VEGETATION SEEDS SETTLING PATTERN ON ALTERNATE SANDBARS IN A STRAIGHT CHANNEL AND THE EFFECT ON RIVER BED MORPHOLOGY

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The objective of this study is to observe the characteristics of hydrochory seeds transported by running water on bare sandbars, and to confirm the differences of bed morphology change without vegetation and with vegetation patches on sandbars by means of laboratory experiments. In the experiments, after sandbars were formed, enough amounts of alfalfa seeds were supplied from the inlet section of the flume. The result showed that seeds did not settle at all on sandbars under a constant discharge. On the other hand, alfalfa seeds settled significantly at the front edge of sandbars during the recession stage of the discharge. In addition, alfalfa seeds were settled at the same location on sandbars after alfalfa seeds grew up on sandbars. These results imply that invading vegetation has specific settling characteristics with making vegetation patches on sandbars.

1 INTRODUCTION

Growing vegetation on river floodplains, such as willows has been known to be strongly affected by geomorphological processes such as changing multi-thread braiding rivers to single-thread meandering rivers due to stabilizing river banks [1-3]. In recent years, several researches have reported the characteristics of riverbed morphodynamics on dynamic vegetation effects using numerical models [4]. However, there is limited knowledge regarding the initial step of the vegetation seeds settling processes on bare sandbars during floods, called hydrochory [5], and also riverbed morphodynamics caused by vegetation patches on sandbars. In the previous studies, it has been reported that the pattern of growing vegetation on river floodplains is determined by the interaction between flow and riverbed morphological pattern, and it causes significantly different riverbed morphodynamics [7]. The processes of riverbed morphology caused by growing vegetation patches have not been fully understood yet.

Here, we focused on the characteristics of hydrochory distributed seeds on alternate sandbars and riverbed morphology caused by vegetation patches by means of experimental tests. Growing vegetation on river floodplains causes problems for river management. Vegetation increases the roughness of the floodplain, which can increase the risk of flooding. In particular, pioneer species such as willows invade bare floodplains within a short period after flooding [8]. Clarifications on the characteristics of hydrochory seeds settling and the effects of vegetation patches on bare sandbars are important to control flood in rivers, for instance, such knowledge will be useful to eliminate vegetation patches efficiently before expected floods.

2 EXPERIMENTAL SETUP AND METHODS

The experiments were carried out in a rectangular experimental flume 0.15 m wide, 3.6 m long and with 1/100 slope (Figure 1). We set the flume to such a simple shape because it facilitates application of numeric calculation of the results of this experiment to future study. Bed material of the flume was uniform sand with the mean diameter of 0.78 mm. Table 1 shows the hydraulic conditions in the experiments. At the end of the flume, a thin woody fence was set to maintain a uniform flow depth. The water discharge was set 0.00027 m^3/s in all the experiments. Two experimental cases were used: in Case 1, the water discharge was set constant while seeds were supplied, while in Case 2, the water discharge was decreased as shown in Figure 2. As representative of a hydrochory distributed seeds of pioneer species, we used alfalfa seeds as well as the several references [1, 2, 7]. Experimental cases are summarized in Table 2. As an initial condition, alternate sandbars were formed in the flume. These took around 30 m to create. The height of created sandbars was ~7 mm and the wavelength was ~1.5 m.

Table 1. Hydraulic conditions in the experiments .

Discharge Q (m^3/s)	0.00027
Width of flume B	0.15
Slope I_b	0.01
Mean diameter of sediment d_m (mm)	0.78
Uniform flow depth h_0 (cm)	0.8
Non-dimensional Shear stress τ_*	0.08

Table 2. Experimental cases

Case	Seed Supply (Y/N)	Discharge during seed supply (m^3/s)	Vegetation On sandbar (Y/N)
Case 1	Y	0.000271	N
Case 2	Y	0.000271 ~ 0	N
Case 3	N	0.000271	N
Case 4	N	0.000271	Y
Case 5	Y	0.000271 ~ 0	Y

After creating sandbars, we supplied enough amounts of alfalfa seeds (6g)with the duration time of 1.5 minutes (Figure 2) in order to compare the hydrochory seeds distribution. The volume of alfalfa seeds was decided by a pre-experiment from following two points. First, most of the supplied seeds are transported to the downstream end of the flume at first, and second, the seeds settle on sandbars during water discharge decreasing that it can be confirmed visually. After 2 days in Case 2, alfalfa grew up well on sandbars. Cases 3 and 4 were then carried out under the same hydraulic conditions as Cases 1 and 2, respectively, for comparing the characteristics of bed morphology change with and without growing vegetation. After Case 4 finished, Case 5 was started immediately. In Case 5, 6 g of alfalfa seeds were supplied again from the upstream area of the flume for 1.5 minutes and the specific locations of seeds' settling under an influence of growing vegetation were observed.

