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Assessing the Germination of Dry Forest Species in Relation to Changing Drought and Salinity Conditions

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ခြောက်သွေ့ဒဏ်နှင့်ဆားငံဓါတ်ပြောင်းလဲမှုကိုလိုက်၍ အပူပိုင်းဒေသသစ်မျိုးများ၏ အညှောင့်ပေါက်မှုကို စမ်းသပ်တိုင်းတာခြင်း

စံမင်းရွှေ၊ ဒေါက်တာစံသွင်၊ ဒေါက်တာအစ်အစ်ရွှေဇင်၊ ဒေါက်တာညွှန့်ခိုင်
သစ်တောတက္ကသိုလ်၊ရေဆင်း

စာတမ်းအကျဉ်း

ခြောက်သွေ့ခြင်းနှင့် မြေဆီလွှာဆားငံဓါတ် ပေါက်ခြင်းတို့သည် အပူပိုင်းဒေသတွင် ပေါက်ရောက်သော သစ်မျိုးများ၏ အညှောင့်ပေါက်ခြင်းနှင့် ကြီးထွားခြင်းအပေါ် အဓိက သက်ရောက်သောပြသနာကြီးနှစ်ခုဖြစ်ပေသည်။ အညှောင့်ပေါက်ခြင်းအဆင့်သည် သစ်တော သစ်ပင်များအတွက် အရေးကြီးသောအဆင့်ဖြစ်ပြီး ဆားငံဓါတ်ကို ခံနိုင်ရည် အနည်းဆုံး သော အဆင့်ဖြစ်ပေသည်။ သစ်မျိုးများ၏ ကနဦးကြီးထွားမှုအဆင့်တွင် ခြောက်သွေ့ဒဏ်နှင့် ဆားငံဓါတ်ခံနိုင်ရည်ရှိမှုအား စမ်းသပ်ခြင်းသည် အရေးကြီးပြီး ခြေက်သွေဒဏ်နှင့် ဆားငံ ဓါတ်ကိုခံရည်ရှိသော သစ်မျိုးများကို စမ်းသပ်ရရှိစေနိုင်ပါသည်။ သစ်စေ့အညှောင့် ပေါက် ခြင်းနှင့် ပျိုးပင်အရည်အသွေးတို့သည် သစ်မျိုးများ၏ ခြောက်သွေ့ဒဏ်နှင့် ဆားငံဓါတ် ခံနိုင် ရည်ရှိမှုတို့ကို အဓိကတိုင်းတာသော စံနှုန်း များဖြစ်ကြပေသည်။ ယခုပြုလုပ်သော သုတေ သန စာတမ်းတွင် အပူပိုင်းဒေသတွင် ပေါက်ရောက်သော သစ်မျိုး(၅)မျိုး၏ ခြောက်သွေ့ ဒဏ် နှင့် ဆားငံဓါတ်ခံနိုင်ရည်ရှိမှု တို့ကိုတိုင်းတာရန်၊ သစ်မျိုးများ၏ စတင် အညှောင့် ပေါက်ချိန် နှင့်အညှောင့်ပေါက်နှုန်းတို့ကို နှိုင်းယှဉ်တွက်ချက်ကာ ဖော်ပြထားပြီး ရရှိလာသော သုတေသနရလဒ်များကို အပူပိုင်းဒေသ ရှိ မြန်မာနိုင်ငံ သစ်တောများ ပြန်လည်ထူထောင်ရေး စီမံကိန်းအတွက် သိပ္ပံနည်းကျသော အချက်အလက်များ ထောက်ပံ့ပေးနိုင်ရန် ရည်ရွယ်ပါ သည်။ အပူပိုင်းဒေသတွင်ပေါက်ရောက် သော သစ်မျိုးများဖြစ်သည့် ရှား၊ ကုက္ကို၊ မယ်ဇလီ၊ ယူကလစ်နှင့် အော်ရီးရှားတို့ကို ခြောက်သွေ့မှုအဆင့်(၅)ဆင့်၊ ဆားငံဓါတ်(၅)မျိုး တို့ဖြင့် စမ်းသပ်ကာအညှောင့်မှုကို စမ်းသပ် တိုင်းတာခဲ့ပါသည်။ ခြောက်သွေ့မှုအဆင့်များသည် ကုက္ကိုသစ်မျိုးတစ်မျိုးတည်း၏ စတင် အညှောင့်ပေါက်နိုင်မှုပေါ်တွင်သာ သက်ရောက်မှုရှိပြီး ကျန်သစ်မျိုးများအပေါ်တွင် သက်ရောက်မှုမရှိသည်ကို တွေ့ရှိပါသည်။ ဆားငံဓါတ်သည် စမ်းသပ်သည့် သစ်မျိုးအားလုံး၏ စတင်အညှောင့်ပေါက်မှုအပေါ်တွင် သက်ရောက်မှုရှိပြီး ဆားငံဓါတ်မြင့်တက်လာသည် နှင့်အမျှ သစ်မျိုးများ၏ စတင်အညှောင့်ပေါက်မှုကို ပိုမို နှေးကွေး စေပါသည်။ ခြောက်သွေ့ ဒဏ်နှင့်ဆားငံဓါတ်တို့သည် စမ်းသပ်သည့် သစ်မျိုးများ ၏ အညှောင့်ပေါက်နှုန်းကို ထိခိုက်မှု မရှိစေသည်ကို တွေ့ရှိရပြီး၊ အော်ရီးရှား သစ်မျိုး တစ်မျိုးထဲတွင်သာ ဆားငံဓါတ်မြင့်တက် လာသည်နှင့်အမျှ အညှောင့်ပေါက်နှုန်းသိသာစွာ ကျဆင်းသွားသည်ကိုတွေ့ရှိရပါသည်။

Assessing the Germination of Dry Forest Species in Relation to Changing Drought and Salinity Conditions

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Abstract

Drought and salinity are the two major limiting factors on the germination and growth of forest species in arid region. Germination is the critical and most salt sensitive stage in plant life cycle. Drought and salinity tolerance testing at the initial stages of plant development is of vital importance because drought and salinity tolerance of dry forest species can be expected to achieve. Germination and seedling characteristics are the most viable criteria used for selecting drought and salt tolerance in plants**.** This study aims to assess the response of five dry forest species to drought and salinity at the germination stage, to investigate seed germination percentages and commencement germination of the selected tree species under changing drought and salinity levels, to provide scientifically sound results for the Myanmar Reforestation and Rehabilitation Programme in Central Myanmar. Five Dry Forest species, *Acacia catechu* Willd., *Albizzia lebbeck* (L) Benth, *Cassia siamea* Lam., *Eucalyptus camaldulenis* Dehn. and (*Acacia auriculiformis* A.Cunn.) were selected to carry out the experiment. Five levels of drought such as control, 80% watering, 60% watering, 40% watering and 20% watering and five levels of salinity such as control, 10 dSm^{-1}, 15 dSm^{-1}, 20 dSm^{-1} and 25 dSm^{-1} were used for the study. The results revealed that the drought treatments affect only on the commencement germination of the *Albizzia lebbeck*. In salinity treatment, the commencement germination of the studied species were delayed with the increased in salinity levels. According to ANOVA results, the effect of the drought treatments was not significantly different on the germination percentage of the selected species at $p<0.05$. The results revealed that the effect of the salinity treatment was not significantly different on the germination percentage of the selected species at $p<0.05$, except *Acacia auriculiforms* and the germination of this species, was significantly different at $p<0.05$.

