct seeding methods. It is found that in Orissa 2.24 million hectares is under broadcasting whereas 1.64 million hectares is only under transplanting. This may be due to varying socio-economic condition of the people, non-availability of labour in peak transplanting seasons and non-availability of suitable transplanting machines. Timeliness of transplanting is essential for optimizing the yield and this can only be achieved through mechanical transplanting. A delay in transplanting by one month reduces the yield by 25% and a delay of two months reduces the yield by 70% (Rao and Pradhan, 1973). Manual transplanting of paddy requires about 300-350 man-hours per ha. In spite of huge labour requirement, plant-to-plant and row-to-row spacing are not achieved and hence mechanical weeding is not possible. Optimizing plant density and timeliness of operation in paddy is considered essential for optimizing paddy yield which may be possible if dependence on hired labour is minimized (Chaudhury et al. 2005). So it is high time for mechanizing the transplanting operation. Mechanical transplanting needs a suitable transplanter and performance of the transplanter depends on nursery mats and sedimentation period. To maintain proper density of seedlings, one nursery raising device has been developed at GBPUA&T, Pantnagar which saves about 33.33 per cent labour and 72.02 per cent time over manual mat raising method (Sharma and Singh, 2004). For the operation of paddy transplanter, the soil flow caused by sinkage is the most critical factor affecting the performance of transplanter. Thus, if the desirable sinkage at which a particular transplanter work effectively is known, operator can take quick decision regarding machine operation at any time (Garg et al. 2000). The objective of this present study is to optimize the sedimentation period for proper functioning of the selected three rice transplanters for sandy loam soil.

2. MATERIALS AND METHODS

The technical specification of the three transplanters namely OUAT transplanter (T_1), CRRI transplanter (T_2) and Yanji transplanters (T_3) used for the evaluation are presented in Table 1.

Table 1. Technical specification of different transplanters used in the experiment

Sl No	Specification	OUAT transplanter	CRRI transplanter	Yanji transplanter
1	Type of machine	Manual	Manual	Power operated 2.4 kW air cooled diesel engine
2	Manufacturers address	Kalinga Engineers, Bhubaneswar	CRRI, Cuttack	Yanji Rice transplanter plant, peoples Republic of China
3	Model	Ajit	-	2ZT-238-8
4	Overall dimensions, cm			
	Length	130.0	127.0	241.0
	Width	94.5	117.0	213.1
	Height	62.5	62.0	130.0
5	Weight, kg	28.0	22.5	320.0
6	Type of float	Modulated plastic	GI sheet	Fiber glass
7	No. of rows	4	4	8
8	Row spacing, cm	20.0	24.0	23.8
9	Finger			
	Type	Fixed fork	Fixed fork	Fixed fork
	Length, mm	140	120	130
	Width, mm	11	17	10
	Gap, mm	5	11	5
10	Width of seedling gate, mm	20	14	17

2.1 Nursery Preparation

Mat type nursery was raised on a field adjacent to the experimental plot in order to minimize the transportation time. The field preparation was similar to that of conventional nursery raising and was ploughed thrice by Bose plough and leveled by planking. The field was left as such for one day and then water was drained out from the field and polythene sheet of 50 to 60 gauge of 1.0 m x 6.0 m each was spread over the leveled field keeping 50 cm gap between each bed. Polythene sheet at the rate of 60 m^2/ ha i.e. 10 numbers of such polythene sheet was used for preparation of nursery per hectare of transplanting. Then small holes were made on the polythene sheet and a prefabricated wooden frame of size 2.0 m x 1.0 m x 2.0 cm was placed over the sheet. Puddled soil was filled inside the frame from both sides of the bed in such a way that the soil was free from any stone, stubble and grass. The soil in the frame was then leveled with the help of a wooden bar. Thereafter frame was removed for further use in mat raising and the same procedure was followed. Sprouted seeds of Swarna variety at the seed rate of 45 kg/ha were spread uniformly over the mat. To protect the seeds from the birds, the mats were covered with straw. Water was sprinkled twice a day by rose cane until there was complete emergence of seedlings. After 4^{th} day the straw was removed from the mats and water was applied by flooding and standing water in the mats was maintained as in the case of conventional nursery. Transplanting was done by using 20 days old seedlings.

