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Study on Seed Germination and Seedlings Growth of Bamboo (Dendrocalamus hamiltonii)

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Abstract. Bamboos are naturally propagating both sexually and asexually from seeds and rhizomes. In this study two experiments were carried out in a greenhouse to evaluate the influence of seed orientation (embryo-end-up, lay-flat and embryo-end-down) and sowing depth (3, 6 and 9 mm) of the bamboo *Dendrocalamus hamiltonii* on seed germination, seedling survival and growth after 60 days. Factorial design in two blocks containing 90 samples was used. Plastic pots filled with a mixture of sand, agricultural soil and peat (rate 3:1:1 and 2:2:1, respectively). Seeds were sown in two soil treatments. Seed germination and seedling survival rates in first soil (3:1:1) were 24 and 66.6 percent and in second soil treatment (2:2:1) were 31.1 and 85.7 percent, respectively. Mean seedlings height was higher at 6 mm depths and embryo-end-down in both soil treatments (11.5 and 27.5), it had significant difference in two soil treatments ($P < 0.05$). Mean seedlings height didn't show significant difference among seed orientation and sowing depth.

Key words: Bamboo, Seed germination, Seedling growth, *Dendrocalamus hamiltonii*

Introduction

Bamboos are tall perennial grasses with tree stature that grow up to about 30 m in height and 35 cm in diameter. They belong to the Poaceae (Gramineae) family and Bambuseae subfamily (OHRNBERGER, 1999). The main stem of the aboveground part of the plant is the culm, while the underground part constitutes the rhizome and root system. Most bamboo plants flower only once in their lifetime (14 to 50 years in most species) and then die soon. They emerge again from germinating seeds if the site is not severely disturbed by detrimental factors such as rodents, fire and etc. These phenomena were actually observed in bamboo forests (LIESE, 1985). Bamboo naturally propagates both sexually and asexually from seeds and rhizomes. Artificial propagation by vegetative methods includes planting of off-sets, culm cuttings, layering, and grafting of rhizome (EMBAYE, 2003). Most bamboos are found on sandy loam to loamy clay soils, derived from river alluvium or frequently from the underlying rock. *Dendrocalamus* species, after germination, produce a grass-like seedling the first year. The plumule, which appears as a conical bud covered by sheathing scaly leaves, develops rapidly into a thin wiry stem bearing single leaves, alternate at the nodes, the leaf bases covering the stem (HUBERMAN, 1956). *Dendrocalamus hamiltonii* Nees et Arn. ex

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Munro is a large caespitose bamboo, culms 10-20 m high, 10-16 cm in diameter, thin walled with 0.75-1.25 cm thickness (RAWAT, 2007), internodes 30-50 cm, sheaths stiff and persistent (HUBERMAN, 1956). Its seeds are like those of wheat, seed year happen in intervals of 30 years and flowering nature is gregarious and sporadic (AHLAWAT et al., 2002).

The aim of the current study is finding out the optimum sowing depth and seed orientation that could be recommended for successful seedling production and growth of the *Dendrocalamus hamiltonii* in greenhouse conditions.

PITTMAN (1965) records enhanced germination and early growth for corn seeds oriented with respect to magnetic lines of force. PATTEN & VAN-DOREN (1970) found substantially higher emergence and seedling growth of corn with embryo end-up than with embryo-end-down orientation. MAUN & RIACH (1981) studied sand deposition effects on seedling emergence of *Calamovilfa longifolia* at field sites and greenhouse plantings. They found that seedling emergence was negatively correlated with planting depth.

SANCHEZ & KING (1994) identify sowing depth as one of the most important factors that affect seedling emergence, survival and subsequent onward growth of acacia species from Ethiopia.

CHEN & MAUN (1999) sorted seeds of *Cirsium pitcheri* into three groups (small, medium and large) and buried at 2, 4, 6, 8, 10 and 12 cm depths in plastic pots filled with unsterilized sand, Data showed that percent seed germination and emergence of seedlings were not related to seed size. However, both variables were negatively correlated with depth. Seedling emergence occurred from a maximum depth of 6 cm with most seedlings emerging from 2 cm depth.