Keywords: drought, dry forest species, germination, salinity stress.

Assessing the Germination of Dry Forest Species in Relation to Changing Drought and Salinity Conditions

1. Introduction

Germination is the critical and the most salt-sensitive stage in the plant life cycle and compromising the establishment of seedlings (Klob and Barsch, 2010 and Karagić et al., 2010). Drought and salinity of soil are the two major environmental factors limiting the germination and growth of forest species in arid and semi-arid regions and play an important role in determining the germination and development of seedlings (Kalefetoglu et al., 2009). These two factors are affecting the plants in a similar manner, primarily by reducing the water potential (Petrović and Jovičić, 2006). Plants have evolved a number of complex protective mechanisms to overcome and survive in stressful environmental conditions (Mahajan and Tuteja, 2005). Successful seedling establishment depends on the frequency and the amount of precipitation, as well as the species and the ability of seeds to germinate and, grow while soil moisture and osmotic potentials decrease (Roundy, 1987).

Studies on the response of forest trees species to several environmental stresses at different stages of development are very important for improving the regeneration capacity and also lead to the successful establishment of plantations (Tayseer, 2010). It has been long known that seeds that are exposed to unfavorable environmental conditions, like water stress and salinity, the germination of seeds are difficult. Drought and salinity tolerance testing at the initial stages of plant life cycle is of vital importance, because of the species which can tolerate to drought and salinity could be expected to achieve a rapid establishment of seedlings (Petrović and Jovičić, 2006).

In the Dry Zone of Myanmar, the forest types are dry forest in nature. Nowadays, deforestation has occurred in a wide range (UNCCD, 2005) and the regeneration capacity of dry forest species are challenging by several environmental stresses. Germination and seedling establishment are the first, arguably the most important ‘unknown' but this is also the most vulnerable stage in the life cycle of plants (Benech-Arnold and Sanchez, 2004). Germination and seedling characteristics are the most viable criteria used for selecting drought and salt tolerance in plants (Boubaker, 1996).

Drought is one of the most devastating environmental stresses that affect the growth, development, and production of plants (Jajarmi, 2009). Severe drought stress filtered species that are not drought tolerant, and more likely to kill seedlings, rather than adults (Wright, 1992; Coomes and Grubb, 2000; Wright, 2002). Bunker and Carson, (2005) also stated that young seedlings are more susceptible to drought because which have had more time to develop larger root systems to against drought. In spite of the importance of seedlings in forest dynamics, most research efforts have focused on the effects of drought on larger size classes tree (Condit et al., 1995, 1996; Wright et al., 1999; Nakagawa et al., 2000; Laurance and Williamson, 2001), and few studies had focused on seedling stages (Gilbert et al., 2001; Engelbrecht et al., 2002; Delissio and Primack, 2003; Engelbrecht and Kursar, 2003). In Myanmar, the response of dry forest species to drought and salinity at the germination stage has never, to my knowledge, been experimentally tested.

Soil salinity as one of the major environmental stresses affecting the plant growth and production (Nikolova et al., 2005). Salinity affects seed germination through osmotic effects (Blisset al., 1986), ion toxicity (Hampson and Simpson, 1990) or a combination of the two (Huang and Redmann, 1995). Production of green buds and seeds is strongly affected by drought and salinity stress, resulting in poor plant establishment in dry and saline soils (Afzal et al., 2005). Furthermore, high intracellular concentrations of both Na^+ and Cl_2 can inhibit the metabolism of dividing and expanding cells (Neumann, 1997), retarding germination and even leading to seed death. Germination seems very sensitive in their development stages with increasing salinity (Sosa et al., 2005; Zare et al., 2006). Despite the importance of seed germination under salt stress (Chapman, 1974; Ungar, 1995), the salt tolerance mechanisms in seeds is relatively poorly understood, especially most of the studies were emphasized on about salt tolerance physiology and biochemistry in vegetative plants (Hester et al., 2001; Garthwaite et al., 2005; Hu et al., 2005; Ren et al., 2005; Kanai et al., 2007). NaCl salinity may also affect germination by facilitating the intake of toxic ions, which may cause change of certain enzymatic or hormonal activities of the seed (Smith and Comb, 1991). These physicochemical effects upon the seed seem to result in a slower and/or lower germination.

Seed germination is an important and vulnerable stage in the life cycle of plants and determines seedling establishment and plant growth. Furthermore, seedling recruitment is often considered the critical stage in forest dynamics, because of the greater susceptibility of seedlings, rather than trees, to the myriad inimical forces acting upon them and because canopies are composed of individuals that have passed through this vulnerable seedling stage (Harper 1977; Wright 1992, 2002). Enhancement of seed germination may result in better seedling establishment especially under salinity and drought stresses condition (He et al., 2002).

2. Objectives

This study aims**:**

(a) To assess the response of five dry forest species to drought and salinity at the germination stage,

(b) To investigate seed germination percentages and commencement germination of the selected tree species under changing drought and salinity levels, and

(c) To provide scientifically sound results for the Myanmar Reforestation and Rehabilitation Programme in Central Myanmar.

3. Materials and Methods

The effects of drought and soil salinity stress on the germination of five dry forest species at the nursery stage were examined. The species selected to carry out experiment were Sha (*Acacia catechu* Willd.), Kokko (*Albizzia lebbeck* (L) Benth), Mezali (*Cassia siamea* Lam.), Eucalypt (*Eucalyptus camaldulenis* Dehn.) and Auri-sha (*Acacia auriculiformis* A.Cunn.). The studied species were selected based on two basic criteria (i) most of the species were dominant species in Central Dry Zone of Myanmar and (ii) most species were widely used in Dry Zone plantations.

3.1 Seed sources and seed pre-treatment methods

Acacia catechu, *Cassia siamea* and *Eucalyptus camaldulenis* seeds were obtained from the Seed Center of Forest Research Institute, Yezin. *Albizzia lebbeck* seeds were collected from the natural dry-forest of Mahlaing Township. *Acacia auriculiformis* seeds were collected from the campus of Forest Research Institute, Yezin. The seeds of the selected species were collected prior to two months before sowing in the nursery. The seeds were air-dried for two weeks and stored in containers.

