JASEM ISSN 1119-8362

Full-text Available Online at
www.bioline.org.br/ja

J. Appl. Sci. Environ. Mgt. 2005
Vol. 9 (2) 57 - 59

The Growth Performance of Exotic and Indigenous Tree Species in Rehabilitating Active Gold Mine Tailings Dump at Shamva mine in Zimbabwe

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ABSTRACT: The objective of the study was to compare the performance of exotic (*Eucalyptus grandis* and *Acacia saligna*) and indigenous (*Acacia polyacantha* and *Bauhinia thonningii*) tree species in rehabilitating active gold mine tailings dump. The seedlings were produced in a nursery and transplanted onto the tailings dumps during the rainy season in the years 2000, 2001 and 2002. The saplings were monitored for survival rates one year after transplanting and growth performances by measuring root collar diameters and heights. There was no significant difference among the species in survival. The mean height increment of the exotics significantly surpassed indigenous tree species. *E. grandis* performed best followed by *A. saligna*. *Bauhinia thoningii* showed the lowest height increment. Root collar diameters were highest for *A. polyacantha*, followed by the exotics. There was no significant difference for the mean root collar diameter and height between the exotics. It was concluded that both exotic and indigenous tree species could be used for the rehabilitation of mine tailings. *@JASEM*

Mining tailings dumps destroy wildlife habitats and leach out toxic minerals into streams and groundwater if not properly rehabilitated. In many instances, these dumps have been abandoned, with limited or no rehabilitation treatment (Gardner, 2001). If the mining industry is to contribute effectively to sustainable development, it must develop and consistently apply sound environmental management practices to minimize on and off site environmental impacts. There are cases in which tailings dumps have been effectively rehabilitated to agriculture, forestry, nature conservation, urban or industrial land uses (Laurence, 2001; Moffat, 2001). Of all the methods, revegetation is the most documented and widely used because it is most practical and economic though it is often slow due to the hostile conditions such as toxicity of heavy metals (Troung, 1999). In the process of vegetative rehabilitation, the normal ecological succession using low-cost techniques should be initiated, so that the environment can enrich itself naturally in terms of biodiversity (Mudorch-Eaton *et al*., 1997).

Those involved in rehabilitation projects have recognized the importance of using indigenous species not only for environmental reasons, but also to meet the livelihood and cultural needs of local communities who may depend on forest products and services (Sarrailh and Ayrault, 2001). Although the idea of using indigenous species in vegetation of slime dams is now widely accepted there is need for continued investigation into the establishment of indigenous species, which perform comparably to exotic species on tailings dams. The overall objective of this study was to compare the performance of exotic tree species namely, *Eucalyptus grandis and Acacia saligna* and indigenous tree species, *Acacia polyacantha,* and *Bauhinia thonningii* in rehabilitating active mine tailings dump.

MATERIALS AND METHODS

Description of the study area: The project was carried out on the active Shamva Mine slime dump, in Zimbabwe, which was established in 1982. The dump is terraced and rises at 0.121 m/year at a slope of 26 %. Each year four terraces are built and vegetated. The total area revegetated by 2004 was 7.15 ha. Common tree species growing in the area are *Terminalia sericea, Acacia. karroo, Acacia. polyacantha, Uapaca kirkiana* and *Combretum.* The grasses are made up mostly of *Hyparrhenia filipendula, Hyperthelia dissoluta, Brachiaria brizantha, Pogonathria squarrosa, Craspedorachis rhodesiana* and *Eragrostis* species (Shoko and Tobani, 2002).

Materials: Two indigenous (*Acacia polyacantha and Bauhinia thonningii*) and two exotic (*Acacia saligna* and *Eucalyptus grandis*) tree species were tested for their potential use in the rehabilitation of a mine dump. Seedlings of the four tree species were raised in a nursery in planting sleeves, 100 x 150 mm. The seedlings were planted on terraces with a spacing of 2 m x 2 m during 2000, 2001 and 2002.

Measurements: Ten percent sampling intensity was used for each species from each planting year. Trees were selected randomly for measurement of height

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using height rods and root collar diameter using callipers. Survival percentages of the four species within the same year of establishment were compared.

Statistical Analysis: The data was analysed separately for height, root collar diameter and survival. Analysis of variance (ANOVA) was conducted using the Statistical Package for Social Sciences (SPSS Version 10) with the following model of analysis:

$$Y_{ijk} = u + S_i + Y_j + e_{ijk}$$

Where: Y_{ijk} is the dependent variable (e.g. height), u is the overall mean, S_i is the effect of species, Y_j is the effect of year and e_{ijk} is the random error. Statistical differences between treatment means were assessed using the Tukey Studentised Range test.

RESULTS

Pair-wise comparisons for species survival performance showed that there were no significant differences ($P > 0.05$) among all species (F value 0.400) for the all the plantings at one year of age. The mean survival percentage of *E. grandis* was 77.33±15.5, for *A. saligna*, 74.67±25.9, *A. polyacantha* had 83.00±15. and finally *B.thoningii* had 66.67±14.9. *A. polyacantha* depicted the highest variation in survival rates as shown by the relatively high standard deviation. The results for mean height and mean root collar diameter are shown in Table 1. There was no significant difference ($P > 0.05$) in mean height between exotic species (*E. grandis and A saligna*) within the same age group, however, the exotic species were significantly ($P < 0.05$) taller than indigenous species. Between the indigenous species, *A. polyacantha* had a greater mean height than *B. thonningii* in all the three age groups.