EMBAYE (2003) used a randomized complete block design to evaluate seedling emergence, subsequent survival and growth of bamboo (*Oxytenanthera abyssinica*). Seeds were sown in plastic pots that filled with mixture of sand and peat (rate 3 sand: 1 peat). Top of the soil surface and at 2.5 mm depth achieved faster and higher seedling emergence than those sown at 5 and 10 mm depths. However, mean seedling height and number of leaves per seedling were higher in 5 and 2.5 mm depths than surface and 10 mm depths. There were significant quadratic relationships between sowing depth and seedling height ($p=0.034$) as well as number of leaves per seedling ($p = 0.032$), both peaking around 5 mm soil depth. Lay-flat orientation, which was the most frequent position in broadcast sowing, was recommended at 5 mm sowing depth for the lowland bamboo based on overall performance in seedling emergence, survival and growth.

DAMIZADE (2004) planted seeds of *Capparis* deciduas in nursery for evaluating germination and survival rates of seedlings.

ZHAO et al. (2007) sorted seeds of *Nitraria sphaerocarpa* into three size-classes and buried at 2 cm depths in plastic pots filled with sand under controlled greenhouse condition. Two weeks after seedling emergence, seedlings were buried in sand to various depths of 0, 33, 67, 100 and 133% of their mean height. Seedling height, mass and absolute height growth rate in partial burial treatments were higher than those of the unburied and completely buried treatments. In each seed size class, with increasing burial depth, or in each burial depth, with decreasing seed size, there was a tendency that both biomass allocation to root and biomass allocation to belowground stem increased, while biomass allocation to aboveground stem decreased.

TABARI & TABANDEH (2007) investigated germination rate of Tilia platyphyllos at 1.5 and 3 cm of sowing depth and watering was done with two regulations: everyday and every other day. Results showed treatment composition of 3 cm sowing depth and everyday watering was the most germination rate than 1.5 cm sowing depth with every other day watering.

ZHANG & MAUN (2007) examine the effects of sand burial on seed germination, seedling emergence and establishment of *Panicum virgatum* L. on the foredunes of Lake Erie. In the field, all the seedlings established in one growing season had originally emerged from sand burial depths of less than 12 cm. Within this burial range, seedlings from shallower burial depths had lower chances of establishment than expected, whereas those from deeper burial depths had higher probabilities of establishment than expected.

AZMY & APPANAH (1998) planted *Gigantochloa ligulata* at FRIM and results showed the seedlings developed in the second week after sowing. With 1:3 soil-sand rate and the germination was 76%.

Materials and Methods

This research is composed of literature review work and greenhouse experiment. Seeds were collected from Indian bamboo stands. Three experiments including soil, sowing depth and seed orientation were implemented. The experiments period was 60 days. Factorial design was used in the experiments: plastic pots were filled with a mixture of sand, agricultural soil and peat (rate 3:1:1 and 2:2:1 sand, agricultural soil and peat, respectively). There were two blocks that each of them consisted of 45 pots. Sowing depth experiment was determined based on average size of the seeds and consisted of one, two and three times of seed size i.e. tree treatments as 3, 6 and 9 mm at soil depth, respectively. It tried to select uniform size of seeds. The seeds were soaked with clean water for 12 hours and were sown in embryo-end-up, lay flat and embryo-end-down orientations at different soil depths. The amount of watering was adequate moisture to maintain in the soil to avoid seed desiccation while keeping it below field capacity to ensure adequate oxygen supply. The treatments were done through the greenhouse at 27°C temperature and 80% relative humidity. Seedlings heights were measured every 20 days.

Results and discussion

First seed germination emerged 8 days after sowing and continued 8-14 days. Germination period of the species is expressed 8-28 days (AHLAWAT et al., 2002). The period for some species of *Dendrocalamus* is 2-3 weeks and about *Oxytenanthera abyssinica* is reported 14 days after sowing (EMBAYE, 2003).

Germination and survival rates in different soils are shown in Table 1.

Seed germination rate in soil 1 based on sowing depth after 60 days was in the order 9mm > 6mm > 3mm and survival rate followed 6mm > 9mm > 3mm and in soil 2 the amounts were 6mm >9mm > 3mm and 3mm > 6mm > 9mm respectively. In both of soils the most survival rates were related to shallow sowing depth and medium surface. CHEN & MAUN (1999) and ZHANG & MAUN (2007) approved the fact about other species, it maybe happens because of access to light quickly (PITTMAN, 1965) and water maintenance around the seeds (CHEN & MAUN, 1999). Differing results are documented on seedling growth in shallow sowing depth and significant difference between germination and survival of seedlings (MAUN & RIACH, 1981; SANCHEZ & KING, 1994; CHEN & MAUN, 1999; ZHAO et al., 2007). Seeds of *T. platyphyllos* were germinated in high deep soil better than shallow depth; the reason is probably for seed dormancy and physiological characteristics of seeds (e.g. seed size) (TABARI & TABANDEH, 2007). Seed treatment with water showed significant difference in seedling survival rate of *C. deciduas* (DAMIZADEH, 2004); we used the treatment in this study. Although, changing soil rates in different treatments were illustrated significant difference of survival rates about the species (DAMIZADEH, 2004).

