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Effect of initial edaphic factors on survival and growth of forest tree seedlings in Ranchi, Jharkhand

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Abstract
Present research was conducted at forest department reforestation site Bhusur (Jharkhand) in 2018-19 to find out the maximum growth and yield of some important tree species in the available soil conditions of the locality. The experiment was laid out in Randomized Block Design with 4 treatments (T_1 is *Cassia siamea*, T_2 is *Acacia auriculiformis*, T_3 is *Melia azedarach* and T_4 is *Tectona grandis*) and 5 replications. Findings of the experiment revealed that, in case of plant height, diameter, girth, and number of branches among four species, *Acacia auriculiformis* showed the maximum growth. And *Cassia siamea* showed the maximum crown spread. In case of basal area and volume *Acacia auriculiformis* has showed more basal area and volume. *Cassia siamea* has showed the maximum survival %, followed by *Acacia auriculiformis*, *Melia azedarach* and least is *Tectona grandis*. The soil of the site is sandy loam which suits *Acacia auriculiformis* to grow better than *Cassia siamea, Melia azedarach and Tectona grandis.* In respect to all, the growth parameters of *Tectona grandis* showed the least growth as well as survival percentage.

Keywords: *Acacia auriculiformis, Cassia siamea,* edaphic factors, forest seedlings, growth, *Melia azedarach*

Introduction
The growth of tree is influenced by several factors like edaphic, climatic and genetic conditions as well biotic factors interference. And its cumulative effect matters a lot in growth and propagation of the plants. The mineralisation process of soil will be affected by tree species that can maintain nutrient cycling in the forest ecosystem, which might be occur by their effect on soil physiochemical properties (Ushio *et.al*, 2010) [1]. Plants try to adjust and adapt to the physical environment at the same time they modify the physical environment. They have a remarkable effect up on the soil on which they grow and also show alteration in the local climate as well as micro climate. The site quality will be mostly determined by the properties of soil or other features of sites, which affect the quantity and quality of growing place for tree roots" (Coile 1952) [2]. Soil is a complex expression physical, chemical and biological process therefore physical and chemical properties at a particular area reflect past and present condition (Robertson & Gross, 1994) [3]. Different zone or area of soil has different physical and chemical properties which influences growth and survival of the trees. The properties of the soil are the important factor for the growth of the plants. Among them, the most important factor is soil fertility, i.e., the essential nutrients available in the soil, for the growth of plants. The proper knowledge and understanding of different types of forest soils and the typical relationship between various trees of the forest and the life of other plants is therefore important to study. Soil texture is important from the point of view of plant growth granular structure possesses more volume of air and water than other types of soil structure. Several species such as *Eucalyptus globulus* and *Cryptomeria japonica* in India and *Pinus petula* in South Africa and *Tectona grandis* in Java have shown at least 4-6 times more growth than in their original home and the native vegetation of site. It means site were really capable of supporting vegetation of high productivity but due to some restrictive factors the potential was not harvested (Champion and Seth, 1968) [4].

Keeping in mind these facts, the present experiment was conducted to see the effect of initial physio-chemical properties of soils of the site on the survival and growth of the forest tree seedlings in plantations on degraded land in Ranchi district in the state of Jharkhand.

Materials and methods

The experiment was conducted in the year 2018-2019 at Bhusur forest area of Kanke, Ranchi, Jharkhand which falls on the sub-zone-V of the Jharkhand region as per Agro climatic Zone classification. The general climate of the region is sub-tropical with mean daily temperature of about 22.8˚C. The hottest month is mid may, temperature goes up to 40˚c and the coldest month is mid-January, temperature drops down to 0.18˚c.The maximum temperature ranges from 21˚c to as high as 42˚c and the minimum temperature ranges from 2.6˚c to 21.8˚c. The annual rainfall varies from 900-1400mm. The mean relative humidity is about 64% in the area. This type of climate is favorable for sub-tropical dry deciduous forest. The soil of the site is sandy loam mixed with siliceous and quartzite rock, acidic in reaction having pH 5.07 (Jackson, 1973) [5], poor in nitrogen (186.90 kg ha^{-1}; Subbiah and Asija, 1956) [6] and phosphorous (11.36 kg ha^{-1}; Hanway and Heidal, 1952) [7] and moderate in potassium (147.84 kg ha^{-1}; Bray and Kurtz method, 1945) [8]. The soil organic carbon of the initial soil sample was 0.198% (Walkley and Black, 1934) [9]. The experiment was arranged in randomized block design with 5 replication of 4 treatments i.e. T_1 - *Cassia siamea*, T_2 - *Acacia auriculiformis*, T_3 - *Melia azedarach*, T_4 - *Tectona grandis*. The size of the quadrats was 40m x 10m.

