African Journal of Biotechnology Vol. 8 (17), pp. 4094-4099, 1 September, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Full Length Research Paper

Germination of *Themeda triandra* (Kangaroo grass) as affected by different environmental conditions and storage periods

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Accepted 7 August, 2009

Low rainfall in range areas restricts germination, growth and development of majority of range grasses. However, germination and establishment potential of forage grasses vary and depends on environmental conditions. *Themeda triandra* is an excellent known grass to grow under different environmental conditions. *T. triandra* naturally grows over an extensive geographical range on many soil types. Germination of *T. triandra* is the key factor in its establishment or re-establishment because its germination varies widely which is also affected by storage periods of seed. Germination response of *Themeda* to storage period was conducted in the laboratory. Four storage periods (Fresh seed, 6, 12 and 18 months old) seeds were sown in laboratory in germination trays placed in growth chamber in completely randomized design. Germination was counted till 40 days after sowing and percentage calculated thereafter. The 12 month old seeds gave the maximum 84% germination. On the basis of laboratory experiment, 12 months seeds were sown at 3 diverse locations (Rawalpindi, Jhelum and Talagang) with 4 spacing treatments (20, 30, 40 and Broadcast) in completely randomized block design. Germination was recorded for 40 days after sowing (DAS) and the maximum germination was observed in 25 - 30 DAS depending on the environmental conditions of experimental sites. Closer plant spacing (20 cm) gave the maximum (79%) germination at high rainfall area (Rawalpindi) while the least (52%) was recorded for the wider plant spacing at low rain fall area (Talagang).

Key words: *Themeda triandra*, germination, location, storage period, environment.

INTRODUCTION

The total land area of Pakistan, including Azad Kashmir, is 88 m/ha. The majority of the country falls in the arid and semi-arid zones, with a natural vegetation of tropical thorn bushes and small tress, while the sub-tropical and temperate zones in the foothills and high mountains have coniferous tree species as leading natural flora (Mohammad, 1989). The country is known as an agriculture country and agriculture, livestock production and forestry are main land uses in the country. The majority of the rangelands receive less than 200 mm rainfall and those are situated on rocky soils, deserts and rough topography. So, output is very low and it is not possible to utilize the area for sustained farming purposes (Mohammad, 1989).

Themeda has received the most attention due to its wide geographical distribution in the pre-European landscape. Several authors have suggested that *Themeda* re-establishment is an important first step for grassland restoration (Phillips 1999; McDonald, 2000). *Themeda* grows rapidly from seed and can assume basal diameters of 15 cm in a single growing season (McDougall, 1989). *Themeda* can be effectively restored to small-medium sized areas using seedlings or potted plants (Cole et al., 2000) or by transplanting intact sods from existing remnants (McDougall, 1989). However, large scale seeding technologies are needed if the aim is to restore *Themeda* to areas greater than several hectares (Sindel

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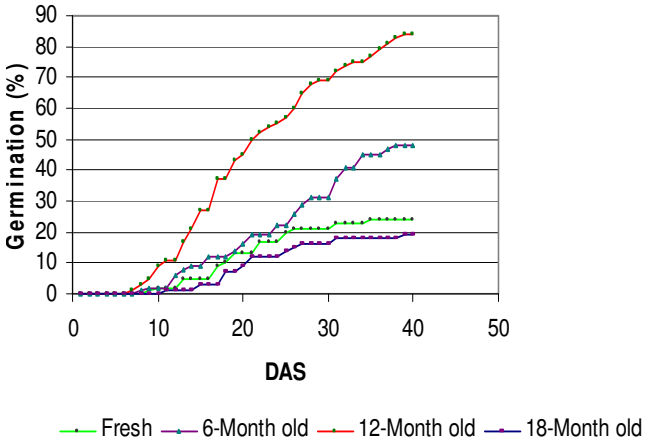

Figure 1. Effect of different storage periods on germination (%) of Kangaroo grass at 40 days after sowing (DAS) 2005-06 and 2006-07.

et al., 1993). Seed structures influence seed dispersal and the selection of micro sites suitable for germination and establishment and thereby affect establishment and survival rates (Peart, 1979, 1984). However, Ritchie and NeSmith (1991) were of the opinion that the temperature during germination affect the rate and time required for germination, while, Flores and Briones (2001) in a study of six desert species at three temperatures (12, 20 and 26°C) found that as temperature increased, the onset of germination was earlier and the time required for 50% germination decreased. Temperatures below 15°C delayed germination of Salicornia rubra (Khan et al., 2000). Germination rate for *T. triandra* is highly variable for different storage periods of its seed (Phillips, 1999).