2.2 Field Preparation

The field was prepared with tractor-operated rotary tiller. After first rotatilling, the field was flooded with water and kept as such for 7 days and then second rotatilling was done on 8^{th} day and the field was leveled by a plank. The field was then divided and sub-divided as per the experimental design. The data obtained were analyzed using split plot design of experiments.

2.3 Transplanting

Transplanting was done by OUAT rice transplanter, CRRI rice transplanter and self propelled Yanji rice transplanter at different sedimentation period of 24, 32, 48 and 56 hours. Hill to hill spacing in Yanji rice transplanter was set at 12 cm and depth was set at 3.0 cm for entire experiment and for manually operated transplanters (OUAT and CRRI) care was taken to maintain 10 to 12 cm hill-to-hill spacing. The mat nursery was cut as per the tray size of the respective transplanter.

2.4 Design of Experiments

The experiments were conducted using split- plot design. The main-plots were three different transplanters namely OUAT transplanter (T_1), CRRI transplanter (T_2) and Yanji transplanter (T_3) while the sub-plots were the sedimentation period such as 24, 32, 48 and 56 hours. Each treatment was replicated thrice.

3. RESULTS AND DISCUSSION

The performance of the selected three transplanters with respect to various sedimentation periods are presented in Figure 1 to 8. The ANOVA of the dependant parameters are presented in Table 2 and 3.

3.1 Float Sinkage

The average float sinkage was observed to vary between 0.44 to 2.42 cm for OUAT transplanter (T_1), 0.49 to 2.58 cm for CRRI transplanter (T_2) and 0.98 to 4.65 cm for Yanji transplanter (T_3) under the sedimentation period ranging from 24 to 56 hours as shown in Figure 1. The results indicated that as the sedimentation period increased, the float sinkage decreased for all the transplanters under study. The float sinkage decreased sharply for T_1 and T_2 as the sedimentation period increased from 24 to 32 hours but it showed a gradual decrease under T_3. When sedimentation period increased from 32 to 48 hours, float sinkage decreased gradually for T_1 and T_2 but it decreased sharply for T_3. The float sinkage values did not change appreciably for the sedimentation period from 48 to 56 hours. The reason of higher sinkage at a lower sedimentation period (24 hours) may be due to partial settlement of soil particles and loose condition of soil while a gradual decrease at a higher sedimentation period is due to increase in hardness of soil surface. This hardness of soil could sustain the float pressure of the transplanters resulting in lower sinkage. Transplanter T_3 showed a higher sinkage than other transplanters for all the sedimentation period and this may be due to its higher float contact pressure of 16.42 g/cm^2. At 32 hours sedimentation period, the sinkage of float was found to be within 1 to 2 cm for T_1 and T_2 while the same values were observed at 48 hours for T_3. Studies with rice transplanters conducted at Punjab Agricultural University (PAU), Ludhiana indicated that transplanting should be done neither in too soft nor in hard soil. It was further reported that float sinkage less than 1.0 cm signifies hard field condition, which might pose problem in penetration of transplanting fingers into puddled soil (Garg *et al*, 1997**).** As float sinkage of higher than 2.0 cm is an indicator of soft soil, transplanting may be done at a float sinkage in between 1 to 2 cm. The float sinkage of more than 2.0 cm observed for all the transplanters at 24 hours sedimentation period indicated that it was too soft for transplanting. The float sinkage of less than 1.0 cm observed for T_1 and T_2 at 48 and 56 hours sedimentation period indicated that it was hard for transplanting with these transplanters. However for T_3, the float sinkage of more than 2.0 cm was observed at 24 and 32 hours sedimentation period and less than 1.0 cm at highest sedimentation period of 56 hours. If float sinkage with respect to sedimentation period is considered as a yardstick for selecting optimum period for transplanting, it may be said that T_1 and T_2 require 32 hours sedimentation period while T_3 requires 48 hours sedimentation period for transplanting.

The effects of transplanters and sedimentation period on float sinkage were found to be highly significant as shown in Table 2. The interaction of transplanters and sedimentation period on float sinkage was also highly significant.