3 RESULTS AND DISCUSSION

3.1 Characteristic of seed distribution

In Case 1, seeds did not deposit on sandbars at all (Figure 3b). The constant discharge in Case 1 emulated an overbank flow condition, in which a relatively high flow velocity on sandbars did not allow seed deposition on the sandbars. Thus, all of the seeds were transported toward the end of the flume. Conversely, in Case 2, seeds were deposited only at the front edge of the sandbars (Figure 3c). These results imply that seeds distributed during flood and deposited during the recession stage. Figure 3d shows the results of Case 5, where alfalfa seeds settled at the same location, the front edge of the sandbar, as Case 2. This demonstrates that, for this experiment, seed settling characteristics are strongly related to discharge, and minimally affected by growing vegetation of same species.

3.2 River bed morphodynamics

Figure 4 shows the elevation profile in the cross-section of the initial alternate sandbars; the bed elevation at the front edge of the sandbar is significantly higher than that of the other areas of the sandbar. These bed forms might cause shallow depths at the front edge of the sandbar compared to that of other regions when water discharge is decreasing, and also make the flow velocity faster than that of the other areas on the sandbar. In addition, it also would cause recirculation flow at the boundary area between the front edge of sandbars and the main channel. This flow would make increase seed capture and cause the seed deposition areas on bare sandbars.