T. triandra naturally grows over an extensive geographical range on many soil types (Moore, 1973) and adaptations to a wide variety of soils might be expected. Hagon and Chan (1977) found higher levels of germination in clay than sandy soils. By contrast, Sindel et al. (1993) suggested that surface sown seed might survive better in sandier soils because the callus and radicle can more easily penetrate between large sand grains. *Themeda* seedlings appear to have only modest nutritional requirements at establishment (Groves et al., 1973). Hagon and Groves (1977) found that added fertilizer affected neither emergence nor survival of *Themeda* and recommended against adding fertilizer to boost *Themeda* in the field.

T. triandra being a new introduction in the range lands of Pakistan. The plant has not been studied under dif-ferent environmental conditions (where moisture avail-ability, temperature and seed vary). Keeping in view the potential and problem those may come in the way of its establishment, the present study was conducted with the objective to explore the germination potential of seed stored for different period of time and their response under different environmental conditions.

MATERIALS AND METHODS

In vivo study was conducted to test the germination response of *T. triandra*. Seeds of four storage periods, freshly collected seeds, seeds stored for 6, 12, and 18 months were used in this study. 100 seeds for each storage period were sown in plastic trays of 52 cm long 25 cm wide and 7.5 cm deep filled with soil. Trays were arranged in completely randomized design. These trays were placed in a growth chamber at 24°C for 40 days and watered after every 4 days. Germination of seeds was recorded after 10, 20, 30 and 40 days when further germination stopped. Germination percentage was calculated by counting the total numbers of plants present in the each tray.

To explore the effects of environmental and soil variations on the germination percentage of *T. triandra* (Kangaroo grass) field experiments were conducted at three locations during 2005 - 06 and 2006-07. On the basis of *in vivo* experiment 12 months old seeds were used for field experiment. In the experiments seeds of Kangaroo grass with awns were sown in a randomized complete block design (RCBD) with 4 replications. Prior to sowing, the land was prepared by plowing with cultivator twice and then planked to have a well pulverized seedbed. The grass seeds were sown in a plot size 6 x 3.5 m. Seeds were sown by hand keeping plant to plant distance as 20, 30, 40 cm and row to row distance of 50 cm. Broadcast method was also used as a control treatment. Plant to plant distance was made by using the marker before sowing. Experiments were conducted at three locations; PMAS-Arid agriculture university, Rawalpindi (PMAS-AAUR) high rainfall area with average annual rainfall of (1000 - 1200 mm/annum) at the latitude of 33.40° N and 44.30° E, range areas of Jhelum which is medium rainfall area with average annual rainfall of (650 - 850 mm/annum) at 31.20° N and 72.10° E and Talagang low rainfall area (450 - 550 mm/annum) at 32.56° N and 72.53° E. The seeds were sown at three locations during the early part of monsoon season, in mid July, 2005 and for second year during mid July, 2006. Germination was recorded at regular interval that is, 10, 20, 30 and 40 days after sowing from all three sites. Thereafter germination percentage was calculated.

Statistical analysis

The data was statistically analysed using computer statistical programme MSTAT C (Freed and Eisensmith, 1986). Analysis of variance techniques were applied to test the overall significance of the data. Least significance differences test at 5% probability level was used to compare the means (Steel and Torrie, 1990).

RESULTS AND DISCUSSION

Laboratory germination trial

Germination of *T. triandra* is affected by seed dormancy. As described by Whalley and Langkamp (1987), dormancy after seed fall is common in Australian grasses. Mott (1974) and Brown (1982) reported that seed dormancy is often related with structures enclosing the caryopsis. Therefore, before starting the field experiments percent germination of *Themeda* grass for different storage periods of seeds was tested in laboratory. Percent germination of Kangaroo grass for different storage periods presented in Figure 1 showed the maximum germination (84%) at 40 days after sowing (DAS) for the seed stored for 12 months followed by 48 and 24% for 6