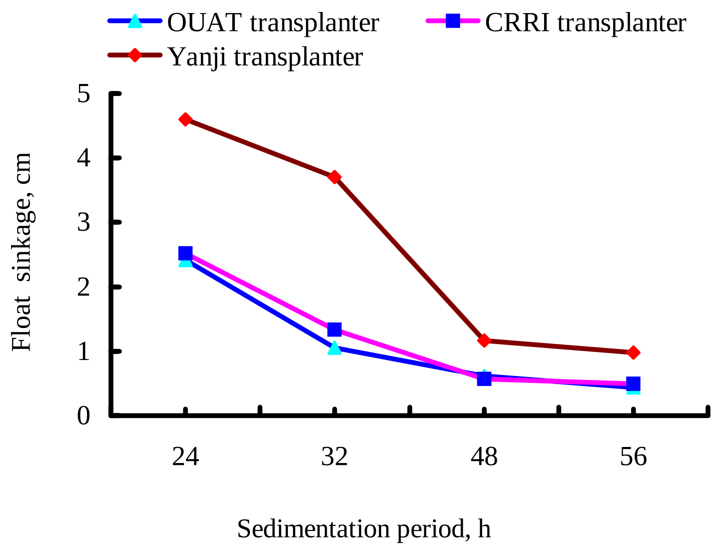

Figure 1. Effect of sedimentation period on float sinkage.

3.2 Draft Requirement of Transplanters

The mean draft of T_1 was observed to be varied from 16.31 to 18.91 kgf for soil sedimentation period between 24 to 56 hours. The drafts were in the range of 12.95 to 16.79 and 65.06 to 73.54 kgf for T_2 and T_3 respectively for the same sedimentation period as shown in Figure 2. The draft requirement of all the transplanters increased with increase in sedimentation period. Draft requirement of transplanter was attributed mainly due to bulldozing of soil due to float sinkage and friction between the soil and the float. In sandy loam soil (sand: 75.8 %), the frictional effect is more dominant than the bulldozing action of the soil. At lower sedimentation period, though the sinkage was more, the lubricating effect of soil off set the draft requirement due to bulldozing effects of soil. The lubricating effects of soil decreased with increase in sedimentation period. Therefore, with increase in soil sedimentation period from 24 to 56 hours, though the sinkage decreased, the frictional resistance increased due to hardness of soil interface. This increase in frictional resistance almost off set the decrease in draft due to reduced sinkage and hence an increase in draft was observed with increase in sedimentation period. The reduction in sinkage was relatively lower when the soil sedimentation period increased from 32 to 56 hours but the frictional resistance continued to increase causing an increase in draft. Evaluation of transplanters at PAU, Ludhiana with different sedimentation period indicated similar results (Garg, *et al*., 1997).

The effects of transplanters as well as the sedimentation period on the draft requirement were observed to be highly significant. The interaction of transplanters and sedimentation period on draft requirement was also found to be highly significant as shown in Table 2.

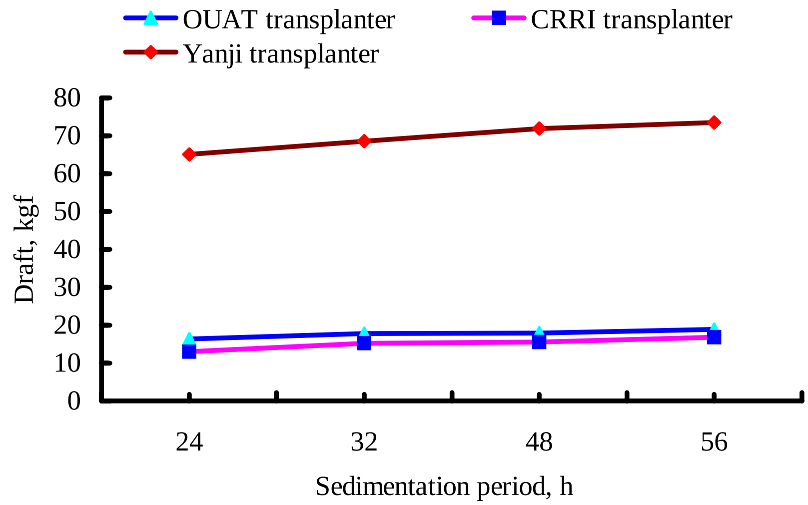

Figure 2. Effect of sedimentation period on draft.

