# Research reports

## Studies on the germination of mission grass (*Pennisetum polystachion* (L.) Schultes) seeds

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### Summary

**Effects of several environmental factors on germination and emergence of mission grass ( *Pennisetum polystachion* (L.) Schultes) were examined in laboratory and greenhouse studies. Mission grass seeds need light for germination which was much lower in the dark (24%) than in sunlight (59%). The optimum temperature, 35°C resulted in 59% germination. Germination was reduced under simulated moisture stress, and no germination was observed at -1.25 MPa. Maximum germination occurred at pH 6 and was 18% at 43 mM of NaCl.**

**The percentage of emergence reduced with increasing planting depths. Greater emergence was obtained when seeds were sown on the soil surface (63%), but no seedlings emerged when seeds were planted 10 cm deep. Shade levels of 35 and 70% reduced dry matter by 25 and 48% respectively, compared to plants grown in full sunlight. The number of tillers also decreased with increasing shade levels.**

### Introduction

Mission grass (*Pennisetum polystachion*), a member of the Poaceae family is a tough annual or perennial grass that has a wide distribution in tropical Asia and Africa. It is found extensively in cultivated fields, gardens, wastelands, and roadsides. In Malaysia, the species is recorded in several crops such as banana and cassava and in rubber and oil palm plantations (Lee 1988). Our field observations revealed that mission grass prefers dry conditions and well-drained soils. This weed competes vigorously with most crops and has become a serious problem in southern and eastern provinces of Thailand (Prateep *et al.* 1988); and the species found in Malaysia might have originated from there (Baki *et al.* 1988). Mission grass can grow 50–300 cm tall with numerous tillers. The inflorescence is made up of yellow brown, cylindrical spikes 10–26 cm long. Spikelets are sessile and characterized by 3-lobed lemmas. It has been reported to produce an average of 345 seeds per spike and 23 500 seeds per plant (Noda *et al.* 1985), and is known to spread mainly by seeds.

Several environmental factors are known to promote or inhibit weed seed germination (Egley and Duke 1985, Taylorson 1987). Temperature, moisture, light and pH requirements for germination vary considerably depending on the species (Wilson 1979, Eberlein 1987, Shaw *et al.* 1987, Jain and Singh 1989). Some weed species can emerge from a wide range of planting depths (Singh and Achhireddy 1984, Balyan and Bhan 1986, Shaw *et al.* 1987) while others must be close to the soil surface (Biswas *et al.* 1975). Detailed studies on the effects of environmental factors on mission grass have not been reported. An understanding of germination biology can help to predict the potential for its spread into new areas and be useful in developing effective control measures. The purpose of this research was to examine the effects of some environmental factors on germination and growth of mission grass.

### Material and methods

Hand-harvested mission grass seeds were obtained along the roadside near Bandar Baru Bangi, Selangor. The seeds were removed from the inflorescence and were stored for one month at room temperature until used in experiments. In all experiments, 50 seeds were placed in a 9 cm petri dish lined with two sheets of Whatman No. 2 filter paper, which was then moistened with 5 mL of distilled water or the appropriate solution described later for the pH, salinity and moisture stress experiments. Preliminary experiments indicated that fungicide seed treatment was not needed. Unless otherwise noted, germination tests were conducted at 27°C in a 12 h dark / 12 h light regime (175 $\mu mol.m^{-2}.s^{-1}$). Seeds were considered germinated when the radicle attained a length of 1 mm. Germination counts were taken at two day intervals over a 14 day incubation period. Data of germination were expressed as per cent and analysed using arc sin transformation. The results reported here were recorded after 14 days of incubation. The seedlings in each petri dishes were dried in the oven at 55°C for 48 hours, and weighed.

Treatments were replicated five times in a randomized complete block design. Data were subjected to analysis of variance, and means were compared with an LSD test at the 5% level of significance.