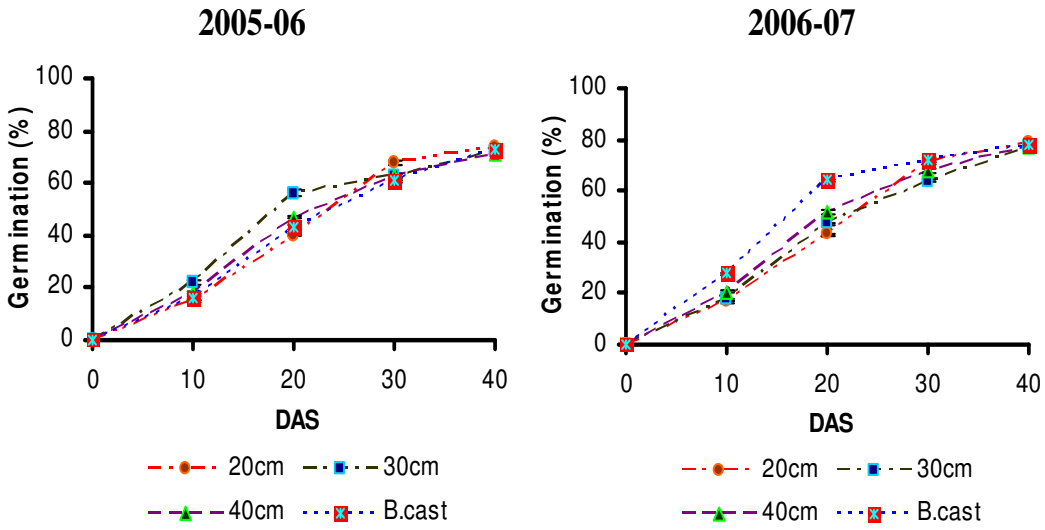

Figure 2. Effect of spacing and broadcast method on germination of Kangaroo grass at Rawalpindi during 2005-06 and 2006-07.

months stored seeds and fresh seeds respectively, while the least germination (19%) was observed for 18 months old seed.

Results of laboratory experiment revealed that the best seeds to be used in the field sowing were 12 months old seeds as the storage time increased germination of *Themeda* up to certain level and after that it decreased. From results, it can be suggested that period of dormancy for *Themeda* is 12 months and after that seed viability decreased and that is why least germination was observed for 18 months old seeds. *Themeda* dormancy involves grouping of embryo dormancy and mechanically resistant glumes (Groves et al., 1982). Results observed in this experiment are in confirmation to the findings of Groves et al. (1982), who concluded that seed germinability progressively improved over time in all regions, but the time required to achieve highest germination varies from 12 months to 28 months and even 48 months.

Germination under field conditions

Percent germination presented in Figure 2 showed statistical differences for plant to plant spacing treatments at Rawalpindi during year 2005 - 06 and 2006 - 07. During 2005 - 06, germination percentage for 20 cm spacing treatment was observed statistically significant from rest of the treatments while broadcast method and 30 cm spacing treatments were statistically similar from each other, whereas, both were observed significant with 40 cm spacing treatment. Percent germination for 20 cm spacing was observed maximum 73.85% (± 0.32) followed by 72.84% (± 0.76), 71.88% (± 0.93) for broadcast method (control treatment) and 30 cm spacing treatments, respectively, while the least germination of 71.13 % (± 0.26) was observed for spacing of 40 cm. For first 20 days, the maximum germination was observed for spacing treatments of 30 and 40 cm followed by broadcast method and 20 cm, respectively, whereas, for the last 20 days, the maximum germination was observed for 20 cm and broadcast method.

During 2006 - 07 germination percentage for plant to plant spacing treatment of 20 cm and broadcast method was statistically similar while both treatments were observed significantly different from treatments of 30 cm and 40 cm, whereas 30 cm and 40 cm spacing treatments were similar from each other. Percent germination for plant to plant spacing of 20 cm was observed maximum 78.69% (± 0.46) followed by 78.35% (± 0.51), 77.16% (± 0.47) for broadcast method and 30 cm spacing, respectively, while the least 76.79% (± 0.43) germination was observed for plant to plant spacing of 40 cm. For first 20 days, the maximum germination was observed for broadcast and spacing treatments of 40 cm followed by 30 and 20 cm, respectively, whereas, for the last 20 days, the maximum germination was observed for 20 cm and broadcast method.