Acacia catechu, Albizzia lebbeck and *Cassia siamea* seeds were soaked in hot water for three minutes before sowing in the seed beds. While *Acacia auriculiformis* seeds were soaked in hot water for five minutes before sowing. After soaking, the hot water was removed and soaked in the water. *Eucalyptus camaldulensis* seeds were not exposed to any pre-treatment methods.

3.2 **Watering procedure for drought treatment**

Five levels of drought (water stress) were used to test the germination of the selected species. The seeds were sowed in the seed beds and irrigated with the five levels of water (100% watering, 80% watering, 60% watering, 40% watering and 20% watering). The amount of irrigation water for each level was calculated based on the average monthly rainfall in planting season in dry zone (80 mm per month). Seedbeds for 100% watering, 80% watering, 60% watering, 40% watering and 20% watering were watered with 1350 ml, 1150 ml, 800 ml, 550 ml and 270 ml per day.

3.3 **Preparation of saline soil**

Five levels of soil salinity (electrical conductivity) were used to test the germination of the selected species. Sodium chloride (NaCl) 51.42g, 77.12g, 102.82, 128.54g was thoroughly mixed with 20 kg of soil, to give the soil electrical conductivities of $10dSm^{-1}$, $15dSm^{-1}$, $20dSm^{-1}$ and $25dSm^{-1}$. The electrical conductivity of the control soil was $0.10dSm^{-1}$. The electrical conductivity of the soils was measured by the used of DS-51, HORIBA Conductivity Meter.

3.4 Experimental design

The experiment was carried out at the nursery condition of Forest Research Institute, Yezin in May to June 2017. In this test, germination percentage and commencement germination of the species at all levels of salinity and drought were tested. For the germination test, 100 seeds for each species will be used and carried out the experiment. A total of 5000 seeds were used for the whole experiment. In salinity treatment plots, the seed beds were watered with 1350 ml per day. In all treatment plots, watering was done on every alternate day. Seed germination was considered after the radicle had emerged to 2 cm in height. Germinated seeds were counted and recorded daily until the germination has stopped.

4. Data Analysis

Germination percentage and commencement germination of the selected species were recorded. Germination percentages of the selected species were calculated by the formula;

$$\text{Germination Percentage} = \frac{S}{T} \times 100\% \text{ (Soltani et al., 2002)}$$

In which, S is the number of germinated seeds, T is the total number of seed, STATISTICA for Windows (Version 9.0, Statsoft, Inc., Tulsa, USA) were used for all for data analyzing the process. All of the graphs were plotted in Microsoft Excel 2013. The exponential relation was developed to find the correlation between both drought and salinity stresses and germination percentage of the species.

5. Results

5.1 Effects of drought and salinity on germination of five dry forest species (Within Species)

5.1.1 ***Acacia catechu***

Results showed that the effects of drought and salinity were not significant ($p<0.05$) on the germination percentage of the *Acacia catechu* (Table:1 and 2). In drought treatments, the highest germination percent was related to the 40% watering treatment (96%) and the lowest was germination was (86%) at 60% watering (Figure:6). In salinity treatments, the highest germination percent was related to the concentration of $15dSm^{-1}$ (92%) and the lowest was to the concentration of $25dSm^{-1}$ (62%) (Figure:7). The effects of drought treatments were no effect on the commencement germination of the *Acacia catechu* and the species started to germinate three days after sowing in all drought treatments (Figure:1a). However, the salinity treatments were delayed the commencement germination of the *Acacia catechu*. In control treatment and the concentration of $10dSm^{-1}$ the commencement germination of the species was three days after sowing and in the concentration of $25dSm^{-1}$ the germination was five days after sowing of seeds (Figure:1b).

5.1.2 *Albizzia lebbeck*

Results showed that the germination percentage of the *Albizzia lebbeck* was not significantly different in all drought levels (Table:1). The commencement germination of the species was delayed with the increase in drought treatment. In control treatment, the germination started four days after sowing and six days after sowing of seeds in the 20% watering treatment (Figure 2a). The effect of salinity was not significant ($p<0.05$) on the germination percentage of the *Albizzia lebbeck* (Table:2) and was delayed the commencement germination of the species (Figure 2b). In drought treatment, the highest germination percentage was related to the control treatment (76%) and the lowest was related to the 60% watering treatment (56%) (Figure:6). In salinity treatments, the highest germination was related to control treatment (76%) and the lowest was to the concentration of $25dSm^{-1}$ (39%) (Figure:7). However, the germination percentage of the species dropped with the increase in salinity. The commencement germination of the *Albizzia lebbeck* was delayed with the increase in salinity and in control treatment the germination started four days after sowing and in the concentration of $25dSm^{-1}$ the germination was started seven days after sowing (Figure:2b).

5.1.3 *Cassia siamea*

In *Cassia siamea*, the effects of drought and salinity were not significant ($p<0.05$) on the germination percentage (Table:1 and 2) and the effect of drought was not also effected the commencement germination of the species (Figure:3a). In drought treatment, the highest germination percent was related to the control treatment (65%) and the lowest was related to the concentration of $25dSm^{-1}$ (38%) (Figure:6). In salinity treatment, the highest germination percent was related to the control treatment (65%) and the lowest was to the 20% watering treatment (50%) (Figure:7). In salinity treatment, the germination started four days after sowing in control treatment and germinated six days after the sowing of seeds (Figure:3b).

5.1.4 *Eucalyptus camaldulensis*

The results showed that the effects of drought and salinity were not significantly affected ($p<0.05$) the germination percentage (Table:1 and 2). The commencement germination of the *Eucalyptus camuldulensis* species was not affected by drought treatment (Figure:4a). In drought and salinity treatments, the highest germination percentage was obtained at the control treatment (81%) and the lowest was related to the 20% watering (59%) and concentration of $25dSm^{-1}$ (48%) (Figure:6 and 7). Germination started five days after the sowing of seeds in control treatment and seven days after seed sowing in the concentration of $25dSm^{-1}$ salinity (Figure:4b). However, the germination percentage of the *Eucalyptus camuldulensis* was decreased associated with the increase in drought and salinity stresses.

5.1.5 *Acacia auriculiformis*

The effects of drought stress was no significantly affecting ($p<0.05$) the germination percentage of and affect the commencement germination of the *Acacia auricumiformis* (Table:1 and Figure 5a). However, the germination percent of the species was dropped with the increase in drought stresses and the highest germination percent was related to the control treatment (86%) and the lowest was related to the 20% watering stress (38%) (Figure:6). On the other hand, the germination percentage of the *Acacia auriculifomis* was significantly affected ($P\leq0.05$) (Table:2) but the commencement germination of the species was the same in all salinity treatments (Figure:5b). In salinity treatment, the highest germination was obtained at the control treatment (86%) and the lowest was at the concentration of $25dSm^{-1}$ (43%) (Figure:7). The germination percentage of the *Acacia auriculiformis* was significantly dropped with the increased in salinity stresses.

