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Research article

GROWTH RESPONSE OF *JUNIPERUS PROCERA* (HOCHST. EX ENDL.) ON CALCARIC CAMBISOL AND EUTRIC REGOSOL IN THE DRYLANDS OF NORTHERN ETHIOPIA.

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ABSTRACT: This study was conducted in Sekota District, a degraded dryland area, Northern Ethiopia. The objective of this study was to evaluate the potential growth response of *Juniperus procera* on Calcaric Cambisol and Eutric Regosol which are dominant soil types in the study area. Seedlings of *Juniperus procera* with the same age were planted in the field in June 2010 in a randomized complete design at the two soil types. Data on survival, height and root collar diameter were recorded every six months. As a result, height growth response was higher on Eutric Regosol than Calcaric Cambisol and were significantly ($p<0.0039$) different. Growth in RCD also reviled that there was highly significant ($p<0.001$) difference between the two soil types. High mean value of RCD was recorded in Eutric Regosol (1.12mm), while it was low in Calcaric Cambisol (0.96mm). The survival result also showed that 20% on Calcaric Cambisol and 45% on Eutric Regosol. Thus, the unfavorable nature of the soil in the area associated with other abiotic factors such as moisture stress and the long dry season which extended from seven to nine months in the study area, clearly explains the poor survival and growth response of this species.
Keywords: Survival, growth response, *Juniperus procera*, dryland, Calcaric Cambisol, Eutric Regosol.

INTRODUCTION

Juniperus procera forests of the Afromontane areas of Ethiopia have considerable economic value at a local and national level, whilst their ecological importance is an issue of global concern [2]. However, over-exploitation of the resource presents a significant threat to the continued existence of the *Juniper* forests [6]. *Juniperus procera* is included on the IUCN red list of endangered species, and the ecological and economic importance of the juniper forests of Ethiopia has resulted in a great interest in their restoration [17]. The features of the deterioration of the *Juniper* forests can be seen in large areas lost their trees and other areas stricken by die-back where many of their trees are partly or completely dead [3]. In addition, these forests suffer from low capacity of the natural regeneration that some researchers attributed it to biological stresses caused by specific insets infecting *Juniper* cones [11]. Forest plantations, using *Juniperus procera* tree species can play an important role in the tropical ecosystem rehabilitation [9]. However, successful seedling establishment and growth depends on the soil condition and the stored soil moisture to ensure survival into the next growing season [18]. Weeds [15]; Vertebrates [14]; invertebrates [10]; seedling quality [8] are also commonly affects the growth, survival and distribution of trees.In line to this, however, many forest plantation and reforestation projects fail due to inappropriate species choice, a consequence of inadequate knowledge about the potential of species and their growth and survival rates under different site conditions which is basic for the plantation success [19]. To support conservation, restoration and sustainable use of the remaining woodlands more information is needed on growth pattern and population dynamics of *Juniperus procera*. Therefore, the objective of this study was to evaluate the potential growth response of *Juniperus procera* under Calcaric Cambisol and Eutric Regosol. This issue is critical to understanding forest establishment and development because the seedling stage suffers high mortality and, therefore, represents a significant bottleneck in the life cycle of trees. Moreover, in the context of an increasing concern about global climate change, this study was an opportunity to assess the potential of *Juniperus procera* for different soil condition investigations in this poorly documented degraded dryland in Northern Ethiopia.

MATERIALS AND METHODS

Site description

The study was conducted in Sekota district one of the Woredas in the Amhara Region of Ethiopia which lies between (12° 38' N Lat, 39° 02' E Long; elevation 2266m above sea level). Sekota was one of the areas most affected by catastrophic droughts in 1973 and 1984, and factors such as soil erosion, soil infertility, and insufficient rainfall all contribute to the woreda's reputation as a food deficit area. Geographically, it has a very rugged topography of mountains, hills and gorges. The mean annual rainfall of the area is 950mm. The mean annual temperature is 16.7°C. The natural vegetation is mainly scattered bushes and shrubs. Calcaric Cambisol and Eutric Regosol are the most dominating soil types in the area [16].

