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Investigations in to the Capacity and Strength of Rhizome Germination in Three Different *Miscanthus* Species

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ABSTRACT

Miscanthus is a perennial rhizomatous grass. Among *Miscanthus* species, *M. sinensis*, *M. sacchariflorus*, and *M.* x *giganteus* and their varieties are widely planted worldwide. However, *M.* x *giganteus* must be propagated vegetatively owing to its sterility. Therefore, its propagation poses significant challenges both economically and to production efficiency. Most *M.* x *giganteus* is propagated by rhizomes that form nodes, internodes, and buds in a similar manner to above-ground stems. Therefore, we investigated the germination rate and strength of three different *Miscanthus* species, *M. sinensis*, *M. sacchariflorus*, and *M.* x *giganteus*. We found that, of these species, *M. sacchariflorus* performed best in terms of both germination rate and strength. The results of the current study could provide the starting point for further and extensive study of rhizome germination in *Miscanthus* species.

Keywords: Germination rate, Germination strength, Mass production, *Miscanthus*, Rhizome

Introduction

Miscanthus is a perennial rhizomatous grass with the C4 photosynthetic pathway (Lewandowski et al., 2000). Although its origins of the genus *Miscanthus* is in the tropics and subtropics, different species are found throughout a wide climatic range in East Asia (Mutoh et al., 1985). This remarkable adaptability to different environments makes this crop suitable for establishment and distribution under various ranges of climatic conditions (Numata, 1974).

Among *Miscanthus* species, *M. sinensis*, *M. sacchariflorus* and *M.* x *giganteus* and their varieties are widely planted worldwide. Clifton-Brown et al. reported that *M. sinensis* is used in Japan for forage and thatching, and *M. sacchariflorus* is in China in the cellulose industry (Clifton-Brown et al., 2008). *M.* x *giganteus* has been extensively studied since 1983 for combustion to produce heat and electricity in Europe (Lewandowski et al., 2000). Further, agricultural energy sources are expected to be more than 800 million tons annually to the US biomass industry for the production of liquid transportation fuels by the year 2030 (Perlack et al., 2005).

M. x *giganteus* must be propagated vegetatively due to its sterility. Thus, propagation both efficiently and economically is the great challenge. Most *M.* x *giganteus* is propagated by rhizomes that form nodes, internodes and buds similar to above-ground stems (Anderson et al., 2011). They also serve as an overwintering storage organ in the soil as the source of each year's initial above-ground growth. However, there is no many researches about the mechanisms and efficient methods to make them germinate for each sub-species. Besides, to produce seedlings for mass production, it is required to have uniform germination rate and strength. Hence, we investigate the germination rate and strength of three different *Miscanthus* species including *M. sinensis*, *M. sacchariflorus*, and *M. giganteus*.

Materials and Methods

Three different *Miscanthus* species including *M. sinensis*, *M. sacchariflorus*, and *M. giganteus* were selected. Each rhizome number of them are 21, 25, and 25, respectively. Each rhizome (2 cm) were planted in the 20 cm-diameter pots with artificial soil (Wonyebumyong, Dongbufarm Hannong, Seoul, Korea) at the greenhouse in Nonsan-si, Chungcheongnam-do, Korea on March 10th 2010 and the germination capacity and strength of them was examined on May 30th 2010. Germinability (germination rate) is calculated by (the number of germinated rhizome in 80 days after planting/total number of planted rhizome) × 100 and germination strength is calculated by (the number of germinated rhizome in 10 days after planting /total number of planted rhizome) × 100.

Germination speed (GSP) = $\frac{n_i}{n_t}$

Mean germination time (MGT) = $\frac{\sum_{i=1}^{k} n_i t_i}{\sum_{i=1}^{k} n_i}$

Mean germination rate (MGR) = t_i-MGT

Coefficient of variation of the germination time (CVG) = $\frac{s_t}{\bar{t}}100$

Variation of the mean germination time (VGT) = $\frac{\sum_{i=1}^{k} n_i (t_i - \bar{t})^2}{\sum_{i=1}^{k} n_i - 1}$

Standard deviation of the mean germination time (SDG) = $\frac{\sum_{i=1}^{k} (t_i - \bar{t})^2}{\sum_{i=1}^{k} n_i - 1}$

, where $\bar{t}$ is the mean germination time, n_i is the number of germinated seeds, and k is the last day of germination.

Germination uncertainty (UNC) $= -\sum_{i=1}^{k} f_i$,

$f_i = \frac{n_i}{\sum_{i=1}^{k} n_i}$, where n_i is the number of germinated seeds, and k is the last day of germination as stated above.

Germination Synchronization index (SYN) $= \frac{\sum_{i=1}^{k} C_{n_{i,}2}}{C\sum n_{i,}2}$,

$C_{n_{i,}2} = \frac{n_i(n_i - 1)}{2}$, where $C_{n_{i,}2}$ is the combination of germinated seed.

Results and Discussion

The days for germination after planting was up to 50 days in *M. sinensis* while others were up to 13 days (Table 1). *M. sinensis* started to germinate from day 7 after planting that is 3 days slower than others. *M. sinensis* and *M. sacchariflorus* had 86% and 88% of germination rate, respectively, while *M.* x *giganteus* had 68%.

Table 1. Number of germinated rhizomes of three *Miscanthus* species after 50 days

The germinated day after planting	Accumulated germination (total number of rhizome planted)		
	Miscanthus sinensis (21)	*Miscanthus sacchariflorus* (25)	*Miscanthus x giganteus* (25)
Day 5	0	1	3
Day 6	0	5	3
Day 7	4	8	10
Day 8	5	15	13
Day 9	5	16	15
Day 10	11	18	15
Day 11	14	22	15
Day 12	14	-	16
Day 13	15	-	17
Day 14	16	-	-
Day 15	16	-	-
Day 20	17	-	-
Day 50	18	-	-
Not germinated	3	3	8

Notably, *M. sinensis* did not uniformly germinated. Germination strength of three *Miscanthus* speices were 52%, 60%, and 72% in *M. sinensis*, *M.* x *giganteus*, and *M. sacchariflorus*, respectively (Table 2). Overall, *M. sacchariflorus* performed best in terms of both germination rate and strength among three species.

Table 2. Summary of germination variables for three different *Miscanthus* species

	M. sinensis	*M. sacchariflorus*	*M.* x *giganteus*
Germinated Seed Number (GRS)	18	22	17
Germination Seed Percentage (GRP)	86	88	68
Mean Germination Time (MGT)	12.33	8.18	7.7
Mean Germination Rate (MGR)	0.081	0.122	0.13
Germination Speed (GSP)	8.11	12.22	13
Germination Uncertainty (UNC)	2.6	2.53	2.25
Germination Synchronization Index (SYN)	0.16	0.16	0.21
Variance of the Mean Germination Time (VGT)	94.5	3.3	4.72
Standard deviation of the Mean Germination Time (SDG)	9.72	1.81	2.17
Coefficient of Variance of the Mean Germination Time (CVG)	78.81	22.2	28.2
Germination strength	52	72	60

Un-even germination causes different growing rate and costs a lot to manage large field. Thus, it is crucial to have uniform germination rate and strength to produce seedlings for mass production. Further, it would be beneficial to reduce germination days after planting. There could be many other factors affecting germination days such as soil depth, the size of rhizome, and soil temperature. It may be useful to investigate of the germination rate/strength on those matters. We hope that this information in the current study would be the start point to further and extensive lists of rhizome germination of *Miscanthus* speices.

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