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Evaluation of *Eucalyptus* Clones Under Seasonal Waterlogging Conditions in South-Western Punjab

AVTAR SINGH[1] and GPS DHILLON[2]*

[1]PAU Research Station, Punjab Agricultural University, Bathinda 151001,India.
[2]Department of Forestry & Natural Resources, Punjab Agricultural University, Ludhiana 141004, India.

Abstract

Eucalyptus is widely planted genus in many continents due to its rapid growth, several uses and good adaptability to climates and soil types. This study was based on nine *Eucalyptus* clones/progenies (C-413, C-3020, C-2135, C-7, C-2045, C-411, C-526, C-316 and seedlings) planted at farmers field experiencing seasonal waterlogging. The experiment was planted following randomized block design with plot size of 12 trees replicated four times. The survival of Seedlings, C-7, C-413, C-526 and C-316 was better and varied from 78.3 to 88.3 percent. Significant differences were found for tree height and diameter at age of 2 and 4 year, and volume index at age of 4 year. The tree height and diameter at breast height at 4 year age varied from 5.93 to 6.76 m and 56.4 to 87.6 mm, respectively. The relative ranking on basis of volume index was C-413>C-316>C-411>C-7>C-526. Clones C-413, C-316, C-7 and C-526 were promising based on adaptability and growth traits.

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Introduction

The plantation forestry based on fast growing tree species is promoted across the globe to meet the demand of wood based industries. Afforestation on marginal lands and reforestations with Eucalyptus sp. exceed 20 million hectares, in more than 90 countries.[1] Brazil, India and China are the major countries where, *Eucalypts* are widely grown in commercial plantations to produce raw material for the industry (pulp and paper, charcoal, sawn timber, wood panels) but also in small woodlots for the production of firewood and charcoal for domestic uses. The main species of *Eucalyptus* planted in northern India are E. *camaldulensis* and E. *tereticornis*. The farmers have adopted its better productivity, short rotation, straight stem, self pruning nature and better economic returns. Many wood based industries have started to raise large scale *Eucalyptus* plantations as it provides variety of uses such as timber, construction boles, firewood, honey, pulp, and paper. *Eucalyptus* has the ability to withstand the salinity, drought and

CONTACT GPS Dhillon dhillongps1@pau.edu Department of Forestry & Natural Resources, Punjab Agricultural University, Ludhiana 141004, India.

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waterlogging conditions and also acts as recreational areas, windbreaks, shelterbelts etc.[2,3] *Eucalyptus* plantations can also improve degraded lands by stabilizing soils, improving soil nutrient status and increasing soil organic matter through enhancement of aboveground litter production.[4,5] The advances vegetative propagation technology has enhanced the productivity and uniformity of plantations. The innovative farmers have found clonal Eucalyptus to be highly productive even on marginal lands.[6,7]

Seasonal flooding or waterlogging is a serious problem in India. These areas are prone to waterlogging during monsoon when rainfall exceeds the drainage capability of the soil. In some conditions, the seepage from canals also results in waterlogging resulting in excessive water in the root zone and anaerobic conditions. The crops and other vegetation are badly affected due to nutrient deficiencies or toxicities, root death and/or decreased water uptake. It is estimated that out of the total 2.64 lakh hectare land of Muktsar Sahib District of Punjab, about 84,000 hectares area face seasonal or permanent waterlogging conditions.[8] *Eucalyptus* trees are known to have ability to control rise in water table and reduce waterlogged.[9,10] These studies were based on using seedling based plantations. However, no clonal screening study has been conducted under waterlogged conditions. The present study was planned to screen the commercial clones and compare it with the seedlings. The study conducted till more than half rotation age, reports the comparative adaptability and productivity potential of commercial *Eucalyptus* clones under the extremes of moisture conditions.

Materials and Methods

Study Area

The study was conducted on farmers field at village Uraang in District Muktsar Sahib, Punjab and is located at 30°19'26"N latitude, 74°20'25"E longitude and 194 m altitude). The soils are loamy sand and the area was low lying and prone to periodic flooding and subsequent water-logging conditions during rainy season. The same site had drought like conditions during the summer. The annual *kharif* and *rabi* crops in that tract used to get damaged. The physical and chemical properties of the study site are given in Table 1.