Observations on growth parameters i.e. seedling height, diameter of the seedling, crown width of the seedling and number of branches/seedlings were recorded in 5 sample seedlings from each plot and average was taken for calculation.

Measurement of Seedling volume

Volume of the seedling was calculated using the formula $g^2/4\pi*l$.

Where
g= girth of the seedling
π= 4.13 or 22/7
l= length of the seedling

All data had been calculated by the Unit, Centimetre cube than it had been converted into cubic feet.

Measurement of basal area

Basal area was calculated by using formula, $g^2/4\pi$. All data had been calculated by the Unit, Centimetre square than it had been converted into square feet.

Where g= girth of the seedling

π= 4.13 or 22/7

Measurement of Survival percentage (%)

Surviving plants in each quadrat was counted at the time of recording seedling traits (height, diameter, basal area etc.) And the survival per cent was calculated out as follows:

Survival (%) =total number of seedling survived/total number of seedlings× 100

The data recorded on various parameters were subjected to statistical analysis for statistical validity of the results and interpretations. The significance of different sources of variation were tested by variance ratio of mean sum of square (F –test) at probability level of 5% using usual method of data analysis as mentioned in (Panse and Sukhatme, 1967) [10]. The statistical analysis was done by data analysis tool package of Excel (MS Office 2007 package).

Results and discussion

Initial Physico-chemical properties of soil

Table-1 contains the mean value of analysed data for the available soil conditions in the experimental site. The moisture percentage of the soil was 11.11%, soil texture was sandy loam, soil organic carbon was 0.198%, pH was 5.07, soil available Nitrogen was 188.90, soil available Phosphorus was 11.36 and soil available Potassium was 147.84kg/ha.

Table 1: Initial physico-chemical properties of soil in the plantation site

Parameters	Mean
Soil Moisture	11.11%
Soil Texture	Sandy loam
Soil organic carbon	0.198 %
Soil pH	5.07
Soil available nitrogen	186.905 kg per hectare
Soil available phosphorus	11.36 kg per hectare
Soil available potassium	147.84 kg per hectare

It was depicted from the study that the texture of the mixed plantation site was sandy loam. A sandy soil can hold soil moisture for lesser period of time as compared to the sandy soil. Srivastava (1993) [11] had estimated that the *Eucalyptus* sp. had high water holding capacity in the soil. There was more soil moisture under eucalyptus than a nearby open area even after three consecutive drought years. The initial pH of soil of the study site was 5.07. According to Killham (1994) [12], decomposition of soil organic matter releases organic acids leading to decrease in pH in forest. The initial soil organic carbon was observed at plantation site was 0.198%. The mixed stand of forest species seemed to be the best plantation system, as it increased soil organic matter and fertility level and improved soil structure (Salim *et al.* (2018) [13]. Chaubey, *et al.*, (1988) [14] found that litter production was 1.5-2.0 times greater in the teak plantations (20-23 year) than in adjoining forests in Madhya Pradesh.