#### *Temperature*

Germination experiments were conducted in a growth incubator at a constant temperature of 20, 27, 30, 35 or 40°C and at alternating temperatures of 20 / 30, 30 / 35 and 30 / 40°C. Constant and alternating temperature chambers provided 12 hours each of dark and light.

#### *Light*

Light requirements were determined by comparing germination in petri dishes wrapped in aluminium foil with those exposed to light with an intensity of 175 $\mu mol.m^{-2}.s^{-1}$ PAR. The germinator provided 12 hours of exposure to light and 12 hours to darkness. The effect of $8.6 \times 10^{-5}$ M gibberellic acid ($GA_3$) was determined by wrapping petri dishes in foil and adding $GA_3$ to the germination medium.

#### *Simulated moisture stress*

Moisture stress was simulated with solutions of mannitol (d-mannite) that would provide osmotic potentials up to -1.25 MPa (Wilson 1979).

#### *pH*

Buffered pH solutions were prepared using 0.1 M potassium hydrogen phthalate in combination with either 0.1 M HCl or 0.1 M NaOH to obtain solution pH levels of 3, 4, 5 and 6. A 0.025 M borax solution was added in combination with 0.1 M HCl to prepare solutions with pH levels of 7, 8 and 9 (Shaw *et al.* 1991).

#### *Salinity*

To study the effects of salinity on germination, reagent grade NaCl was used to prepare saline solutions of 0 (control), 4.3, 8.6, 17, 43, 86 and 100 mM as described by Reddy and Singh (1992). Five millilitres of the appropriate solution was used as the germination medium.

#### *Depth of planting*

Seeds were planted in plastic trays at depths up to 10 cm in soil (Serdang Series, sandy loam soil) collected from an experimental plot at Universiti Pertanian Malaysia, Serdang, Selangor. The trays

were kept at 30 ± 5°C on greenhouse benches. Trays were watered as needed to maintain adequate moisture. Fifty seeds were planted in each of five replicates per depth condition. Seedlings were considered emerged if shoots appeared at the soil surface. Emergence was recorded every two days over a period of 14 days.

*Shading*

Seeds of mission grass were pre-germinated in petri dishes in the laboratory. Four germinated seeds were transferred into each pot containing 3.5 kg of Serdang Series soil. The pots were placed on benches in the greenhouse at 30 ± 5°C for about four weeks before being transferred under four shading levels, viz. 0% (control in full sunlight) 35, 55 and 70%. The shade structures were 1.5 × 1.5 × 1.5 m and the netting was placed on the top and each side of the structures. There were 10 pots for each of the shade levels with three replications. The number of tillers and plant dry weight were determined four weeks after the seedlings being transferred under shade. The plants in each pot were removed at the soil surface, and dry weights were recorded.

**Table 1. Effect of various temperature regimes on germination of *P. polystachion* seeds in growth incubators after 14 days.**

| Temperature (°C) | Germination (%) |
|---|---|
| 20 | 20 |
| 27 | 58 |
| 30 | 56 |
| 35 | 59 |
| 40 | 38 |
| 20/30 | 20 |
| 30/35 | 28 |
| 30/40 | 20 |
| $LSD_{(0.05)}$ | 8 |

**Table 2. Effect of light or dark and $GA_3$ ($8.6 \times 10^{-5}$ M) on germination and growth of *P. polystachion* seeds.**

| Treatment | Germination (%) | Wet weight per plant (mg) |
|---|---|---|
| 12 h light/12 h dark | 59 | 2.9 |
| Dark | 24 | 0.3 |
| 12 h light/12 h dark + $GA_3$ | 60 | 3.0 |
| Dark + $GA_3$ | 50 | 2.0 |
| $LSD_{(0.05)}$ | 10 | 0.5 |

## Results and discussion

*Temperature*

The optimum germination temperature for mission grass was between 27 and 35°C, with 59% germination recorded at 35°C (Table 1). Germination of seeds began after 48 hours at 35°C, but it was delayed at 20°C and 40°C. High temperatures are known to be detrimental to the germination of many weed species (Fernandez-Quinantilla *et al.* 1990). Germination of mission grass seed was not enhanced by alternating temperature regimes. Fluctuating temperatures of 30/35°C every 12 hours resulted in only 28% germination. The results indicate that mission grass has the capacity to germinate under a range of temperatures and this may be one of the reasons for the continuous emergence of this weed throughout the year.