3.3 Depth of Transplanting

The depth of planting obtained with selected transplanters at four levels of sedimentation period were found to be in the range of 2.88 to 5.04, 3.05 to 6.16 and 4.00 to 8.69 cm for treatments T_1, T_2 and T_3 respectively at different sedimentation period of 24, 32, 48 and 56 hours as shown in Figure 3. It was found that the depth of planting decreased with increase in sedimentation period for all the transplanters. This was attributed due to decrease in sinkage of float with increase in sedimentation period. As depth of planting has significant effect on floating hills, desired depth of planting is very important during operation of a transplanter (Dewangan et al. 2005).The desired depth of planting of 3 to 4 cm was observed with T_1 at sedimentation period of 32 and 48 hours while for T_2 it was observed at 48 and 56 hours and for T_3 at 56 hours. The higher depth of planting in case of T_3 was due to its higher sinkage in all the four levels of sedimentation period as compared to other transplanters.

It was found that the effects of transplanters and sedimentation period on depth of planting are highly significant and their interaction on depth of planting was also found to be highly significant as shown in Table 2.

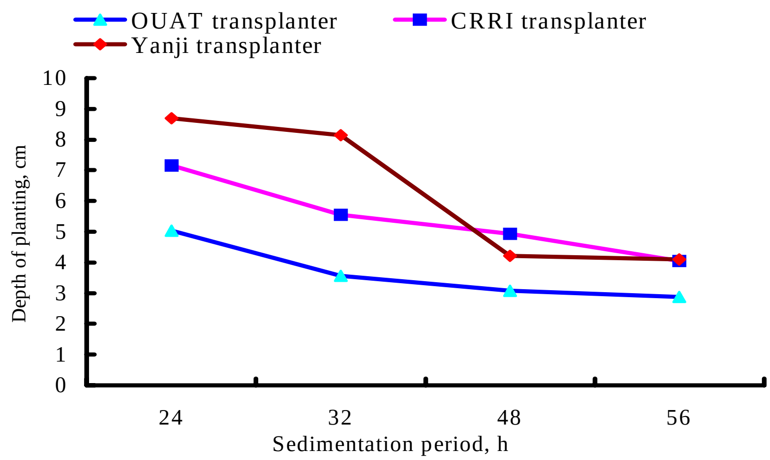

Figure 3. Effect of sedimentation period on depth of planting.

3.4 Floating Hills

The percentage of floating hills varied between 0.80 to 2.84, 1.46 to 3.62 and 0.57 to 2.14 for treatments T_1, T_2 and T_3 respectively at 4 levels of sedimentation period varying from 24 to 56 hours as shown in Figure 4. It was found that the percentage of floating hills decreased with increase in sedimentation period from 24 to 32 hours and then increased with increase in sedimentation period from 32 to 56 hours. The higher floating hills in lower sedimentation period may be due to poor anchorage of seedlings in soft soil and movement of puddled soil and water along with the float. A study conducted at GBPU&T, Pantnagar obtained the similar results (Behera et al. 2007). The minimum percentage of floating hills 0.57 to 1.46 per cent was observed at 32 hours of sedimentation period for all the transplanters. This may be due to proper anchorage of seedlings with soil and less flow of puddled soil and water with the float at this sedimentation period. As the sedimentation period increased the soil hardness increased and it could not provide proper anchorage and gripping force to seedlings resulting higher floating hills in sedimentation period beyond 32 hours.

It was found that the effects of transplanters as well as the sedimentation period on the percentage of floating hills were highly significant while their interaction was insignificant as shown in Table 2.