Initial available nitrogen in soil in the study site was 186.905. According to Nazir and Netajini, (2014) [15], nitrogen content in soil is related to organic matter content of the soil which was also observed by in their study. According to Jha *et al.*, (1984) [16], if the soil is rich in organic matter, it is definitely rich in total nitrogen also. Haan (1977) [17] also analysed that the availability of nitrogen depends upon the amount and properties of organic matter. Initial available phosphorus in soil of study site was observed to be 11.36. Pande and Sharma (1993) [18] noted teak and sal conserved more nutrients than pine and eucalyptus, and conservation of nitrogen and phosphorus was found greater than that of other nutrients which supported our findings and explained the reason for having low concentration of available phosphorus under eucalyptus plantation and acacia plantation site. Initial available potassium of the soil in plantation site was estimated at 147.84. The low content of available phosphorus may be attributed to the low clay content of the soil as it was found to be Sandy loam. Kaila (1965) [19] observed in his study that potassium fixation by samples of many soils of Finland increased with clay content which indicated that soils with higher clay contents were likely to contain more non-exchangeable potassium.

The above findings revealed poor fertility status of the soil of the site. Soil is the major source of nutrients for the growth of plants and while determining the degree of soil physico-chemical characteristic is very necessary to evaluate the soil fertility. Organic matter is also one of the major factors that determine soil quality and serves as nutrient source which enhances the productivity as well as improve physical and biological properties of soils.

Survival percentage of tree seedlings

Data on survival of different tree species at Bhusur (Ormanjhi) is presented in table - 2. A perusal of the table revealed significant difference in survival of tree species. Maximum survival of different seedling species was observed in case of *Cassia siamea* ($T_{1,}$ 73.38%) which was followed by as well as statistically at par with *Acacia auriculiformis* ($T_{2,}$ 72.39%). Minimum survival of seedling was recorded with *Tectona grandis* $T_{4,}$ (47.00%). However, it was statistically at par with *Melia azedarach* (T_3, 64.05%). In short, survival percentage was maximum in *Cassia siamea* and was followed by *Acacia auriculiformis*, *Melia azedarach* and was least in *Tectona grandis*. Time of planting and quality of seedling at the time of planting is important for survival of seedlings in the field (Porteous, 1993) [20]. It was found that survival of seedlings was increased by a mean of 10% when carefully planted. Smith (1986) [21] recommends that seedlings should be planted so that moist soil is packed around the roots and no large air spaces left in the planting hole. Also, seedlings should be planted firmly enough to resist a gentle tug by hand. Roots should be placed in the ground with as little distortion as possible (Trewin, 1995) [22]. Metcalf (1987) [23] notes that although a number of indigenous plants can be planted relatively deep it is desirable not to plant deeper than the soil line on the stem of the plant. Porteous (1993) [20] states that bare-root indigenous seedlings must be planted at the depth that they were growing in the nursery. Planting conifers with the root collar above the ground line has been found to reduce survival; but there was no significant difference in survival between planting the root collar at ground level and the root collar below ground level (Shiver *et al.*, 1990) [24]. Rate of uptake of nutrient and survival of tree species depends on the water availability (Lodhiyal and Lodhiyal, 1997) [25]. In ecological restoration survival is also influenced by planting density. Evert (1972) [26] found that mutual competition was definitely one of the factors causing tree deaths for stand ages ranging from 12to 40 years with spacing less than 1.83 m. The proportion of trees surviving increased as spacing increased up to a maximum of 1.83m. However, at spacings greater than 1.83m death in stands appeared to be attributed either to random causes, heavy grass competition, diseases, fire or rodents.

