A NEW SYSTEMATIC TRIAL DESIGN FOR THE OPTIMIZATION OF INTERSPECIFIC WEED CONTROL

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Summary A novel systematic competition experiment was designed and tested for the investigation of spatial and threshold aspects of interspecific competition resulting from *in situ* weed communities in commercial *Eucalyptus* plantations. The design was applied at three diverse sites in Zululand (South Africa) and found to supply valuable information about weeding practices. Row weeding was found to be preferable to inter-row weeding in all three of the sites, but the onset of weed-induced tree suppression differed according to the development of competitive weed levels. At these sites acceptable row weeding widths varied between 200 and 240 cm. The maximum tolerable weed biomass for eucalypt trees in the region covered by the three experiments was found to be between 1500 and 2000 kg ha^{-1}.

INTRODUCTION

In the subtropical region of Zululand (South Africa), *Eucalyptus* clonal hybrids for use as pulp are grown over short rotations ranging from seven to nine years. Intensive weeding, practised from establishment in order to reduce interspecific competition, ensures that canopy closure will be achieved from as early as nine months after planting. If unchecked, interspecific competition between the trees and the weeds cause initial significant yield losses which are likely to be carried through to harvesting, resulting in a loss in final timber yield and an associated increase in the rotation time. Limited post-canopy closure weed control is carried out due to the ability of trees to exclude competing vegetation, predominantly by shading. For these reasons pre-canopy closure weed control is seen as critical and various establishment weed management options are practised which range from a minimal ring weeding to complete chemical or manual weed control.

Table 1. Description of weed competition trials.

	Duzi Estates	Nseleni	Central Area
Species	*E. grandis* clone TAG70	*E. grandis* clone TAG70	*E. grandis* x *urophylla* hybrid GUA376
Planting date	18/08/92	18/08/92	20/08/92
Espacement	3 × 2.5 m	3 × 2.5 m	3 × 1.8 m

Previous weed management trials have shown that when compared to a complete weeding, a row weeding may achieve similar gains in tree performance, with a resultant reduction in the areas to be weeded (Schumann *et al.* 1993). This may be translated into economic as well as the expected environmental gains. A need was therefore established to optimize existing minimum threshold weeding recommendations across diverse sites of varying weed communities employing different methods of site preparation.

Of the various trial designs available for use in competition studies, as described by Radosevich (1987) and Cousens (1995), none were found to be suitable for the specified requirements. A new design, incorporating the notable attributes of Nelder and Neighbourhood designs, and dubbed the 'Wedge Design', was planned and tested on *Eucalyptus* clonal hybrids on three diverse sites in Zululand in 1992. The idea of a replicated, continuous, and comprehensive competition gradient, which could be analysed by non-linear regression, as well as the relative ease to replicate this compact design over different sites, were particularly appealing aspects.

MATERIALS AND METHODS

The 'Wedge Designs' consist of interleaved wedges of weedy and weed-free ground superimposed onto newly planted tree rows (Figure 1). By interleaving wedges of weedy and weed-free ground, a wide range of weeding intensities was tested with five replications per site in three diverse areas of Zululand (Table 1). The sites were chosen to estimate the repeatability of results under different site conditions and to determine the influence of different land use histories on weed populations. Weeds were cleared by hand around trees in the designated weed-free zones, and with a knapsack sprayer using glyphosate (Roundup™, 3 L ha^{-1} product) as required. Monthly non-destructive measurements of tree height, crown diameter, and root collar diameter were taken, and above-ground dry weed biomass was determined by destructive quadrat sampling. In order to compare standardized tree performance over time, the crown growth reduction from weed competition was calculated for each tree at a given time by subtracting its crown diameter from the maximum (weed-free) crown diameter in a given wedge. This calculation was repeated for every