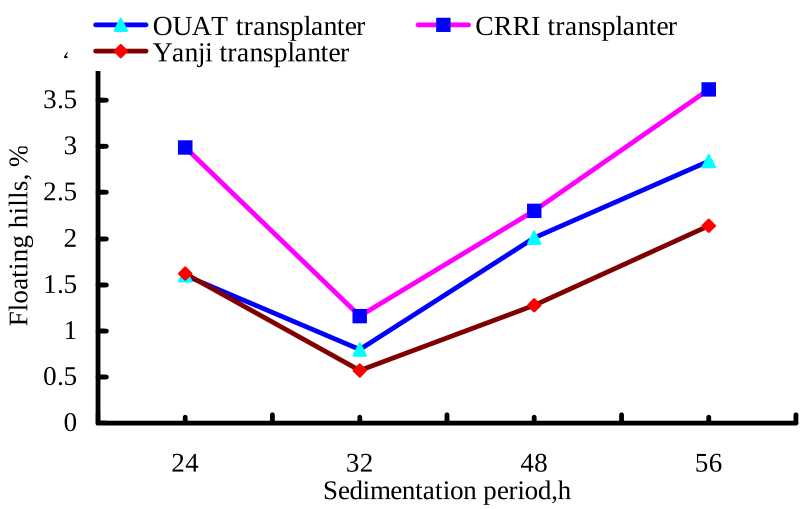

Figure 4. Effect of sedimentation period on floating hills.

Table 2. ANOVA of float sinkage, draft, planting depth and floating hills

Sources of variation	Degrees of freedom	F_{cal}			
		Float sinkage	Draft	Planting depth	Floating hills
Replication	2	0.00273	1.081	0.865	1.180
Main-plot	2	576.126 **	29133.68 **	4354.764 **	55.422 **
Sub- plot	3	238.876 **	72.941 **	1980.501 **	47.513 **
Interaction	6	20.110 **	11.573 **	253.686 **	1.792

** Significant at 0.01 level

3.5 Mechanical Damaged Hills

The mean percentage of damaged hills varied from 0.34 to 0.94 for T_1, 3.25 to 5.32 for T_2 and 3.86 to 5.18 for T_3 under different sedimentation period under study as shown in Figure 5. The minimum damaged hills was observed at 32 hours sedimentation period and it then increased with increase in sedimentation period from 32 to 56 hours in all the treatments. The highest mechanical damage was observed at lowest sedimentation period of 24 hours in all the treatments. It was observed that at lower and higher sedimentation period the seedlings were not released from the fingers due to inadequate soil anchorage and stuck in the fingers and get damaged in subsequent strokes of the fingers.

The effects of transplanters as well as sedimentation period on mechanical damaged hills were highly significant. The interaction of transplanters and sedimentation period on mechanical damaged hills was found to be significant at 5 per cent level of significance as shown in Table 3.

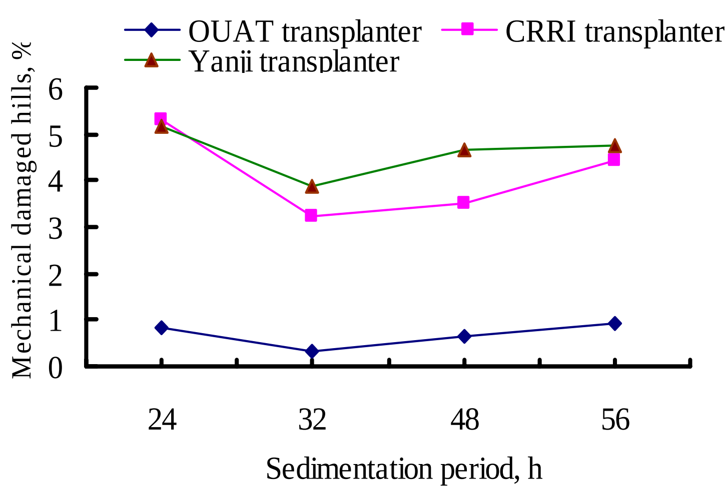

Figure 5. Effect of sedimentation period on mechanical damaged hills.

3.6 Buried Hills

The mean percentage of buried hills were found to be in the range of 0.10 to 4.73, 0.38 to 5.43 and 0.06 to 23.13 for treatments T_1, T_2 and T_3 respectively at different sedimentation period between 24 to 56 hours as shown in Figure 6. It was found that the percentage of buried hills decreased with increase in sedimentation period for all the transplanters. Sinkage of float is more at lower sedimentation period, which caused more amount of soil to flow along with the float. Therefore, at lower sedimentation period, more number of hills were buried under the soil due to more sinkage of float and more amount of soil flow along with the transplanter. On the other hand, at higher sedimentation period, the float sinkage was not enough to carry the puddled soil along with the float resulting in minimum buried hills. A study conducted at GBPU&T, Pantnagar obtained the similar results (Behera et al. 2007). The maximum buried hills of 4.73, 5.43 and 23.13 per cent were observed with T_1, T_2 and T_3 respectively at lowest sedimentation period of 24 hours. This higher percentage of buried hills was mainly due to the flow of soil on both sides due to sinkage of float. The buried hills gradually decreased from 1.47 to 0.10 in T_1, 4.03 to 0.38 in T_2 and 18.29 to 0.06 percent in T_3 with increase in sedimentation period from 32 to 56 hours. This result is in accordance with the studies conducted by Singh *et al.,* 1981**.**