Table 1. The mean height (cm) and mean root collar diameter (cm) of exotic and indigenous tree species.

Year of Planting	Species	Mean Height +SE	Mean root collar diameter+ SE
2000	*E. grandis*	255.14±13.201	3.41±0.407
	A. saligna	255.77±13.201	3.96±0.407
	A. polyacantha	190.22±13.201	5.00±0.407
	B. thonningii	71.17±13.201	1.53±0.407
2001	*E. grandis*	167.37±6.516	2.63±0.190
	A. saligna	170.32±6.516	2.52±0.190
	A. polyacantha	96.46±6.516	3.75±0.190
	B. thonningii	55.50±6.516	1.17±0.190
2002	*E. grandis*	129.91±8.114	2.77±0.197
	A. saligna	131.02±8.114	2.70±0.197
	A. polyacantha	67.71±8.114	2.25±0.197
	B. thonningii	41.03±8.114	0.91±0.197
Significance Species		***	***
	Year of planting	***	**

***, **, * The mean difference is significant at the 0.001, 0.01, 0.05 level respectively.

The height mean annual increments (HMAI) for the populations of the same species showed significant differences ($P < 0.05$). *E. grandis* for the 2000 and 2001 populations showed a HMAI of 37.46 cm/year compared to the 2001 - 2002 with 87.77 cm/year. A HMAI of 39.3 cm/year for *A. saligna* for 2000-2001 populations was also significantly different from 85.45 cm/year for 2001 - 2002. The populations for *A. polyacantha* had a mean height increment of 28.75 cm/year for the 2000-2001 populations compared to 93.76 cm/year for the 2001 - 2002 period. However, this was not the same with *B. thoningii* whose populations gave some constant height increment of 14.47 and 15.67 cm/year for 2000 - 2001 and 2001 - 2002 planting years, respectively. The highest increment in height was observed for *A. polyacantha* with 28.75 to 93.76 cm/year from the first to second year of planting. There was no significant difference ($P > 0.05$) in the mean root collar diameters (MRCD) of exotic species (*E. grandis and A saligna*) within the same age group for all the three plantings. *B. thonningii* consistently had the lowest MRCD than the other three species. *A. polyacantha* performed significantly ($P < 0.05$) better than *E. grandis* and *A. saligna* in 2000 and 2001 but there was no significant difference ($P > 0.05$) for the 2002 populations. The mean root collar diameter increments (MRCDI) showed significant ($P < 0.05$) differences for all the species. The populations of *E.*

grandis show a drop in MRCDI for 2000-2001 populations of -0.14 cm/year but there was a sudden increase for the 2001-2002 of 0.78 cm/year. The same applies to *A. saligna* populations where the 2000-2001 showed a drop of -0.18 cm/year then an increase from 2001-2002 of 1.44 cm. *A. polyacantha* in 2000-2002 populations had a higher MRDCI of 1.5 cm/year but showed a decrease for the 2001-2002 population comparisons. *Bauhinia thonningii* started with a lower MRCDI of 0.26 cm/year but increased to 0.36 cm/year for 2000-2001 and 2001-2002 populations, respectively.

DISCUSSION

Vegetative mine tailings rehabilitation has yielded mixed results both in terms of species survival and performance. The lack of significant differences in survival rates among all the four tree species suggests that their level of adaptation to the tailings conditions is more or less the same. The findings of this study are in contrast to those of Gardner (2001) who reported that imported species of pines and eucalypts failed while local plant species especially *E. marginata* and *Corrymbia callophylla* succeeded in rehabilitating a bauxite mine in Western Australia. Similarly, Olokuye *et al*. (2003) reported that exotic tree and shrub species showed a poorer species survival and performance. This can be attributed to the better adaptation of indigenous vegetation to the poor soils. In contrast, Troung (1999) reported that due to the highly hostile nature of gold mine tailings, revegetation is very difficult and often failed when native species were used. Recognising that the tree species were growing under adverse conditions a lowest survival rate of 66.67 % for *B. thonningii* suggests that the trees performed exceptionally well. The results of this study are in line with revegetation results of iron ore mines in Minas Gerais state, Brazil, where both native and introduced species performed well (Griffith and Toy, 2001). Consistent with findings by Murdoch-Eaton et al. (1997) at Wankie Colliery in Zimbabwe, Acacia species (*A. polyacantha* and *A. saligna*) had good growth performance with respect to mean root collar diameter.

With respect to mean height, exotic species (*E. grandis* and *A saligna*) performed better than indigenous (*A. polyacantha* and *B. thonningii*) for all the three plantings. Such findings compare favourably with literature since traditionally exotic species have been preferred because of their high growth rate (Sarrailh and Ayrault, 2001). In conclusion, the study demonstrates that indigenous tree species compare favourably with exotic tree species in both survival rates and growth performance and can therefore be used in gold mine dump rehabilitation.

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