Experimental design and layout

Juniperus procera was selected for this particular study based on the assumption that this tree species is mainly facing difficulties in growth and survival in the study area, which is highly degraded dryland. Seedlings of *Juniperus procera* with the same age were planted in the field in June 2010 using a randomized complete design at two different soil types (Calcaric Cambisol and Eutric Regosol). Each block at each soil type had five experimental plots with twelve seedlings each. The spacing between blocks and plots was 2m, and the space between trees in a plot was 2m. In each plot, 12 seedlings were planted, and were taken as a sample for data collection. After planting, the site was protected from grazing and human interferences for the duration of the study. Plantation plots were neither irrigated nor fertilized. Survival, height (from ground level to the tip of the plant) and root collar diameter (RCD) were recorded every 6 months from June 2010 up to June 2012.

Survival and growth rate calculations

Survival percentage was calculated as the number of trees surviving by the end of the experiment divided by initial tree number times 100. The relative growth rates (RGRs) for both height and diameter was calculated following the procedure by [12]:

Height; RGR (%): $((H_1-H_o)/$ time in years$)*100$

Diameter; RGR (%): $((D_1-D_o)/$time in years$)*100$

Where: H_0 is the initial plant height in cm, and H_1 is the plant height in cm on any given observation date, D_0 and D_1 were the diameters in mm at the beginning and the end of each period.

Statistical analysis

Statistical analyses were performed to test the growth data of *Juniperus procera* tree species on Eutric Regosol and Calcaric Cambisol using One-way analysis of variance (ANOVA) procedures. Mean comparisons were made using the Tukey Honest Significant Difference (HSD) test at 0.05 significant levels. The JMP 5 package was used to perform all the statistical analysis.

RESULTS AND DISCUSION

Survival rate

Survival data of the species under the present investigation was 20% on Calcaric cambisol and 45% on Eutric Regosol (Table 1). The study area is largely dominated by rock outcrops and the vegetation cover is now sparse with heavily browsed trees and shrubs, stunted growth and poor vitality becoming much more dominant. [13] also stated that, misuse of natural resources has resulted in very serious land degradation in most dry lands of Ethiopia. The top soil of the study area has been removed by erosion, now the bedrock high in limestone covers large parts of the surface. Regarding nutrients this bedrock material is extremely poor; it consists basically of high calcium and magnesium. The original soil cover was probably even initially not more than 30-50 cm thick. This is particularly degradation processes may have been initiated a long time ago by grazing activities. In the present study, poor survival and growth response was observed on Calcaric Cambisol than on Eutric Regosol as this soil type is hard and the roots of *Juniperus procera* probably can't penetrate deep into this bedrock material which in turn results stunted growth and low survival rate. According to [5] compaction of soil results in high dry density which definitely reduced the rate of root penetration and development.

Height and diameter growth

The analysis of variance revealed that there were highly significant ($p<0.0039$) differences in height growth on the two soil types. Thus, the seedlings planted on Eutric Regosol were attained the highest mean value (Table 1). Similarly, the result reviled that there were highly significant ($p<0.001$) differences on the growth of root collar diameter on the two soil types. High mean value of root collar diameter was recorded in Eutric Regosol (1.12mm), while it was low in Calcaric Cambisol (0.96mm).

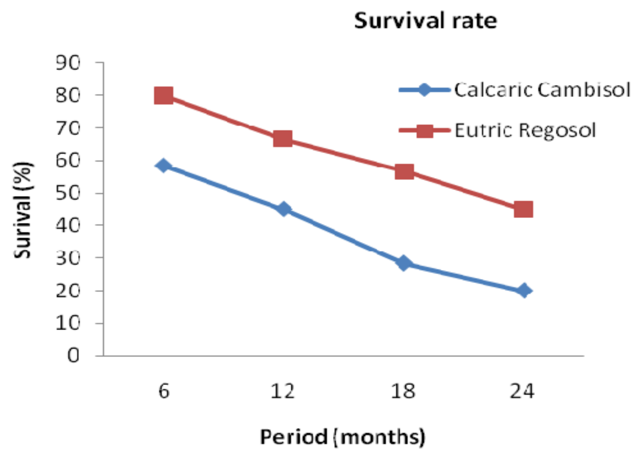

Figure 1. Survival (%) of *Juniperus procera* through sequential growing periods (months) from June 2010 to June 2012 at the two soil types.

Table 1. Mean height, diameter and survival rate of *Juniperus procera* under Calcaric Cambisol and Eutric Regosol in the study area.