The effects of transplanters as well as sedimentation period on percentage of buried hills were highly significant. The reason may be due to the fact that different transplanters have different float contact pressure at various sedimentation periods. The interaction of transplanters and sedimentation period on buried hills was also found to be highly significant as shown in Table 3.

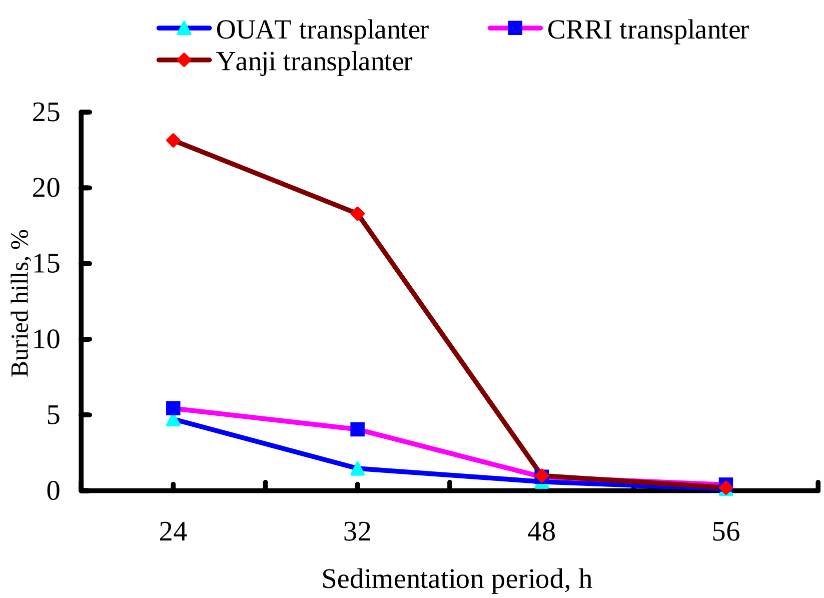

Figure 6. Effect of sedimentation period on buried hills.

3.7 Missing Hills

The percentage of missing hills was found to be varied from 4.92 to 8.71 for T_1, 7.07 to 9.17 for T_2 and 5.50 to 11.31 for T_3 in different sedimentation period as shown in Figure 7. The minimum missing hills were observed at 32 hours sedimentation period for all the transplanters. The highest missing hills were observed at lowest sedimentation period of 24 hours in all the transplanters. This may be due to the reason that at lower sedimentation period many seedlings were not released from the fingers due to insufficient soil griping force. So, these seedlings stuck in the fingers causing excessive missing hills. Evaluation of a Korean rice transplanter in Pakistan and a manual rice transplanter at AIT, Bangkok exhibited the similar results (Khan *et al.*, 1979 and Singh *et al*, 1981). The missing hills were observed to increase as sedimentation period increased from 32 to 56 hours for all the transplanters. This may be due to the reason that, with increase in sedimentation period, the soil hardness increased and the griping ability of puddled soil bed reduced.

The effects of transplanters on missing hills was significant at 5 % level of significance where as the effect of sedimentation period and the interaction between transplanters and sedimentation period on missing hills are highly significant as shown in Table 3.