5.2 **Effects of drought and salinity on germination percentages of five dry forest species (Between Species)**

The ANOVA results (comparison between species) showed that drought stress the significant effect ($p<0.05$) on the germination percentage of five dry forest species (Table:3). In control treatment, the highest germination percentage was related to the *Acacia catechu* (87%) and the lowest germination percentage was *Cassia siamea* (65%). In 80% watering treatment, the highest germination percentage was *Acaica catechu* (89%) and the lowest was *Cassia siamea* and *Albizzia lebbeck* (59%). In 60% watering treatment, the highest germination percentage was *Acacia catechu* (86%) and the lowest was *Cassia siamea* (54%). In 40% watering treatment, *Acacia catechu* has the highest germination percentage (96%) and *Cassia siamea* has the lowest germination percentage (49%). In 20% watering, the highest germination percentage was obtained at the species of *Acacia catechu* (92%) and the lowest germination percentage was obtained at the *Acacai auriculiformis* (43%). According to the results obtained from ANOVA table, *Acacia catechu* obtained the highest germination percentage at all drought (water stress) levels and then followed by *Eucalyptus camaldulensis, Acacia auriculiformis, Albizzia lebbeck* and *Cassia siamea* (Table:3).
The ANOVA results (comparison between species) showed that salinity stress the significant effect ($p<0.05$) on the germination percentage of five dry forest species (Table:4). In control treatment, the highest germination percentage was related to the *Acacia catechu* (87%) and the lowest germination percentage was *Cassia siamea* (65%). In concentration of 10 dSm^{-1} salinity, the highest germination percentage was *Acaica catechu* (86%) and the lowest was *Cassia siamea* (56%). In $15dSm^{-1}$ salinity, the highest germination percentage was *Acacia catechu* (92%) and the lowest was *Cassia siamea* (57%). In concentration of $20dSm^{-1}$ salinity, *Acacia catechu* has the highest germination percentage (84%) and *Cassia siamea* has the lowest germination percentage (40%). In 20% watering, the highest germination percentage was obtained at the species of *Acacia catechu* (62%) and the lowest germination percentage was obtained at the *Cassia siamea* and *Acacai auriculiformis* (38%). According to the results obtained from ANOVA table, *Acacia catechu* obtained the highest germination percentage at all drought (water stress) levels and then followed by *Acacia auriculiformis, Eucalyptus camaldulensis, Albizzia lebbeck* and *Cassia saimea* (Table:4).

6. Discussion

6.1 Effects of drought and salinity on germination percentages of five dry forest species

6.1.1 Effect of drought on germination percentages

The results showed that the effect of the drought treatments was not significantly different ($p<0.05$) the germination percentage of the selected species. However, the germination percentage of the three studied species (*Cassia siamea*, *Eucalyptus* *camaldulensis* and *Acacia auriculiformsis*) decreased with the increased in drought levels, particularly at high drought levels. Surprisingly, the germination percentage of the *Acacia catechu* and *Albizzia lebbeck* were increased after the drought levels of 60% watering. The highest germination percentage (96%) was obtained at 40% watering in *Acacia catechu* and the (76%) at control (100% watering) for *Albizzia lebbeck*. According to Parrotta 1988 and Troup 1921, the species *A. lebbeck* is somewhat less sensitive to drought and germination of freshly extracted seeds was 60 to 90 percent. Germination and early seedling development are favored by sowing seeds just below the soil surface in a loose, moist medium under light shade or full sun (Venkataramany, 1968).

If water absorption disturbed or delayed, could delay in seed metabolic processes and lead to delay in germination of seeds. Reduction of germination process due to drought stress can be related to a decrease in water absorption by seeds. Water availability of the soil is considered one of the principal causes of low germination in seeds (Jajarmi, 2009). Seed germination is triggered by the amount of water the seed can imbibe, which is related to the water potentials of both the soil and the seed (Bewley et al., 2013; Bradford, 2002; Evans & Etherington, 1990; Williams & Shaykewich, 1971).

6.1.2 Effect of salinity on germination percentages

The results revealed that the effect of the salinity treatments was not significantly different ($p<0.05$) the germination percentage of the selected species, expect *Acacia auriculiforms* and the germination of this species was significantly different at ($p<0.05$). Moreover, the germination percentage of the most of the studied species decreased with the increased in salinity levels, particularly at high salinity levels. Except Acacia catechu, the germination percentage (92%) was obtained at the salinity concentration of $15 dSm^{-1}$. The decrease in the germination percentage of the five species with the increase in salinity concentration was in agreement with the results of Tayseer, (2010), A. nilotica, A. senegal, A. lebbeck, E. camaldulensis and C. equisetifolia., Ganapathy, (2007) of Ceiba pentandra and E. camaldulensis, Ramoliya and pandey, (2002 and 2006) of A. nilotica and A. leebeck and Moslem Fetri et al., (2014) of Achillea millefolium.

The salinity in the seed germination stage damage the membrane of the cell, particularly the cytoplasmic membrane that results in increased permeability of the membrane due to the replacement of Ca^{2+} by Na^{+} that resulted to increasing in K^{+} losses (Takel, 2000). Salinity impressed seed germination through osmotic pressure and therefore reduction of water absorption by seeds and also from the toxic effects of Na^{+} and Cl^{-} (Rehman et al., 1996). In this study, reduction of different germination parameters can be related to the reduction of speed and rate of water absorption. In addition to the osmotic effect which reduces the uptake due to the specific toxicity effect of ions, the loss of germination percentage is caused by the interruption of nutrients uptake which has been confirmed by Safarnejad et al., (1996), Penuelas et al., (1997) and Shalhevet, (1993), too.

It has been shown that the raising of salinity increased the uptake of Na, K and P and decreased the uptake of N which can be the reason for the loss of germination percentage (Tarzi, 1995). Salinity may inactivate the germination -affecting enzymes, especially by increasing the uptake of K^{+} which brings about a secondary peak which as a result, inhibits the activation and/or synthesis of germination-affecting enzymes and the uptake of Ca^{2+} increases in a confrontation with Na^{+}. Nabizadeh, (2002) stated that the adverse effect of salinity on plants can be caused by the loss of osmotic potential of root medium, specific ion toxicity and the lack of nutritional ions.