A further perusal of the table revealed significant difference in height of tree species. Further perusal of the table showed that the maximum height was found under treatment *Acasia auriculiformis* ($T_{2,}$ 2.30m) and it was at per with *Cassia siamea* ($T_{1,}$ 1.85m), and *Melia azedarach* ($T_{3,}$ 1.73m). Least was found under treatment *Tectona grandis (*$T_{4,}$ 0.53m). The data in the table also revealed significant difference in number of branches of tree species. A further perusal of the table showed the maximum value was found in case of treatment *Acasia auriculiformis* (T_2,15.82) followed by *Cassia siamea*, (T_1,13.27), and *Melia azedarach* ($T_{3,}$ 3.24) which was at par with the least value which was treatment *Tectona grandis* ($T_{4,}$ 1.77). Significant difference in girth of tree species was also observed. Maximum girth value was found in case of treatment *Acasia auriculiformis* ($T_{2,}$ 1.67cm) which was at par with treatment *Cassia siamea* ($T_{1,}$ 1.39cm) followed by *Melia Azedarach* (T_3,1.23cm) it was at par with the least value *Tectona grandis* ($T_{4,}$ 1.18cm). Data in the table showed significant difference in diameter of tree species. Maximum value was found in *Acacia auriculiformis* ($T_{2,}$ 0.74cm) which was at par with the treatment *Cassia siamea* ($T_{1,}$ 0.68cm), *Melia azedarach* (T_3, 0.21cm), and minimum was found in *Tectona grandis* ($T_{4,}$ 0.2cm).

Table 2: Survival and growth of tree seedlings

Treatments	Survival percentage	Plant height (m)	Number of primary branches	Girth (cm)	Diameter (cm)	Crown spread (m)	Basal area (ft^2)	Volume (ft^3)
Cassia siamea	73.28	1.85	13.27	1.39	0.68	1.93	0.000158	0.0011
Acacia auriculiformis	72.39	2.30	15.82	1.67	0.74	1.69	0.00024	0.0013
Melia azedarach	64.05	1.73	3.24	1.23	0.21	0.95	0.000154	0.0009
Tectona grandis	47.00	0.53	1.77	1.18	0.20	0.31	0.000148	0.0004
C.D.	10.75	0.44	2.45	0.33	0.10	0.23	NS	0.0003
SE($\pm$m)	3.45	0.14	0.79	0.107	0.03	0.08	--	--
C.V. (%)	12.03	19.61	20.61	17.395	17.52	13.75	19.05	26.45

A further perusal of the table revealed significant difference in crown spread of tree species. A further perusal of the table showed that the maximum value was found in case of treatment *Cassia siamea* ($T_{1,}$ 1.93m) followed by *Acacia auriculiformis* ($T_{2,}$ 1.69m), and *Melia azedarach* ($T_{3,}$ 0.95m). Minimum was found in *Tectona grandis* (T_4, 0.31m). The basal area was found maximum in *Acacia auriculiformis* (T_2, 0.00024 ft^2) followed by *Cassia siamea* (T_1, 0.000158 ft^2) and *Melia azedarach* (T_3, 0.000154 ft^2) and least was found in *Tectona grandis* ($T_{4,}$ 0.000148ft^2). Volume of tree species showed significant difference. It was observed maximum in case of *Acacia auriculiformis* (T_2, 0.0013 ft^3) and was followed by as well as at par with volume measured in *Cassia siamea* (T_1, 0.0011 ft^3). However minimum volume was observed in case of *Tectona grandis* ($T_{4,}$ 0.0004ft^3) and was significantly inferior to all other species.

Most of the growth parameters, such as, plant height, diameter, girth, number of branches, basal area and plant volume were better in *Acacia auriculiformis* than all the three other tree species. However, crown spread was maximum in *Cassia siamea.* The growth of plants is normally affected by soil physical characteristics. These include aeration, drainage, moisture and root penetration. All these vary with the type of soil. Poor aeration can limit plant growth. The growth of tree seedlings also depends upon seedling factors such as seedling quality, selection culling, seedling type (i.e. barerooted or containerised), handling and transport of seedlings. Seedling quality is one of the main factors affecting field performance of tree seedlings (Chavasse, 1980) [27]. Seedling quality is defined as the morphological and physiological state of the seedling immediately prior to planting on the site. Seedling quality is affected by nursery site, genetic makeup of the stock, seed, methods of production, the space occupied by the seedling in the nursery bed, time of sowing, age of seedling, time of year seedlings are lifted, nursery weed control methods and effectiveness, seedling nutrition, methods of seedling conditioning, insect attack, diseases and care in lifting, handling and transporting. Seedling quality in forestry has traditionally been measured by morphological features, for example: height, diameter at root collar, sturdiness (i.e. height/diameter ratio), root weight to shoot weight and presence of mycorrhiza. However, it has become clear that both morphological and physiological criteria need to be considered in determining seedling quality (Smith, 1986) [21].