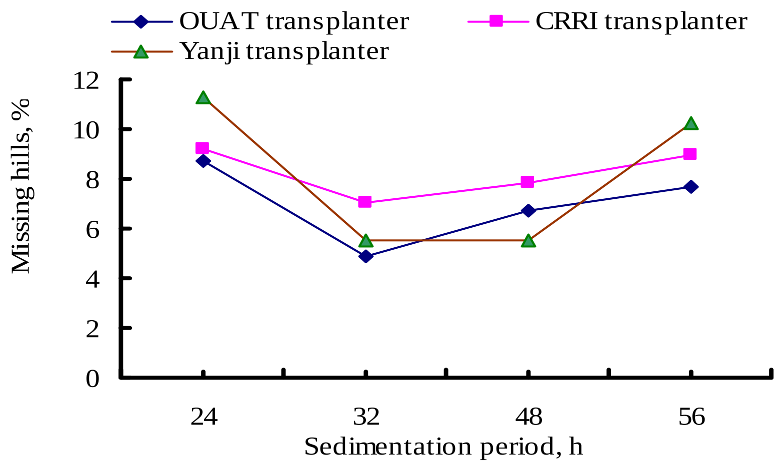

Figure 7. Effect of sedimentation period on missing hills.

3.8 Mortality of Hills

The mean percentage of hill mortality was found to vary from 3.12 to 8.11, 7.32 to 15.38 and 4.74 to 32.61 in treatments T_1, T_2 and T_3 respectively at the sedimentation period between 24 to 56 hours as shown in Figure 8. The minimum mortality of 3.12 and 7.32 per cent were observed for T_1 and T_2 at 32 hours of sedimentation period while the minimum mortality of 4.74 per cent was observed with T_3 at 48 hours of sedimentation period. The highest mortality of hills was observed at lowest sedimentation period of 24 hours with all the transplanters. This may be due to the fact that, more number of hills was buried under the soil at 24 hours sedimentation period because of more height of soil flow. The lowest percentage of hill mortality was observed at sedimentation period of 32 hours in T_1 and T_2 and at 48 hours in T_3 because of less number of unproductive hills caused by the transplanters at these sedimentation period. A higher percentage of hill mortality at sedimentation period of 56 hours was observed for all the transplanters and this may be due to higher percentage of unproductive hills (missing + floating + buried + mechanical damaged hills) at this sedimentation period. It was observed that, in some cases, the mortality of hills is less than the total buried, floating and damaged hills. This may be due to survival of some of the buried and damaged hills. Evaluation of a self-propelled rice transplanter at GBPUAT, Pantnagar with different sedimentation period has shown the similar results (Behera *et al*, 2001).

The transplanters as well as sedimentation period have significant effect on the mortality of hills. The interaction of transplanters and sedimentation period on the mortality of hills was also highly significant as shown in Table 3.

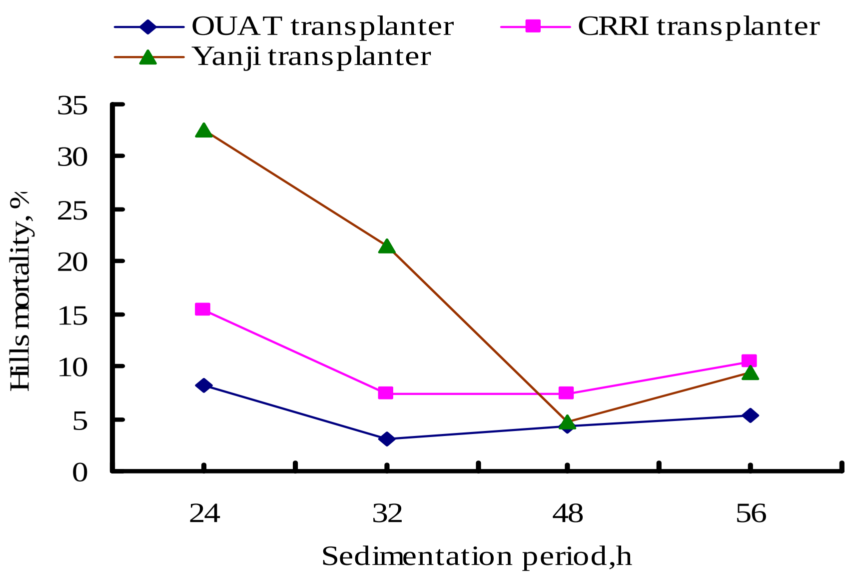

Figure 8. Effect of sedimentation period on mortality of hills.