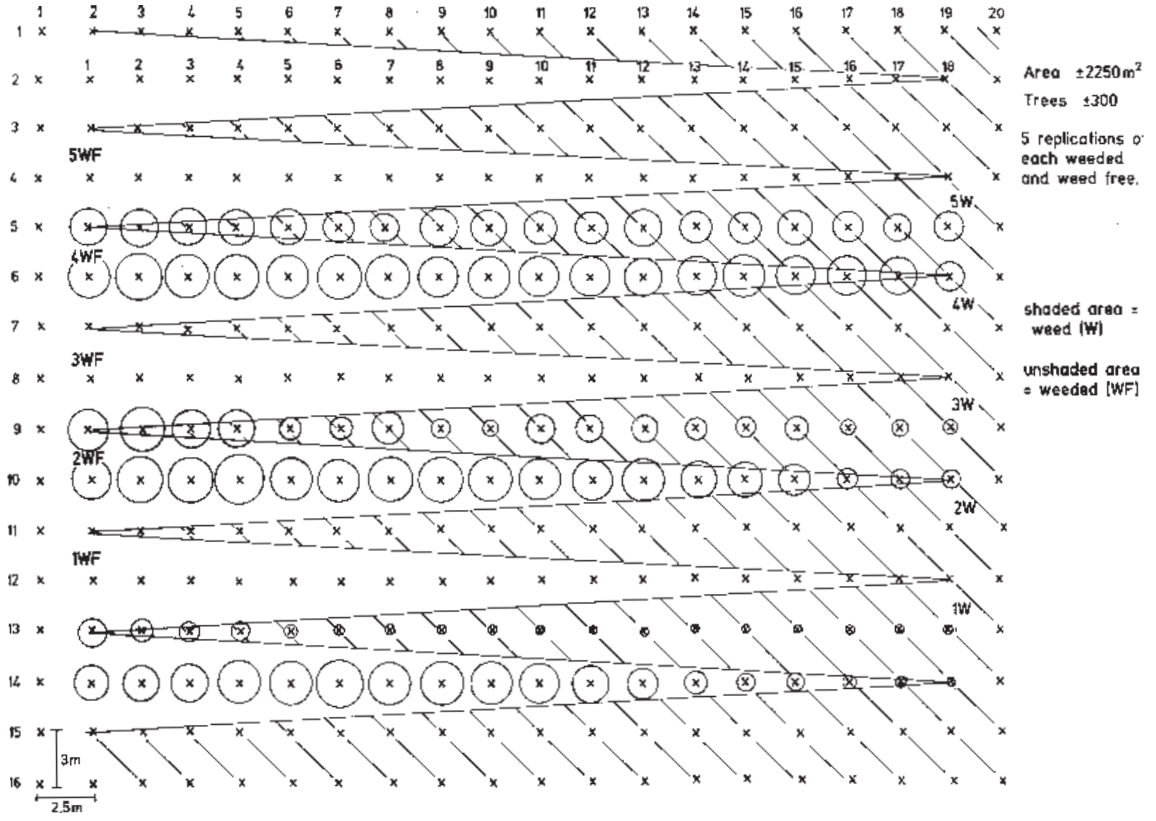

Figure 1. Ground plan of wedge trial design. Tree positions are marked by x's, and circles represent actual tree crown diameters at seven months in (a) rows 13 and 14 – Duzi Estates, (b) rows 9 and 10 – Nseleni, and (c) rows 5 and 6 – Central Area.

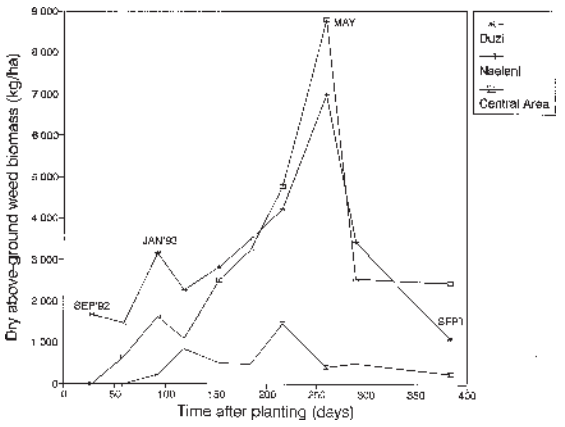

Figure 2. Accumulation of weed biomass over time on three contrasting sites.