Seed germination rate in soil 1 based on seed orientation after 60 days was 60% consisted of embryo-end-down at the 6 mm sowing depth and its survival rate was 100%.

Seed germination rate in soil 2 based on seed orientation after 60 days was 80% consisted of lay flat at the 6mm sowing depth and its survival rate was 100%.

The most survival rate about *O. abyssinica* was explained in lay flat orientation (EMBAYE, 2003). Growth rate is influenced by soil type (AZMY, 2008).

Germination and survival rates at different sowing depth and both soils are shown in Figures 1-6.

The most seedling height was 11.5 cm at age 60 days in embryo-end-down orientation and 6mm sowing depth in soil 1 (Table 4), highest seedling in soil 2 was 27.5 cm at the same orientation and sowing depth (Table 4). The most seedling height was reported at lay flat orientation for O.abyssinic (EMBAYE, 2003) and embryo-end-up for corn (PATTEN & VAN-DOREN, 1970).

The SPSS statistical software package was used to analysis the sets of data. Block means of the different treatments were applied for 3-WAY ANOVA calculations. Seedlings height between two soils were statistically significant differences until 40 days ($P<0.05$). After that the seedlings height growth were independent on soil type. Seed orientations and sowing depths didn't have significant differences on seedlings height ($P<0.05$) (Tables 2 - 4).