Percent germination presented in Figure 3 showed statistically significant differences for plant to plant spacing treatments at Jhelum during year 2005 - 06 and 2006-07. During 2005-06, germination percentage for plant to plant spacing treatment of 20 cm was observed statistically significant with all other treatments while broadcast method and 30 cm treatments were similar from each other, whereas, both were observed significant with plant to plant spacing treatment of 40 cm. Percent germination for plant to plant spacing of 20 cm was maximum 62.07% (± 0.83) followed by 58.98% (± 0.78), 57.89% (± 0.34) for broadcast method and plant to plant spacing of 30 cm, respectively, while the least 54.47% (± 0.54) germination was observed for plant to plant spacing of 40 cm. For first 20 days, the maximum germination was observed for

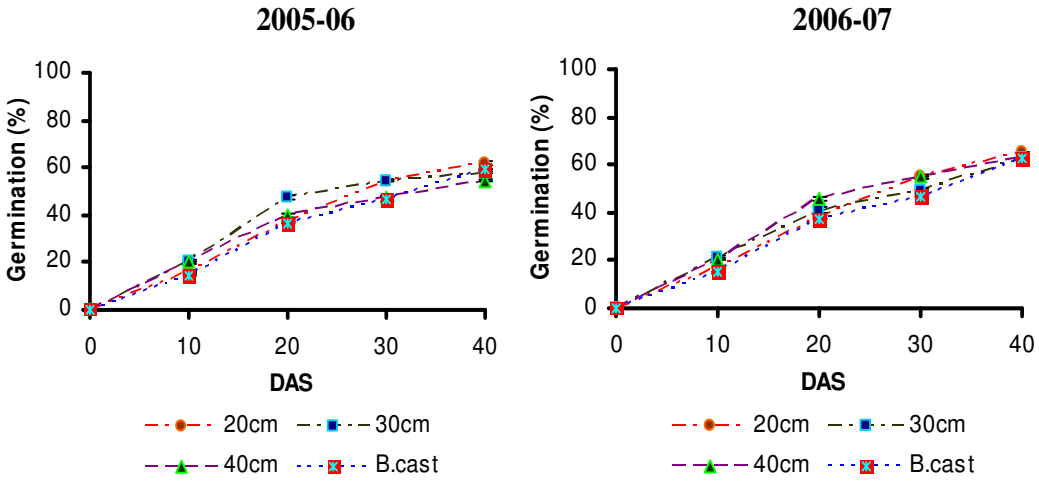

Figure 3. Effect of spacing and broadcast method on germination of Kangaroo grass at Jhelum during 2005 - 06 and 2006 - 07.

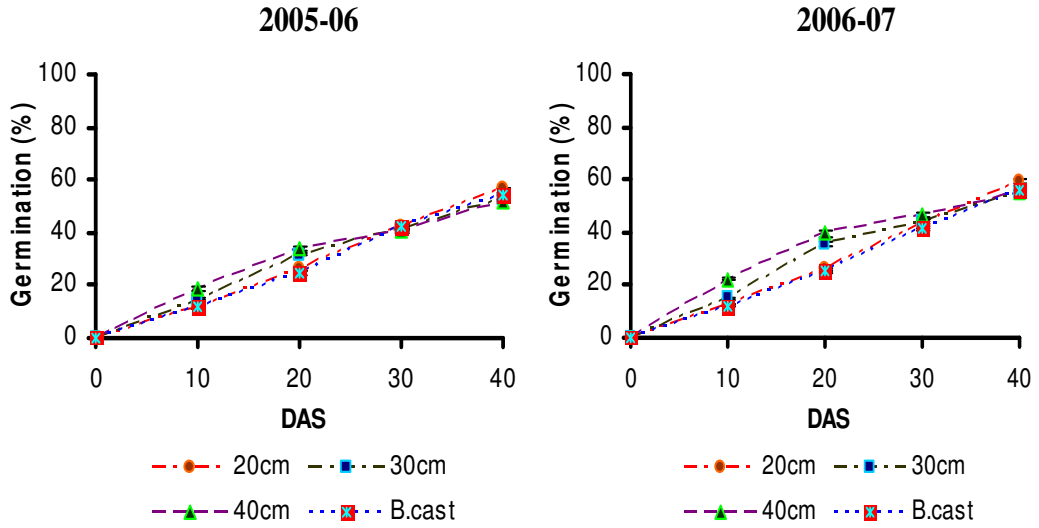

Figure 4. Effect of spacing and broadcast method on germination of Kangaroo grass at Talagang during 2005 - 06 and 2006 - 07.

spacing treatments of 30 and 40 cm followed by 20 cm and broadcast method, respectively, whereas, for the last 20 days, the maximum germination was observed for 20 cm and broadcast method.