6.2 Effects of drought and salinity on commencement germination of the five dry forest species

The results of the commencement germination of five dry forest species tested using five levels of drought treatments and five levels of salinity concentrations showed that seeds of all species were able to germinate at all drought and salinity treatments during the course of experiment period. The drought treatments have no effect on the commencement germination of the four selected species (*Acacia catechu*, *Cassia siamea*, *Eucalyptus camaldulensis* and *Acacia auriculiformis*). However, the commencement germination of the *Albizzia lebbeck* was delayed with the increase in drought levels after 60% watering. Salinity resulted in a general delay in the commencement of seed germination of the five species compared to their respective germination in control treatment, however, the different species showed varied responses to the increased levels of salinity. In salinity treatment, the commencement germination of the studied species was delayed with the increased in salinity levels from up to 15 dSm^{-1} a threshold value for *Acacia catechu* , *Albizzia lebbeck* and *Acacia auriculiformis* and after 10 dSm^{-1} for *Cassia siamea* and after 20dSm^{-1} for *Eucalyptus camaldulensis.*

6.2.1 Effect of drought on commencement germination of seeds

The results were agreement with the results of (Ungar, 1991) and indicate that the effect of salinity on initiation of seed germination is variable and species-specific. The rapidity in seed germination is particularly important in adverse climatic conditions, where salinity is aggravated by scarce and erratic precipitation. Seeds that germinate without delay can make use of the limited soil water pool to establish seedlings before adverse climatic conditions prevail. It is, therefore, logical that the diffusion and reaction of water during seed germination will be reduced by increasing salinity, leading to delay of seed germination (Tayseer, 2010). The difference in germination ability between heteromorphic seeds is suggested to be related to the thickness and hardness of the seed coat that prevents radicle protrusion and water permeability (Yao et al., 2010).

6.2.2 Effect of salinity on commencement germination of seeds

The results obtained from this study were in agreement with the findings of (Rashid et al., 2004) and who stated that with the levels of salinity increase, the initial or commencement germination of all the species is delayed and cessation is facilitated. However, the rate of delayed in germination varies within species. Soil salinity affects germination either by (Mandal and Handoo, 1998a) increasing the osmotic pressure of the soil solution to a plant that will retard or prevent the intake of water or (Uhivits 1946 and Bernstein, 1961) by causing toxicity to the embryo. This effect may slow (Mehta and Desai, 1958) down or completely inhibit germination depending on the level of salt in the medium.

7. Conclusion

From the result of this study, it can be concluded that all studied species can germinate at all drought and salinity levels. However, the germination percentage of all the species were decreased with the increase in drought and salinity levels. The commencement germination of the most studied species was not affected by drought stress, but the commencement germination of the species was delayed with the increased in drought stress. The germination percentages of the studied species did not significantly affect by drought stress. The germination percentages of the studied species did not affect by salinity stress except *Acacia auriculiformis* which germination percentage was significantly decreased by salinity.

Table 1 Germination of five dry forest species in five levels of drought stresses (Within Species)

Species	n	Watering				
		Control	**80%**	**60%**	**40%**	**20%**
Acacia catechu	100	17.0±6.9(a)	18.0±6.6(a)	22.0±4.3(a)	19.0±6.8(a)	23.0±7.6(a)
Albizzia lebbeck	100	6.0±1.3 (a)	6.0±1.1 (a)	4.0±1.0 (a)	5.0± 1.4a)	5.0±0.9(a)
Cassia siamea	100	7.0±3.1(a)	7.0±2.7(a)	6.0±3.0(a)	7.0±2.7(a)	8.0±3.6(a)
Eucalyptus camaldulensis	100	14.0±3.2(a)	11.0±6.4(a)	13.0±8.3(a)	10.0±6.7(a)	15.0±9.8(a)
Acacia auriculiforms	100	5.0±0.7(a)	4.0±0.6(a)	4.0±0.6(a)	4.0±0.7(a)	3.0±0.6(a)

Means ± standard errors are shown for each variable. Within a parenthesis, means followed by different letters were statistically different at $p < 0.05$ (Tukey HSD test). n= Number of replications.

Table 2 Germination of five dry forest species in five levels of salinity stresses (Within Species)

Species		Salinity				
	n	**Control**	**10 dSm^{-1}**	**15 dSm^{-1}**	**20 dSm^{-1}**	**25 dSm^{-1}**
Acacia catechu	100	17.0±6.9(a)	17.0±7.6(a)	23.0±12.8(a)	17.0±6.5(a)	9.0±1.8(a)
Albizzia lebbeck	100	6.0±1.3(a)	7.0±1.6(a)	5.0±1.3(a)	5.0±0.9 (a)	4.0±1.1(a)
Cassia siamea	100	7.0±3.1(a)	5.0±1.8(a)	6.0±2.6(a)	5.0±2.2(a)	5.0±1.4(a)
Eucalyptus camaldulensis	100	14.0±3.2(a)	14.0±6.4(a)	10.0±6.0(a)	8.0±2.3(a)	8.0±2.2(a)
Acacia auriculiforms	100	5.0±0.7(a)	4.0±0.6(ab)	5.0±0.7(ab)	4.0±0.6(ab)	3.0±0.4(b)

Means ± standard errors are shown for each variable. Within a parenthesis, means followed by different letters were statistically different at $p< 0.05$ (Tukey HSD test). n= Number of replications.

Table 3 Germination of five dry forest species in five levels of drought stresses (Between Species)

Watering Level	n	Species				
		Acacia catechu	*Albizzia lebbeck*	*Cassia siamea*	*Eucalyptus camaldulensis*	*Acacia auriculiformis*
Control	100	17.0±6.9(a)	6.0±1.3(b)	7.0±3.1(ab)	14.0±3.2(ab)	5.0±0.1(b)
80%	100	18.0±6.6(a)	6.0±1.1(ab)	7.0±2.7(ab)	11.0±6.4(ab)	4.0±0.6(b)
60%	100	22.0±4.3(a)	4.0±1.0(b)	6.0±3.0(b)	13.0±8.3(ab)	4.0±0.6(b)
40%	100	19.0±6.8(a)	5.0±1.4(b)	7.0±2.7(ab)	10.0±6.7(ab)	4.0±0.7(b)
20%	100	23.0±7.0(a)	5.0±1.0(b)	8.0±3.6(ab)	15.0±10.0(ab)	3.0±0.6(b)

Means ± standard errors are shown for each variable. Within a parenthesis, means followed by different letters were statistically different at $p < 0.05$ (Tukey HSD test). n= Number of replications.

Table 4 Germination of five dry forest species in five levels of salinity stresses (Between Species)

Salinity Levels	n	Species				
		Acacia catechu	*Albizzia lebbeck*	*Cassia siamea*	*Eucalyptus camaldulensis*	*Acacia auriculifromis*
Control	100	17.0±6.9(a)	6.0±1.3(b)	7.0±3.1(ab)	14.0±3.2(ab)	5.0±0.1(b)
10 dSm^{-1}	100	17.0±7.6(a)	7.0±1.6(ab)	5.0±1.8(b)	14.0±6.4(ab)	4.0±0.6(b)
15 dSm^{-1}	100	23.0±12.8(a)	5.0±1.3(b)	6.0±2.6(b)	10.0±6.0(ab)	4.0±0.7(b)
20 dSm^{-1}	100	17.0±6.5(a)	5.0±0.9(b)	5.0±2.2(b)	8.0±2.3(ab)	4.0±0.6(b)
25 dSm^{-1}	100	9.0±1.8(a)	4.0±1.1(ab)	5.0±1.4(ab)	8.0±2.2(a)	3.0±0.4(b)

Means ± standard errors are shown for each variable. Within a parenthesis, means followed by different letters were statistically different at $p < 0.05$ (Tukey HSD test). n= Number of replications.