Experiment Details

The trial was established in the year 2015 at 3x 3 m spacing. Eight clones (C-413, C-3020, C-2135, C-7, C-2045, C-411, C-526 and C-316) and one seedling lot of *eucalyptus* were planted following randomized block design having four replications and plot size of 12 trees. The survival was recorded at age of 4 years. The height and diameter of all the trees within the plot was measured with Ravi multimeter and diameter by a tree calliper. The data on growth traits recorded at two and four years is given in this paper. Statistical analysis was done as per the procedure laid down for completely randomized design (CRD). Critical difference (CD) was calculated for the interpretation of results of the study.[11] Statistical analysis was done by CPCS1 software for windows.

Table 1: Physical and Chemical Properties of Soil from the Experimental Fields

Soil property	Average
Texture	Loamy sand
pH1:2	8.7
EC (dS/m)	3.10
OC (%)	0.39
Available N (kg/ha)	185
Available P (kg/ha)	15.3
Available K (kg/ha)	164

Results & Discussion

The survival data of trees after 4 year age is given in Fig 1 shows that survival was well keeping in view the harsh conditions. It varied from 78.3 to 88.3 percent with significant variation ($p<0.05$) among the *Eucalyptus* genetic entries. The seedlings recorded the maximum value (88.3 %) which was statistically at par with C-7, C-413, C-526 and C-316. The bottom rank for survival was in case of C-3020 and C-2045 with value of 78.3 percent, which was again at par with five clones. The mortality of trees happened during summer months due to dry conditions. The varying survival among the clones can be attributed to their differential genetic make up. The reason of numerically higher survival by seedlings may also be due to deep root system. The variation among the Eucalyptus clones for adaptability is reported earlier also.[2,3]

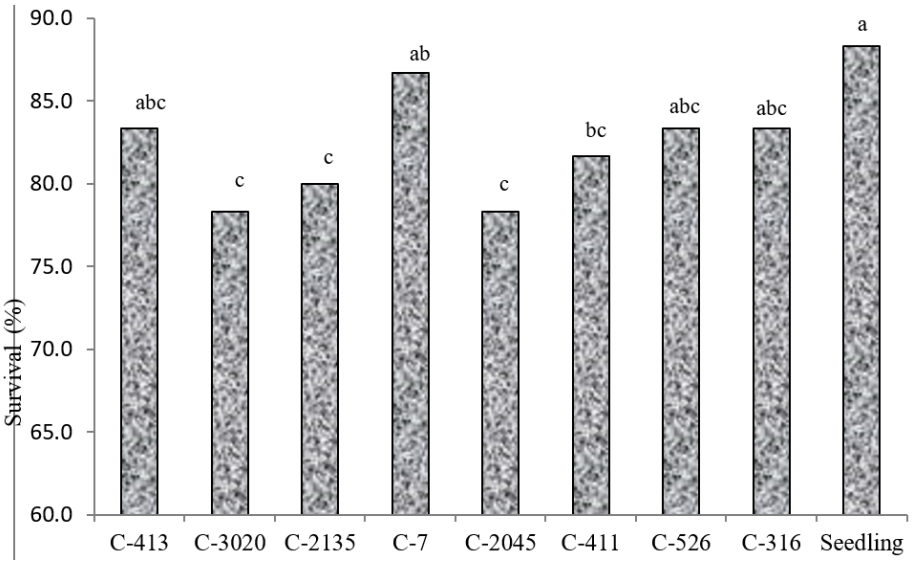

Fig 1: Survival of *Eucalyptus* clones at age of 4 year

The significant differences among the clones were found for tree height at both the ages (Table 2). Clone C-7 recorded the maximum value (3.48 m) at 2 year age and was followed by C-3020, C-413, -316 and C-411 with statistical similar values. The minimum value (2.53 m) was recorded by C-2045. After 4 years, C-3020 attained the maximum value (6.76 m) and was at par with C-413, C-7, C-316 and C-411. C-2045 continued to be at last rank with tree height of 5.93 m which was statistically lower to all others. The diameter at breast height varied significantly ($p<0.05$) at both the ages (Table 3). C-411 had the maximum diameter (52.78 mm) after 2 years which was statistically similar with six other clones. Diameter varied from 56.4 to 87.6 mm. Clone C-316 got the top rank and was closely followed with four other clones C-413, C-411, C-526 and C-7. Significantly lowest value was in case of C-2045.