During 2006 - 07, germination percentage for plant to plant spacing treatment of 20 cm was statistically significant with all other treatments while rest of the treatments were similar from each other. Percent germination for plant to plant spacing of 20 cm was observed maximum 65.12% (± 0.38) followed by 62.50% (± 0.32), 62.50% (± 0.54) for broadcast method and plant to plant spacing of 30 cm, respectively, while the least 62.35% (± 0.95) germination was observed for plant to plant spacing of 40 cm. For first 20 days, the maximum germination was recorded for spacing treatments of 40 and 30 cm followed by 20 cm broadcast, respectively, whereas for the last 20 days, the maximum germination was given by 20 cm and broadcast method.

Percent germination presented in Figure 4 showed statistically significant differences for plant to plant spacing treatments at Talagang during year 2005 - 06 and 2006 - 07. During 2005 - 06 germination percentage for plant to plant spacing treatment of 20 cm was statistically significant with all other treatments while plant to plant spacing treatments of 30 cm and 40 cm were similar from each other, whereas, both were statistically significant with broadcast method. Percent germination for plant to plant spacing of 20 cm was maximum 56.85% (± 0.20) followed by 54.47% (± 0.26), 52.39% (± 0.26) for broadcast method and plant to plant spacing of 30 cm, respec-

tively, while the least 52.01% (± 0.45) germination was given by plant to plant spacing of 40 cm. For first 20 days, the maximum germination was observed for spacing treatments of 40 and 30 cm followed by 20 cm and broadcast, respectively, whereas for the last 20 days, the maximum germination was observed for 20 cm and broadcast method.

During year 2006 - 07, germination percentage for plant to plant spacing treatment of 20 cm was statistically significant with all other treatments; however, other treatments were similar with each other. Percent germination for plant to plant spacing of 20 cm was maximum 59.29% (± 0.66) followed by 56.02% (± 0.26), 55.51% (± 0.61) for broadcast method and plant to plant spacing of 30 cm, respectively, while the least 55.36% (± 0.89) germination was observed for plant to plant spacing of 40 cm. For first 20 days, the maximum germination was recorded for spacing treatments of 40 and 30 cm followed by 20 cm and broadcast, respectively, whereas for last the 20 days, the maximum germination was observed for 20 cm and broadcast method.

Overall, the maximum germination was observed at Rawalpindi followed by Jhelum and least was observed at Talagang during both the years that is, 2005 - 06 and 2006-07. The significant differences among locations might be due to difference in climatic (rainfall + temperature) and physiochemical soil conditions.

During study period 2005 - 06 Rawalpindi received maximum rainfall (high rainfall area) followed by Jhelum (medium rainfall area), while Talagang received less rainfall (low rainfall area). Temperature fluctuation also had some effects on germination at the three locations. It is assumed that high temperatures encouraged *Themeda* seed germination and earlier study have shown that highest germination is achieved at above 30°C (Mott, 1978). In the field, *Themeda* is improbable to germinate until daily maximum temperature reaches 18°C (Hagon et al., 1975). Low germination is reported at low moisture potentials (Groves et al., 1982). Germination potential of *themeda* may be better in clay than in sand (Hagon and Chan, 1977). Thus, findings of present study are in conformity with above conclusion.

It was also observed that germination was maximum for closer spacing while it was least at wider spacing during both the years that is, 2005 - 06 and 2006 - 07. It may be due the utilization of soil moisture in better way by seeds growing at closer spacing than wider spacing. The wider spaces may have made more available moisture which decreased seed viability. The increase in moisture content of the seed reduced its viability has been reported by Senter et al. (1975). The germination of seed from closer spacing crop was considerably higher than the minimum given limit (60%) (Panditav et al., 2005). Thus, results of present study are in line with earlier findings. *Themeda* germination is observed sensitive to water stress as compared to other grasses *(*Hagon and Chan, 1977) and improved germination can be obtained as soil moisture approaches field capacity (Nolan, 1994).

Germination moisture necessities vary geographically and germination is most susceptible to water stress in arid populations (Groves et al., 1982). Hagon and Chan (1977) found higher levels of germination in clay than sandy soils.

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