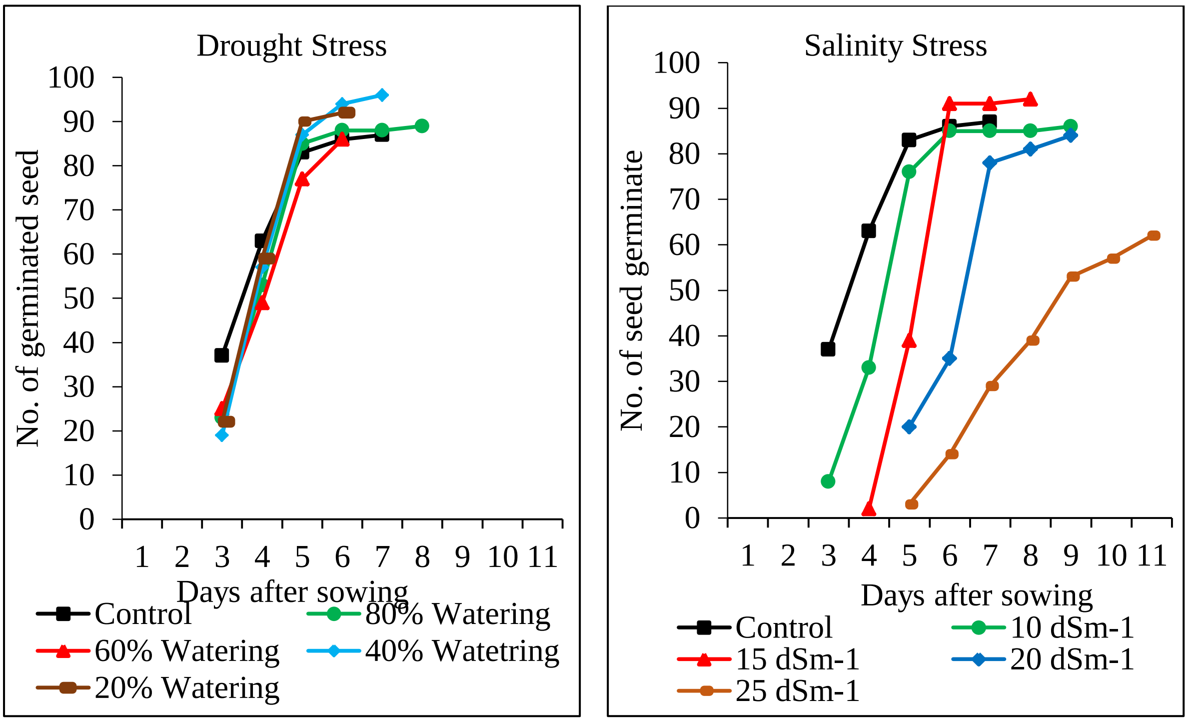

Figure 1 Effect of drought and salinity on commencement germination of *Acacia catechu*

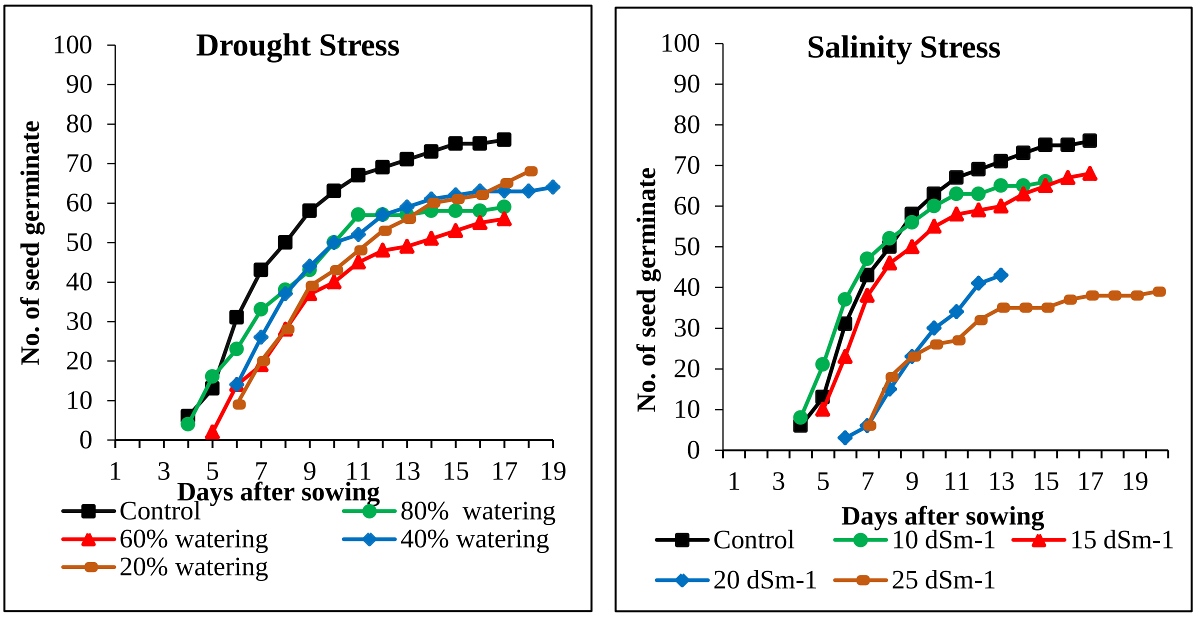

Figure 2 Effect of drought and salinity on commencement germination of *Albizzia lebbeck*