Table 2: Height (m) of *Eucalyptus* clones planted at Village Uraang, Shri Muktsar Sahib

Clone	2 year		4 year	
	Mean (m)	Rank	Mean (m)	Rank
C-413	3.19^{abc}	3	6.75^{a}	2
C-3020	3.36^{ab}	2	6.76^{a}	1
C-2135	2.94^{bcd}	6	6.53^{bcd}	5
C-7	3.48^{a}	1	6.68^{ab}	3
C-2045	2.53^{d}	9	5.93^{e}	9
C-411	3.08^{abc}	5	6.59^{abc}	4
C-526	2.89^{bcd}	7	6.34^{d}	8
C-316	3.10^{abc}	4	6.47^{cd}	6
Seedlings	2.78^{cd}	8	6.36^{d}	7

Table 3: Diameter at breast height (mm) of *Eucalyptus* clones recorded at various ages

Clone	2 year		4 year	
	Mean (mm)	Rank	Mean (mm)	Rank
C-413	48.49^{ab}	4	86.8^{a}	2
C-3020	43.65^{abc}	7	76.3^{c}	7
C-2135	48.92^{ab}	2	79.6^{bc}	6
C-7	48.54^{ab}	3	83.0^{ab}	5
C-2045	43.99^{abc}	6	56.4^{d}	9
C-411	52.78^{a}	1	85.5^{ab}	3
C-526	34.48^{c}	9	83.4^{ab}	4
C-316	44.12^{abc}	5	87.6^{a}	1
Seedlings	41.11^{bc}	8	75.3^{c}	8

Volume index (D^2H) gives a better indication of the growth, as it gives combined values of diameter and tree height. In this study, C-413 recorded the top rank for volume index at 4 year age (Fig 2), but was at par with those of C-316, C-411, C-7 and C-526. Like diameter and tree height, the bottom rank was in case of C-2045 and was statistically inferior to all others.

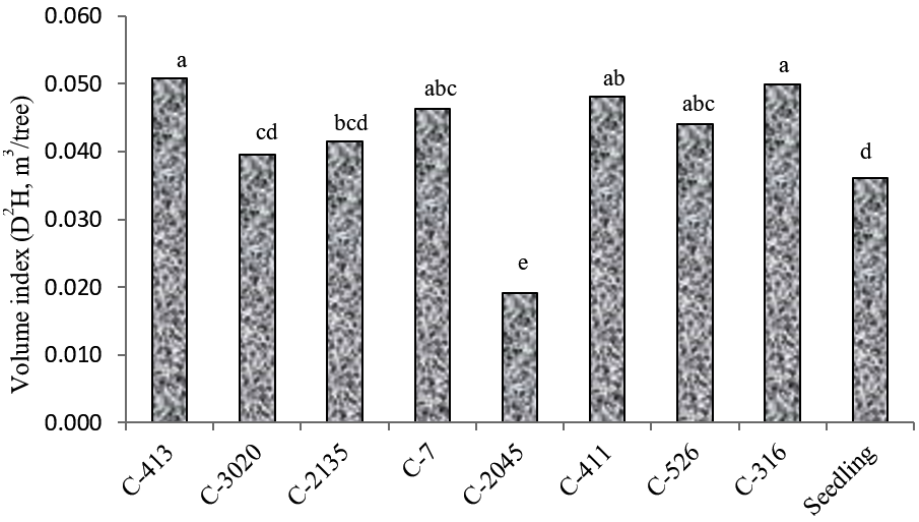

Fig 2: Volume index of Eucalyptus clones after 4 year age

The perusal of results from this study found significant ($p<0.05$) variation among the genotypes for all the growth traits. The differential response of clones tested under uniform conditions may be attributed their different genetic makeup.[6,7,12] Similar type of variation was noticed among the five commercial hybrids of *Eucalyptus urograndis*.[3] The significant variation was also found among six clones of *Eucalyptus camaldulensis* growth and biomass traits.[13] The screening *Eucalyptus* and *Melaleuca* spp. under saline and waterlogging conditions also revealed similar variation.[14]

The present field study has screened the commercial clones and found significant variation for survival, tree height, diameter and volume index. But overall growth is not up to the potential of these clones. The reason may be prolonged flooding in the field which is reported to reduce the photosynthesis, stomatal conductance, and affect negatively on root hydraulic conductivity.[15,16]

Conclusions

The survival, tree height, diameter and volume index varied significantly among the clones. Better adaptability and growth of clones C-413, C-316, C-7 and C-526 under extreme conditions provides the opportunity to plant these genotypes to reclaim similar marginal agricultural lands. Their adoption will enhance the productivity and help in lowering the water table in the area.

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Conflict of Interest

The authors do not have any conflict of interest.

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