The initial growth of tree seedlings is also affected by planting factors which includes timing of planting, site preparation, fertiliser at planting and planting density. Chavasse (1980) [27] considers such planting factors to be the main factors those influence the performance of seedlings in the field after planting. The factors discussed here have the major influences on growth and survival of seedlings planted on a new or disturbed site for the purpose of ecological restoration. Time of planting and quality of seedling at the time of planting is also important for growth and survival of seedlings in the field (Porteous, 1993) [20]. At the time of planting the indigenous seedlings are required to be a minimum height which varies with species, site and climatic conditions. For most plants there is a certain minimum size that needs to be attained, before there are sufficient stored nutrients or conductive tissue, to resume growth after the damage incurred during planting (Smith, 1986). Smith (1986) recommends that conifer seedlings should be at least 10 to 30cmhigh, have a shoot to root ratio not greater than four to one and have a root collar diameter of at least 3mm. Assuming that most of the requirements for seedling growth in forestry situations are likely to be similar, if not identical, to that of ecological restoration, it therefore, seems reasonable to apply the principles of determining forestry seedling quality to seedlings used in ecological restoration. However, it would seem that further research is required.

Planting density also influences the initial growth in ecological restoration. It is almost axiomatic that initial spacing has no effect on height growth of canopy (Lanner, 1985) [28]. Planting density has little influence on height growth except where the stand is very dense or so open that the trees are distinctly isolated (Smith, 1968). However, experiments with wider spacing show the effects of spacing on height growth to be very little. The initial growth of tree seedlings is also affected by application of fertilizers at the time of planting. In case of disturbed sites and problem soils, fertiliser can be applied at planting to overcome early growth stagnation and to ensure planting success where insufficient nutrients are available (Ballard, 1978) [29]. Many indigenous plants grow well on fertile soils without fertiliser; the response from fertiliser is likely to be greatest on poor soils (Porteous, 1993). Fertiliser applied at planting has been shown to result in a greater increase ingrowth when applied in a spade slit 15cm from the seedling than when broadcast over the site or placed in the planting hole (Ballard, 1978) [29]. Fertiliser placed too close to seedling stem or roots can reduce survival of seedlings, for this reason fertiliser is usually placed 15cm from the seedling (Ballard, 1978). Production of dry matter is generally based on the soil fertility and extra management inputs (Lodhiyal *et al*., 2002) [30]. Growth of plant is adversely influenced by the deficiency of essential nutrients. This can be improved by the application of fertilisers (Kozlowski *et al.,* 1991) [31]. The influence of different levels of essential nutrients in soils on economically important species growth and survival has been well researched. Species vary considerably in their capacity to absorb essential nutrients and in their tolerance of limited supplies of essential nutrients (Kozlowski *et al.,* 1991) [31].

Conclusion

From the findings of the present investigation it can be concluded that simple relationships were observed between the soil and vegetation properties. Survival percentage was maximum in *Cassia siamea* and was followed by *Acacia auriculiformis*, *Melia azedarach,* and was least in *Tectona grandis*. Most of the growth parameters, such as, plant height, diameter, girth, and number of branches were maximum in *Acacia auri culiformis*. Crown spread was maximum in *Cassia siamea.* Basal area and volume were maximum in *Acacia auriculiformis*. The soil of the site is sandy loam which suits *Acasia auriculiformis* to grow better than *Cassia siamea, Melia azedarach and Tectona grandis.* Survival as well as overall growth was least in *Tectona grandis*. In practice, right tree species selection for monoculture or mixed plantation establishment on an abandoned or degraded site is most important for the success of plantation. It could be true to conclude that the initial soil properties play a significant role in survival and growth performance of forest tree seedlings on degraded lands.

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