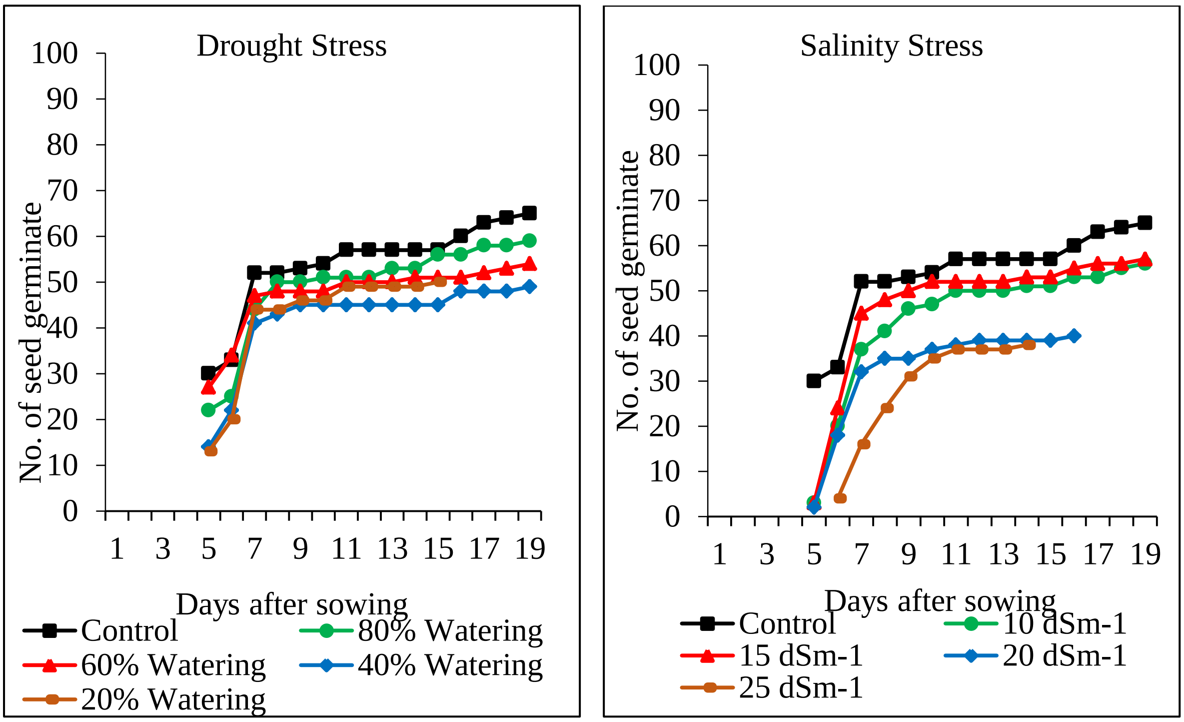

Figure 3 Effect of drought and salinity on commencement germination of *Cassia siamea*

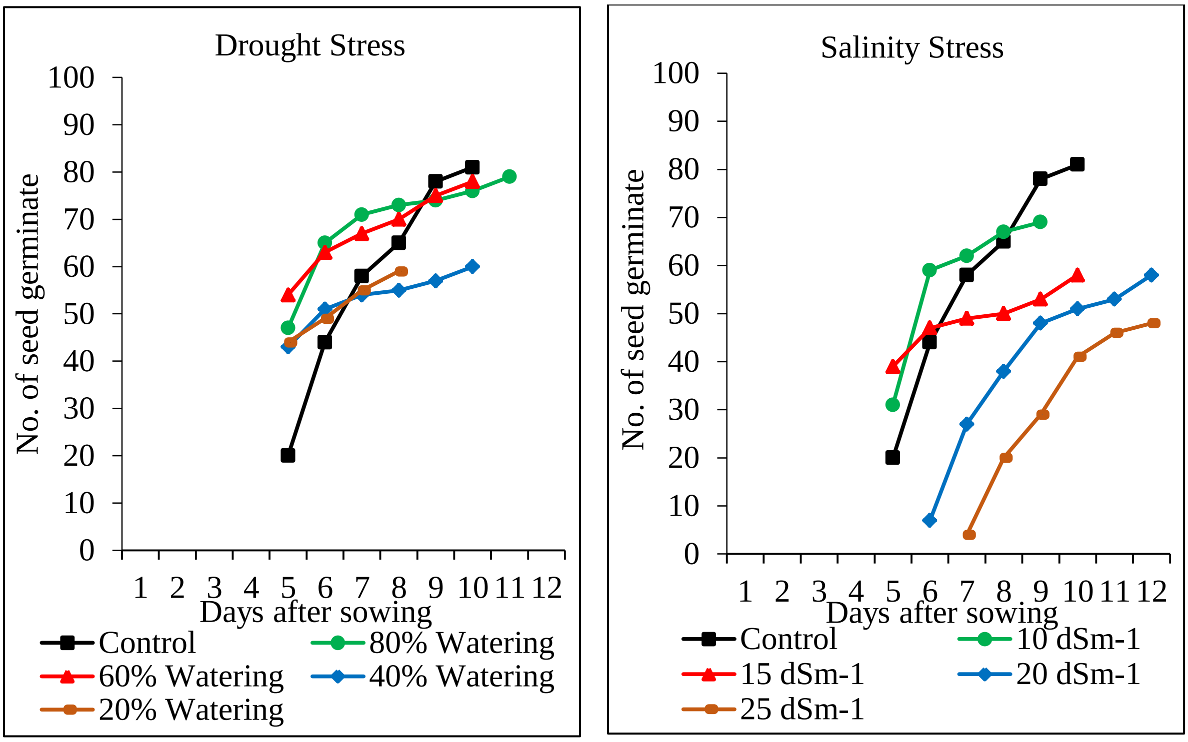

Figure 4 Effect of drought and salinity on commencement germination of *Eucaluptus camaldulensis*