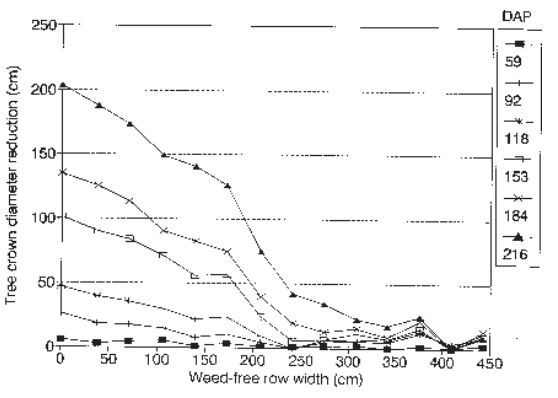

Figure 3. Mean reduction in tree crown growth from weed competition as a result of changing row weedings width and biomass accumulation over time – Duzi Estates. DAP = days after planting.

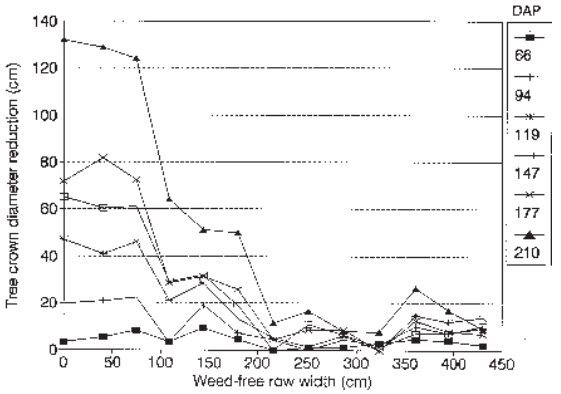

Figure 4. Mean reduction in tree crown growth from weed competition as a result of changing row weeding width and biomass accumulation over time – Nseleni. DAP = days after planting.

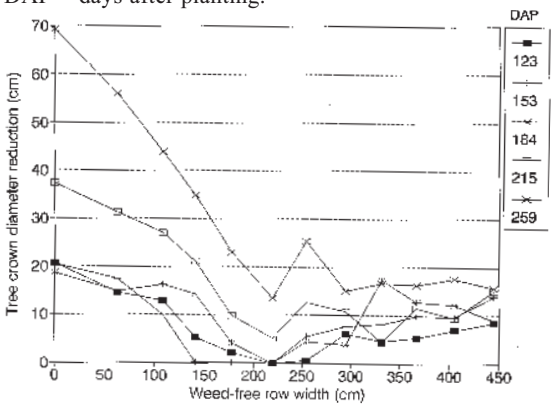

Figure 5. Mean reduction in tree crown growth from weed competition as a result of changing row weeding width and biomass accumulation over time – Central Area. DAP = days after planting.

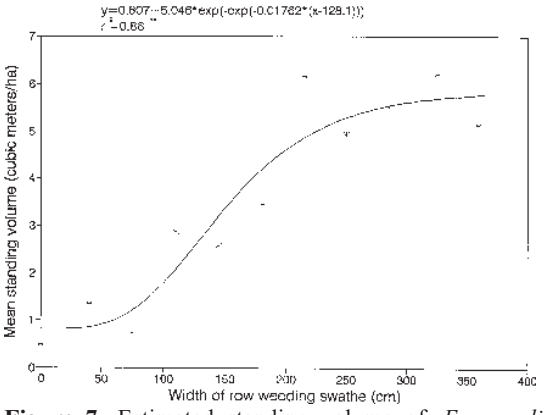

Figure 7. Estimated standing volume of *E. grandis* TAG70 clones after 384 days under a range of row weeding intensities at Nseleni.

assessment date and the results plotted against the weed-free row width (Figures 3–5). The mean standing volume at 12 months was estimated from a cone equation based on the height and root collar diameter of each tree bole and the original stocking (Equation 1).

Equation 1.

$$V = \frac{1}{3} \times \pi \frac{D^2}{4} \times H \times S$$

where:

V = estimated stand volume (m^3 ha^{-1})
D = stem diameter at root collar (m)
H = height of tree (m)
S = stocking (trees ha^{-1})

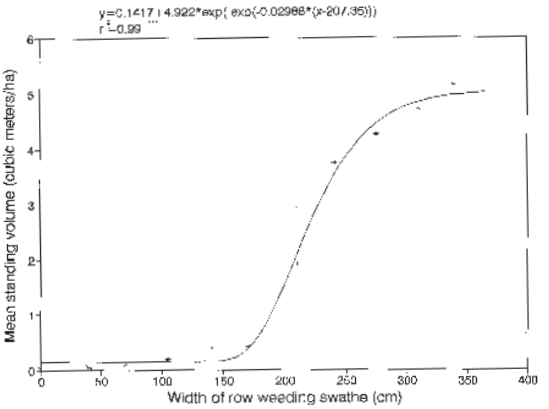

Figure 6. Estimated standing volume of *E. grandis* TAG70 clones after 384 days under a range of row weeding intensities at Duzi Estates.