Table 3. ANOVA of mechanical damage, buried hills, missing hills and hill mortality

Sources of variation	Degrees of freedom	F_{cal}			
		Mechanical damage	Buried hills	Missing hills	Hill mortality
Replication	2	6.266	0.521	0.263	0.633
Main-plot	2	512.811 **	167.309 **	8.823 *	531.951 **
Sub- plot	3	10.174 **	324.630 **	34.646 **	146.671 **
Interaction	6	2.964 *	120.137 **	41.786 **	60.155 **

* Significant at 0.05 level ** Significant at 0.01 level

4. CONCLUSIONS

The following conclusions were drawn from the studies on effect of sedimentation period on the performance of rice transplanters.

- Float sinkage decreased as sedimentation period increased for all selected transplanters studied.
- The draft requirement of transplanters increased with increase in sedimentation period for all the transplanters under study.
- The desired depth of planting of 3 to 4 cm was achieved with OUAT transplanter at 32 and 48 hours sedimentation period while the same was observed under CRRI transplanter at 48 and 56 hours sedimentation period. But a depth of 4 cm was recorded under Yanji transplanter at 56 hours sedimentation period.
- The minimum percentage of floating, mechanical damaged and missing hills were recorded at 32 hours sedimentation period for all the transplanters studied.
- The percentage of buried hills decreased with increase in sedimentation period in all the treatments.
- The minimum mortality of hills was 3.12 per cent for OUAT transplanter and 7.32 per cent for CRRI transplanter at 32 hours sedimentation period while the same was 4.74 per cent for Yanji transplanter at 48 hours sedimentation period.

Hence, it is concluded that in sandy loam soil, 32 hours sedimentation period is most suitable for operating manual rice transplanters while a sedimentation period of 48 hours is suitable for operation of self propelled rice transplanter.

5. ACKNOWLEDGEMENT

The authors are thankful to the Dean, College of Agricultural Engineering and Technology, Orissa University of Agriculture and Technology, Bhubaneswar for providing the facilities to carryout the experiments.

6. REFERENCES

Anonymous, 1999. FAO Production Year Book, Vol. 53

Behera, B. K., B. P. Varshney, T. N Mishra and B. Singh. 2001. Studies on drag force of a transplanter at different sedimentation period, Paper presented at the 35th ISAE convention held at OUAT, Bhubaneswar during 22-24 January.

Behera, B. K., B. P. Varshney and S. Swain. 2007. Ground contact pressure and soil sedimentation period affecting transplanter sinkage and its performance. *Agricultural Mechanization in Asia, Africa and Latin America* Vol. 38, No.1Winter: 29-33.

Chaudhury, V.P.; B.P.Varshney and S.K.Singh. 2005. Self propelled rice transplanter- A better alternative than manual transplanting, Agricultural Engineering Today, Vol. 29(5-6): 32-37

Dewangan, K.N.; E.V.Thomas and B.C.Ghosh. 2005. Performance evaluation of a laboratory model rice transplanter, Agricultural Engineering Today, Vol. 29(5-6): 38-45.

Garg, I. K., V. K. Sharma and J. S. Mahal. 1997. Development and field evaluation of manually operated six-row paddy transplanter. *Agricultural Mechanization in Asia, Africa and Latin America* 28(4): 21-28.

Garg, I.K.; V,K,Mital and V.K.Sharma. 2000. Effect of ground contact pressure and soil settlement period on paddy transplanter sinkage, Journal of Agricultural Engineering, Vol. 37(1): 65-70.

Goel, A. K. 2003. Evaluation of rice transplanters for adoption in Orissa. Unpublished Ph.D. thesis, Utkal University, Bhubaneswar.

Khan, A., A. Sakur, A. D Chaudhury and F.M. Chaudhury. 1979. Modification and testing of Korean paddy transplanter in Pakistan, *Agricultural Mechanization in Asia, Africa and Latin America* Winter, 79-85.

Rao, M. V. and S. N. Pradhan. 1973. Cultivation practices. Rice Production Manual, ICAR; 71-95.

Sharma, S.C. and T.P.Singh. 2004. Pantnagar developed mat type nursery raising device for rice transplanter, Agricultural Engineering Today, Vol. 28(1-2): 70-71

Singh, A., D. Gee-Clough and G. Singh. 1981. Field performance and evaluation of a paddy transplanter. *Agricultural Mechanization in Asia, Africa and Latin America* Spring: 23-30.