Soil type	Height (cm)	RCD (mm)	Survival (%)
Calcaric Cambisol	27.83±0.29b*	0.96±0.12b	20
Eutric Regosol	29.66±0.42a	1.12±0.14a	45

*Values followed by the same letters within each column are not significantly different at $p<0.05$ level according to Tukey Honest Significant Difference (HSD) test. Values are expressed as mean ± standard error. RCD=root collar diameter

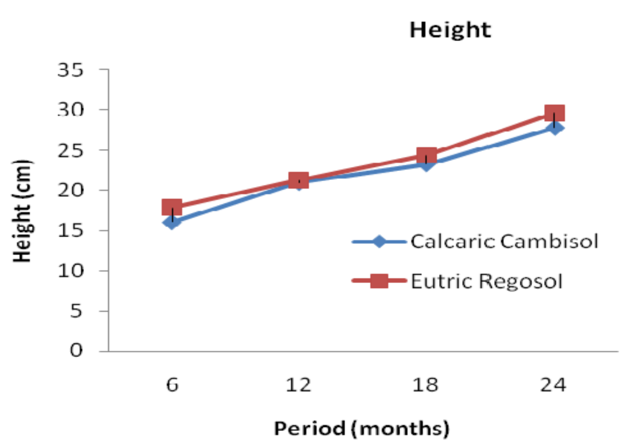

Figure 2. Growth height (cm) of *Juniperus procera* through sequential growing periods (months) from June 2010 to June 2012 at the two soil types.

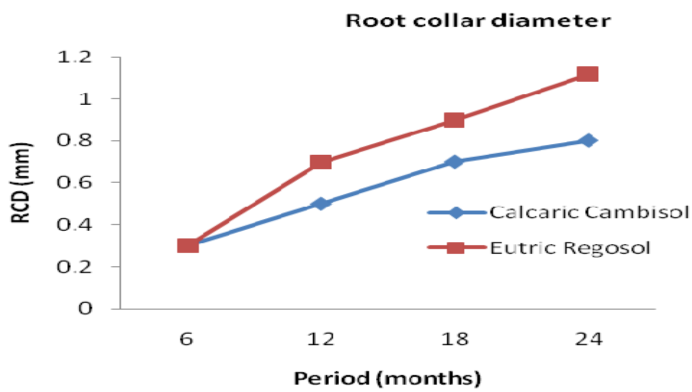

Figure 3. Growth of root collar diameter (mm) of *Juniperus procera* through sequential growing periods (months) from June 2010 to June 2012 at the two soil types.

Relative growth rate

The analysis of variance of relative height and diameter growth rates of *Juniperus procera* on the two soil types showed significant differences (p<0.0189). Thus, both height and diameter RGR averages were higher on Eutric Regosol than Calcaric Cambisol (Table 2). Most notably *Juniperus procera* prefers well-drained soils no heavier than sandy clay [4]. However, in the present study, the mortality was subjectively attributable to unfavorable nature of the soil in the area in combination with other abiotic factors such as drought and moisture stress during the initial growth from October to June, although biotic problems like termites were also experienced during the assessment period.

Table 2. Height and diameter relative growth ratio (RGR) of *Juniperus procera* on Eutric Cambisol and Calcaric cambisol in the study area.

Soil type	Height RGR (cm year^{-})	RCD RGR (mm year^{-})
Calcaric Cambisol	7.63±0.28b*	0.96±0.12b
Eutric Regosol	8.39±0.17a	1.12±0.14a

*Means followed by the same letter are not significantly different at P≤0.05 as determined by Tukey Honest Significant Difference (HSD) test. Values are expressed as mean ± standard error. RGR; Relative growth rate. In the present study, visible problem was also observed in *Juniperus procera* species around the experiment area though it is difficult to point out the real problem, it is visibly facing with dieback problem may be a link with the presence of Skeletic Cambisols on the lime stone parent material. Similarly, [7, 20] stated that soil and belowground competition influence the growth and survival rate of *Juniperus procera.*

CONCLUSIONS

In conclusion, *Juniperus procera* can play a very important role in the regulation of climate, rainfall intensity and consequently the violence of runoff [1, 9]. Hence, it must be must be conserved. One of the major tools for conservation of this species is planting in the appropriate and favorable soil condition.

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