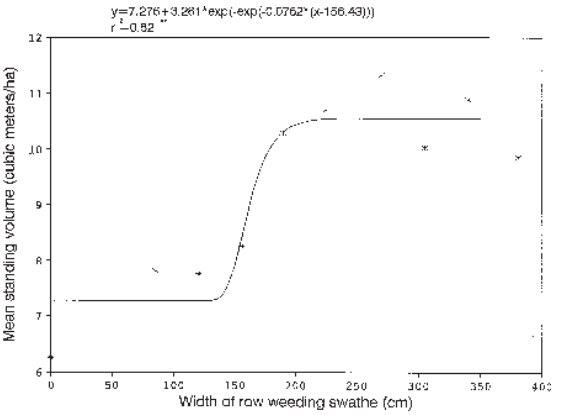

Figure 8. Estimated standing volume of *E. grandis x urophylla* hybrid GUA376 clones after 384 days under a range of row weeding intensities at Central Area.

Since treatments are systematically applied, a valid analysis of variance is not possible and non-linear regression techniques were employed. A gompertz growth curve model (Digby *et al.* 1989) was fitted to the mean volume for the row weeding data sets of each experiment (Figures 6–8).

RESULTS AND DISCUSSION

Competition is a function of both spatial position (closeness) and biomass (size or quantity) and the competitive ability of an inter-row weed strip is not only determined by its horizontal distance from the target crop (as achieved by prescribed row weeding width), but also by the weed biomass remaining on the site. These aspects were made particularly clear by the results obtained from the use of this competition trial design.

Duzi Estates (previously under sugarcane) weed populations proved most competitive because of rapid early growth, especially *Cyperus esculentus*, reaching 3000 kg ha^{-1} dry biomass by the third month and competing strongly with the trees in their most susceptible (youngest) period (Figure 2). Thus for the Duzi site, serious tree suppression was detected from 59 days onwards when the weed biomass was between 1500 and 2000 kg ha^{-1} (Figures 2 and 3). Estimated 12 month standing tree volume performance under different weeding treatments allows for the estimation of minimum weeding requirements (Figure 6). A minimum row weeding swathe of 240 cm was found to be the most acceptable threshold for this site, resulting in 25% volume loss (Figure 6).

The other two trials recorded similar thresholds, but were detected much later due to the slower weed growth (no *Cyperus* initially). For Nseleni (previously burnt *E. grandis* slash), earliest growth suppression was noticed at 94 days, when the site biomass was estimated at about 1800 kg ha^{-1} (Figures 2 and 4). Central Area (an *E. grandis* slash-managed area) weed competition occurred after 215 days with an estimated weed biomass of about 1500 kg ha^{-1} (Figures 2 and 5). Once again, the estimated 12 month standing tree volume performance under different weeding treatments allowed for the estimation of minimum weeding requirements (Figures 7 and 8). For both these sites, a 200 cm minimum row weeding swathe was found to be the most acceptable threshold, with losses of 20% and 1% loss in estimated 12 month standing volume, for Nseleni and Central Area respectively.

It appears logical that a threshold for early weed competition in *Eucalyptus* establishment exists at around 1500 to 2000 kg ha^{-1} dry above-ground biomass. The most serious long-term competitors on all three trials were various annual grasses such as *Panicum maximum* (the *C. esculentus* at Duzi was rapidly succeeded by grasses). Competition from weed levels below this threshold is negligible. Management should therefore aim to restrict weed biomass at all times to below 1500 kg ha^{-1} in the crucial competitive zone of 100 cm radius around a young *Eucalyptus* seedling. The resultant 66% 'minimal' weeding recommendation has the dual advantage of saving up to 33% in weeding costs and reducing soil erosion. The duration of this weeding intensity should be for the first year's weed growing seasons. All trials indicated that canopy closure in uninhibited stands should be attainable by 365 days (tree height 300 cm+), after which weed control can usually be phased out.

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