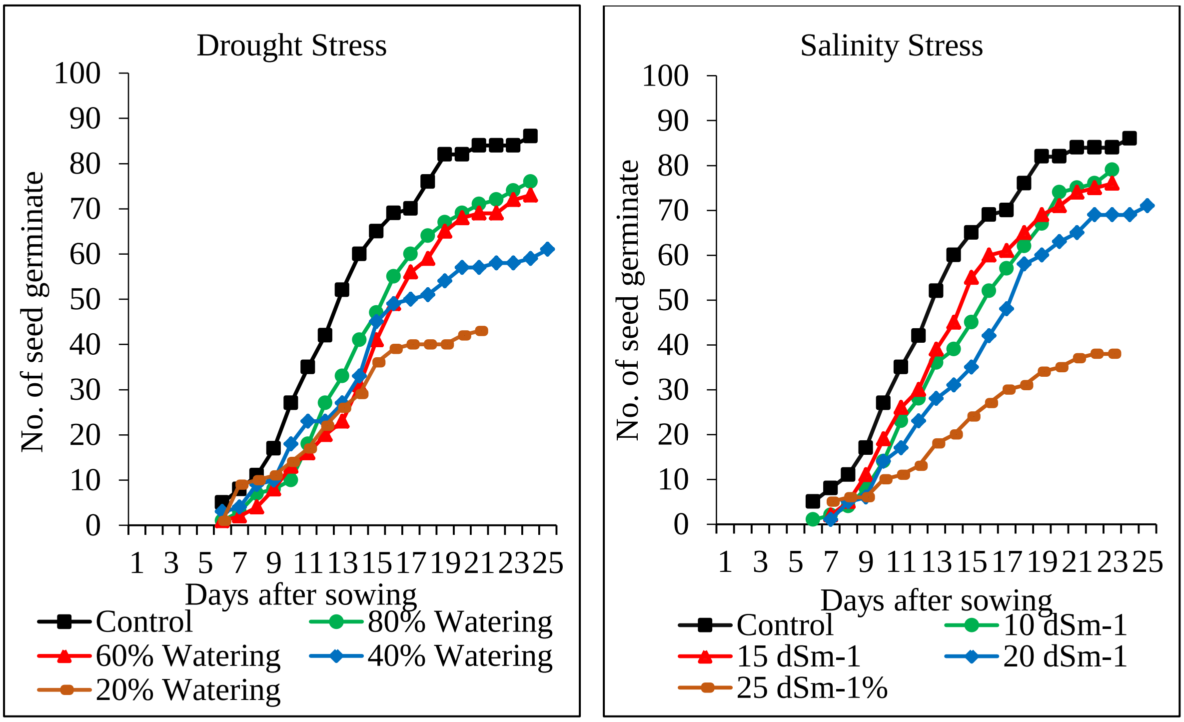

Figure 5 Effect of drought and salinity on commencement germination of *Acacia auriculiformis*

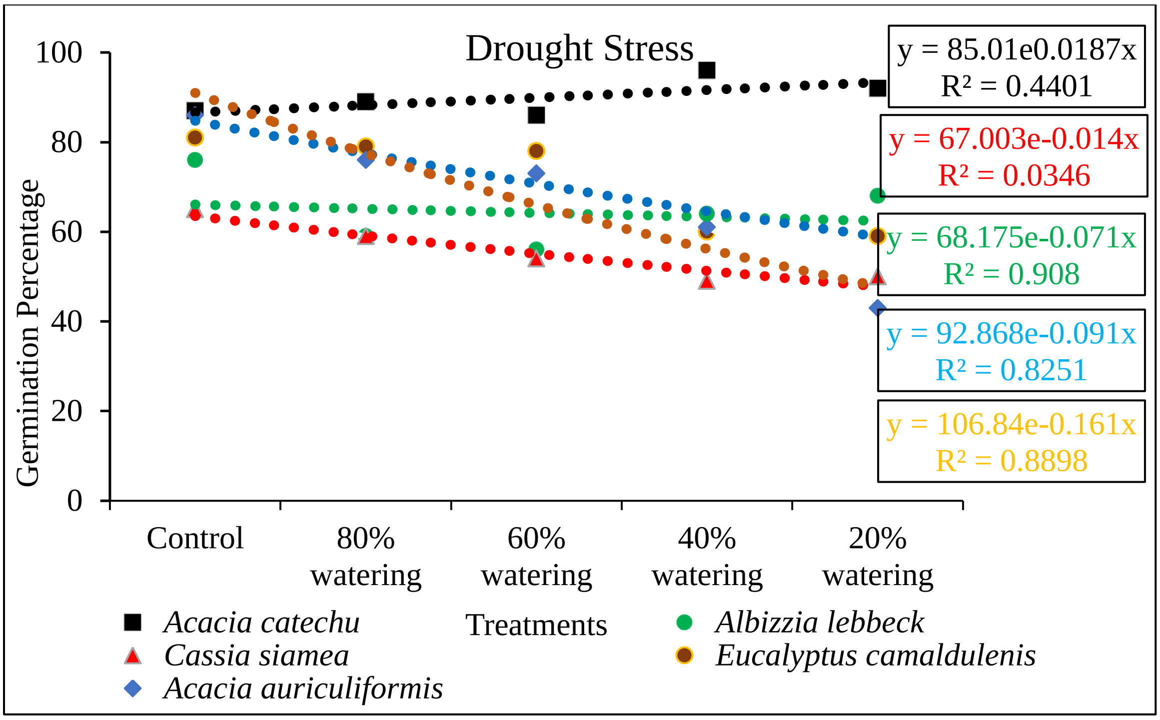

Figure 6 Effect of drought stress on germination percentage of five dry forest species

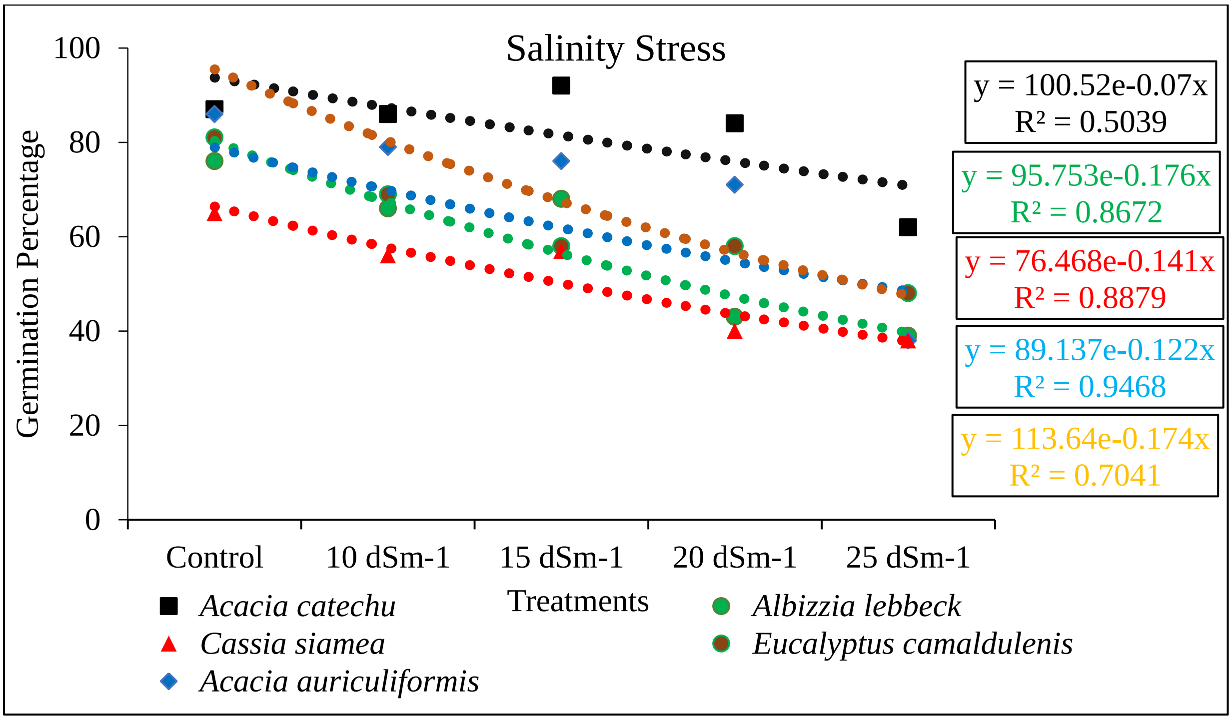

Figure 7 Effect of drought stress on germination percentage of five dry forest species

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