Temperature is considered to be an important factor in seed germination. Some seeds germinate over a wide range of temperatures (Fernandez-Quinantilla *et al.* 1990) while others require critical levels of relatively high temperature (Toole 1973). Our results have shown that mission grass germinated better at constant moderate temperature. Other species, such as honeyvine milkweed (*Ampelamus albidus* (Nutt.) Britt.) and Virginia buttonweed (*Diodia virginiana* L.) have also been reported to germinate better at constant temperatures (Soteres and Murray 1981, Baird and Dickens 1991).

*Light*

Germination of mission grass seeds was less in the dark than in alternating dark and light (Table 2). The addition of gibberellic acid to the growth medium partly overcame the light requirement for germination, as it increased germination in the dark from 24 to 50%. The wet weight measurements of the seedlings showed a pattern similar to that germination rate. These results show that the germination of mission grass seeds had increased under exposed conditions. Thus cultural practices that exclude light could reduce germination.

**Table 3. Effect of osmotic stress on germination rate and growth of *P. polystachion* seeds.**

| Osmotoc stress (MPa) | Germination (%) | Radicle (cm) | Wet weight per plant (mg) |
|---|---|---|---|
| 0 | 58 | 3.5 | 1.6 |
| -0.11 | 48 | 0.8 | 1.4 |
| -0.27 | 43 | 0.6 | 0.7 |
| -0.46 | 42 | 0.1 | 0.4 |
| -0.63 | 34 | 0.1 | 0.4 |
| -0.90 | 24 | 0.1 | 0.3 |
| -1.25 | 0 | 0 | 0 |
| $LSD_{(0.05)}$ | 5 | 0.06 | 0.5 |

**Table 4. Effect of pH on germination of *P. polystachion* seeds after 14 days.**

| pH | Germination (%) |
|---|---|
| 3 | 2 |
| 4 | 44 |
| 5 | 45 |
| 6 | 56 |
| 7 | 49 |
| 8 | 12 |
| 9 | 2 |
| $LSD_{(0.05)}$ | 5 |

*Moisture stress*

Germination, radicle length and wet weight of mission grass seeds decreased when the water stress of the germination medium increased (Table 3). No germination occurred at osmotic stress of -1.25 MPa. Germination of 24% was recorded at the simulated moisture stress of -0.9 MPa. This observation suggests little influence of moisture stress on mission grass seed germination, except under extreme conditions. Better moisture stress tolerance during germination may help in the distribution of the species. Mission grass is found in areas of drier, better drained soils and part of its adaptation could be the ability to germinate in habitats with limited soil water. The time required for germination progressively increased with increasing osmotic stress. The decline in germination rate at -0.63 MPa indicated that the rate of germination slowed as osmotic stress increased from -0.46 MPa.

*pH*

The pH range for germination was between pH 4 and 7 (Table 4) with a maximum at pH 6. Germination decreased at pH levels outside this range, with levels of 2 and 12% at pH 3 and 8, respectively. Ability to germinate over a wide pH range supports the view that mission grass, like *Asystasia intrusa* Bl. (Ismail and Juraimi 1990) and *Paspalum conjugatum* Berg. (Ismail 1985) is adapted to a wide range of soil conditions except to pH extremes.