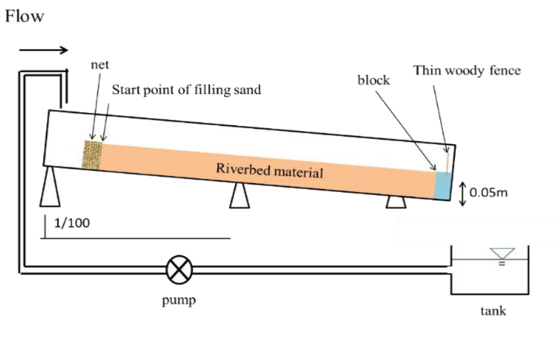

Figure 1. Side view of the experimental flume supply

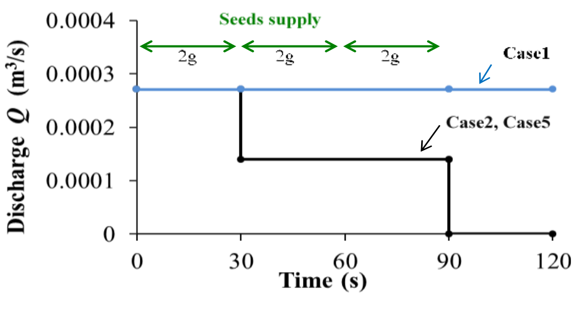

Figure 2. Water discharge during seed

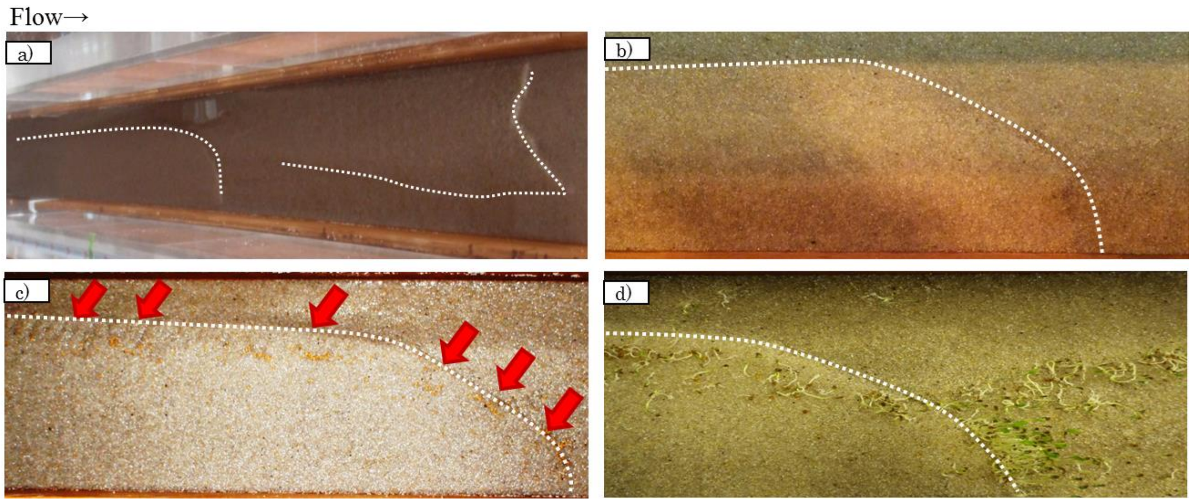

Figure 3. Alternate sandbars and the results of seeds settling location in Case 1, Case 2, and Case 5, a) alternate sandbars in the initial condition, b) Case 1, c) Case2 and d) Case5.

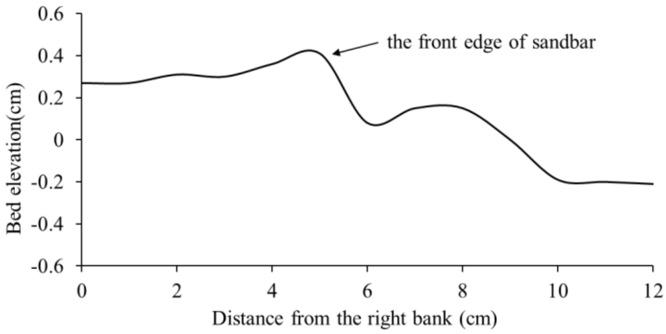

Figure 4. Cross sectional profile of the bed elevation at the most wide area of the initial alternate sandbar for Case1 and Case2.

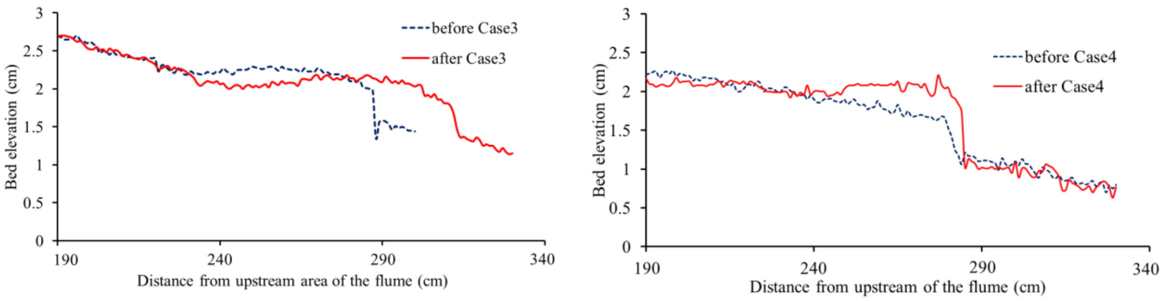

Figure 5. Longitudinal profile of the bed elevation at Y=2.0 cm from the right flume wall, a) Case 3, b) Case 4
blue line : initial condition of experiment (before Case3,4) red line : results of experiment (after Case3,4)

Figure 5 shows the bed elevation profile in the longitudinal direction of the sandbar in Cases 3 and 4. When comparing the bed morphology changes between Case 3 and Case 4, the sandbar without vegetation of Case 3 migrated in downstream. Conversely, in Case 4 (sandbar with vegetation patches), the elevation at the front edge of the sandbar showed significant aggradation (Figure 5). This is because the vegetation patches retard flow.

4 CONCLUSION

This study observed the characteristics of seed distribution by flow and bed morphology changes affected by vegetation patches using flume experiments. The results are summarized as follows:

1. Seeds were not deposited when there were ‘overbank’ flows, but were deposited during the recession stage of discharge events.
2. Hydrochory seeds did not settle uniformly on sandbars. The seeds settled mainly at the front edges of sandbars due to the spatial heterogeneity of flow velocities. In addition, growing vegetation here did not affect the seeds’ settling locations for the same species. These results imply that invading vegetation has specific settling characteristics that lead to vegetation patches on sandbars.
3. Comparing the bed morphology changes without vegetation and with vegetation, the bare sandbars were propagated in the downstream direction while maintaining the shape of the initial sandbars. Conversely, the sandbars with vegetation patches were stabilized and the bed at the front edge of sandbars showed significant aggradation. This may indicate that invading pioneer species facilitate sandbars stability and emergence from the stream, and therefore accelerate invasion of other vegetation on sandbars.

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