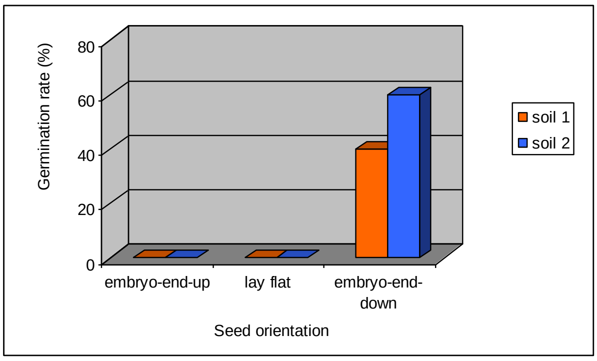

Fig 1. Germination rate in 3mm sowing depth

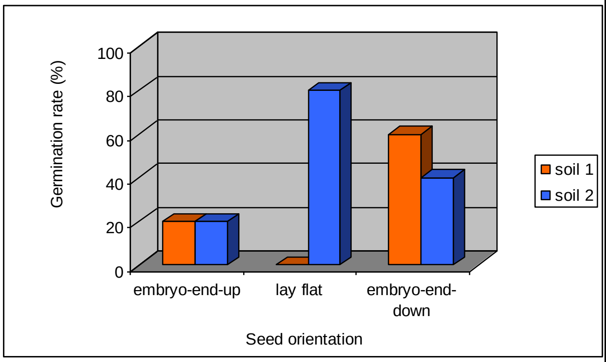

Fig 2. Germination rate in 6mm sowing depth

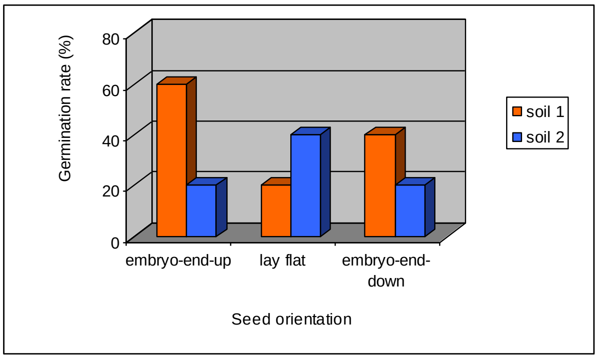

Fig 3. Germination rate in 9mm sowing depth

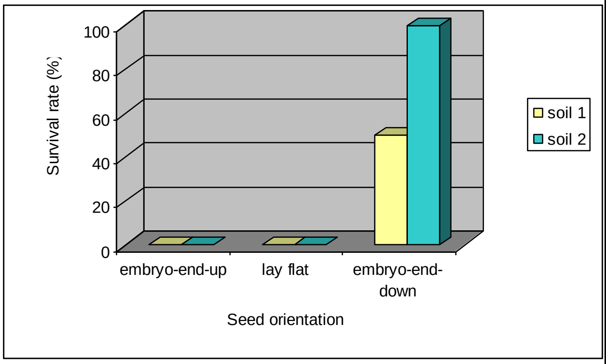

Fig 4. Survival rate in 3mm sowing depth

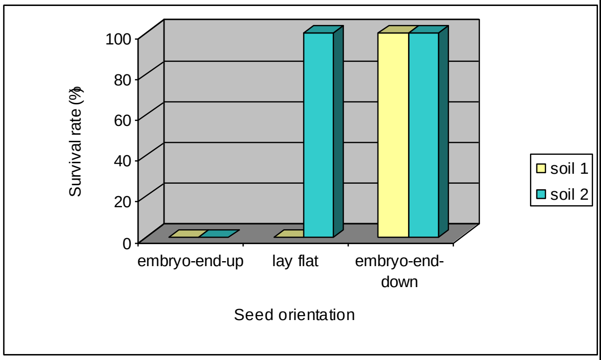

Fig 5. Survival rate in 6mm sowing depth

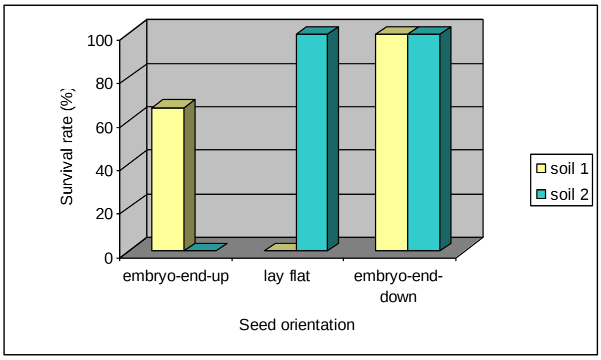

Fig 6. Survival rate in 9mm sowing depth

Table1. Germination and survival rates of two soil treatments

Soil treatment	Seed Germination rate (%)	Seedling survival rate (%)
3:1:1 (Soil 1)	24.4	66.6
2:2:1(Soil 2)	31.1	85.7

Table 2. Relationship of soil, sowing depth and seed orientation with seedling height 20 days after sowing

	Average seedling height								
	3 mm Sowing depth			*6 mm Sowing depth*			*9 mm Sowing depth*		
	Emberyo-end-up	Lay flat	Emberyo-end-down	Emberyo-end-up	Lay flat	Emberyo-end- down	Emberyo-end-up	Lay flat	Emberyo-end- down
Soil 1	0[a]	0[a]	1.4 [a]	3[a]	*0[a]*	3.43[a]	2.45[a]	2 [a]	0 [a]
Soil 2	0[a]	0[a]	4.77[a]	1[a]	*8.88[a]*	10[a]	2.5[a]	7.5[a]	0 [a]

Table 3. Relationship of soil, sowing depth and seed orientation with seedling height 40 days after sowing

	Average seedling height								
	3 mm Sowing depth			*6 mm Sowing depth*			*9 mm Sowing depth*		
	Emberyo-end-up	Lay flat	Emberyo-end-down	Emberyo-end-up	Lay flat	Emberyo-end-down	Emberyo-end-up	Lay flat	Emberyo-end- down
Soil 1	0[a]	0[a]	2 [a]	0[a]	*0[a]*	*6.67[a]*	*4.5[a]*	*0[a]*	*2.25[a]*
Soil 2	0[a]	0[a]	*12 [a]*	0[a]	*13 [a]*	*17.75[a]*	*0[a]*	*10.5[a]*	*0 [a]*

Table 4. Relationship of soil, sowing depth and seed orientation with seedling height 60 days after sowing

	Average seedling height								
	3 mm Sowing depth			*6 mm Sowing depth*			*9 mm Sowing depth*		
	Emberyo-end-up	Lay flat	Emberyo-end-down	Emberyo-end-up	Lay flat	Emberyo-end-down	Emberyo-end-up	Lay flat	Emberyo-end-down
Soil 1	0[a]	0[a]	*10[a]*	0[a]	*0[a]*	*11.5[a]*	*9.5[a]*	*0[a]*	*5.5[a]*
Soil 2	0[a]	0[a]	*10.17 [a]*	0[a]	*20.13 [a]*	*27.5[a]*	*0[a]*	*15.75[a]*	*5[a]*

[a] *Data bearing same letters in a column do not differ significantly from each other at* $P < 0.05$.

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