*Salinity*

Seed germination of mission grass reduced significantly at 4.3 mM NaCl as compared to the control (Table 5). At 4.3

**Table 5. Effect of salinity concentration on germination and growth of *P. polystachion*.**

| NaCl mM | Germination (%) | Radicle length (cm) | Wet weight per plant (mg) |
|---|---|---|---|
| 0 | 56 | 2.4 | 4 |
| 4.3 | 37 | 2.8 | 4 |
| 8.6 | 32 | 3.2 | 5 |
| 17 | 20 | 4.8 | 4 |
| 43 | 18 | 3.2 | 5 |
| 86 | 6 | 1.7 | 2 |
| $LSD_{(0.05)}$ | 7 | 1.5 | 2 |

**Table 6. Effect of depth of seed placement on emergence of mission grass seedlings.**

| Depth (cm) | % emergence |
|---|---|
| 0 | 63 |
| 1 | 53 |
| 2 | 42 |
| 3 | 35 |
| 4 | 22 |
| 5 | 8 |
| $LSD_{(0.05)}$ | 10 |

**Table 7. Influence of shade on plant dry weight and number of tillers of *P. polystachion*.**

| Shade (%) | Dry weight/ plant (gm) | No. Tiller |
|---|---|---|
| 0 | 8.25 | 10 |
| 35 | 6.15 | 6 |
| 55 | 5.41 | 6 |
| 70 | 4.25 | 4 |
| $LSD_{(0.05)}$ | 1.26 | |

and 43 mM NaCl germination was recorded respectively at 37 and 18%. At 86 mM NaCl germination dropped sharply to 6% and no germination was observed at 100 mM NaCl. This suggests that mission grass germination is sensitive to salt stress as compared to *Paspalum conjugatum* Berg. (Ismail 1985). Radicle length and wet weight of the seedlings also showed great reduction at 86 mM NaCl.

*Depth of planting*

Emergence of mission grass seedlings decreased linearly with increased planting depth (Table 6). Maximum emergence from seed placed on the soil surface suggests that no tillage or minimum tillage practices induced enhanced germination of viable seed at the soil surface. These results are consistent with observed severe infestations of mission grass in open undisturbed areas and in wastelands. Evidently, no seedlings emerged from seed planted 10 cm deep. Reduced or lack of emergence of the seedlings at greater planting depths observed in the present study is consistent with the earlier observations made for other weed species (Evetts and Burnside 1972, Oliver *et al.* 1983). Light and seed size generally limit seedling emergence from deep in the soil. Limited light penetration is the probable reason for no emergence of mission grass at the greater depths. The smaller seeds probably contain insufficient food reserves to support seedling emergence from greater soil depths. Decreased emergence rate with increased planting depth has also been reported in several weed species (Biswas *et al.* 1975, Shaw *et al.* 1991, MacDonald *et al.* 1992).

*Shade*

Mission grass plant dry weight decreased with an increase in the level of shade (Table 7). A 35% reduction in available light resulted in a plant dry weight reduction of 25%, while reducing available sunlight by 70% resulted in 48% reduction in plant growth. Numbers of tillers also decreased with an increase in the level of shade. The potential of shade in reducing plant growth has been well documented for a number of species (Boyd and Murray 1982, Shaw *et al.* 1987). Reducing available sunlight results in a reduction in photosynthetic activity (Keely and Thullen 1978, Patterson 1979), and reproductive capabilities can decrease with increasing shade levels (Boyd and Murray 1982, Patterson 1982).

This research has identified a number of specific parameters required for mission grass germination and emergence. The results indicate that this weed is adapted to a fairly wide environmental niche. Under laboratory conditions, mission grass seed germination may occur over a wide range of temperatures. Light is one of the important factors in determining the rate of seed germination. Therefore, maximal seedling emergence occurred at the soil surface. Plant growth also decreased with an increase of shade level. This species could germinate under a wide range of acidity levels which implying that liming or altering by various means to soil acidity would probably not be effective for limiting the establishment of this weed. In addition, mission grass can germinate under moderate moisture stress. Based on this observation, it seems that this species might distribute and establish, especially under tropical conditions.

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