JARRAH PLANTING AND ESTABLISHMENT

(A REPORT ON THE RESULTS FROM EXPERIMENT 20/83)

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Jarrah (Eucalyptus marginata sm.) is indigenous to the southwest of Western Australia where it originally covered some 5.2 million hectares, of which more than half has been demarcated for other purposes, in particular agriculture Wallace (1965) and Harris (1956).

In common with many eucalypts, Jarrah produces a lignotuber. The Jarrah seedling does not immediately develop an upright single dynamic stem like other eucalypts, but slowly develops into a multi-stemmed hemispherical bushy shrub 75-100 centimetre high arising from the lignotuber (Van noort,1960). This static form is a characteristic stage in the development of the Jarrah under natural conditions and such plants are locally known as lignotuberous advance growth (Harris 1956). It is widely recognised that the period for the lignotuberous advance growth to develop a dynamic shoot is in the order of 15 to 20 years or a time when the lignotuber has attained a diameter of at least 10 centimetre (Abbott and loneragan 1984), (Harris 1955), (Van noort 1960). The conditions required for dynamic advance growth to progress into sapling stage are brought about by the reduction in site competition usually by the removal of mature trees through death or by logging operations.

In contrast, artificial regeneration of Jarrah does not follow the normal stages of lignotuber development and most will develop dynamic shoots within 2-5 years on cleared, ploughed lateritic gravels (Kimber unpublished). Most knowledge of Jarrah form and growth was from work carried out in the northern Jarrah forests.

This report is on trials in establishment and development of planted Jarrah seedlings in the southern Jarrah forest. They were established because it was thought that there may be differences in development time and sequences from those in the northern Jarrah forest.

METHOD

Seven separate fully randomised blocks were established on different soil types in Gordon Block 20 km west of Manjimup. The soil types examined were described as ; red podsol, yellow podsol, black gravel, laterite, depositional loam, sand depression and sand gully. Each block contained 9 subplots with three replicates each with three levels of treatment (table 1). There where no controls established to permit comparisons between treatments and untreated controls, however planted Jarrah in a fertiliser trial in Poole block 1984 (strelein unpublished) where unfertilised controls were established is useful as a reference for comparison.

TABLE 1.

Treatment type within blocks.

SUBPLOT N^{O}	VEGETATIVE CONTROL	FERTILISER TYPE
1	RAKED	AGRAS 1
2	RAKED	AGRAS 2
3	RAKED	POTATO E
4	RAKED & SPRAYED	AGRAS 1
5	RAKED & SPRAYED	AGRAS 2
6	RAKED & SPRAYED	POTATO E
7	COMPLETELY CLEARED	AGRAS 1
8	COMPLETELY CLEARED	AGRAS 2
9	COMPLETELY CLEARED	POTATO E

Vegetative control

In each block three replicated vegetative control measures were established;

1. Raked plots; These plots had lines cleared through the vegetation with a rake blade.Lines were 4 metres between swaths. the blade with of the bulldozer was approximately 4 meters wide which allowed a row of jarrah seedlings to be planted either side of the raked row.
2. Raked and sprayed; The raked and sprayed subplots were initially established in the same manner as the raked plots with an additional treatment to spray any remaining vegetation on the raked lines as well as the edges with Tordon 105.
3. Completely cleared; The completely raked or cleared sub plots had all vegetation removed by bulldozer using a rake blade.

Planting

Planting commenced in early July 1983, along raked lines using large jiffy pot (50 x 50 mm) Jarrah seedlings. The seedlings were planted 2 meters apart along rows with a nominal spacing of 4 meters placed either side of the raked lines. The subplots contained six rows of 12 plants with the intention of a one row buffer around each plot leaving 40 trees for assessment.

Fertiliser types

All subplots were fertilised six weeks after planting. Three replicated treatments were applied (table 1), Agras 1, Agras 2 and potato E . Each fertiliser rate was calculated to contain the same amounts of elemental phosphorous (7.5 gms.) this equates to ;

Agras 1	100 gms of fertiliser
Agras 2	72 gms of fertiliser
Potato E	109 gms of fertiliser.

RESULTS AND DISCUSSION

Survival

In 1984 survival and total height was measured 12 months after planting, remeasurements were taken at 24 months and 36 months where form, vigour and growth dynamics were observed (Table 2A,B,C,D). There is no evidence of any significant differences between the three fertiliser types (p>.05). Potato E had only a marginally higher survival rate than either Agras 1 or Agras 2. These fertilisers all have equivalent levels of elemental phosphorous but varied levels of nitrogen which indicates nitrogen was not beneficial in increasing survival of Jarrah. It is possible that Jarrah survival is independent of nitrogen level or the nitrogen was unavailable to the plant either because it had leached from the soil below the root zone or was lost to the atmosphere through denitrification. Any small differences in survival would be more likely attributed to site variations than any beneficial difference from the fertilisers. Christensen (1972) observed increased mortality with increased levels of nitrogen in trials on karri (Eucalyptus diversicolor). This trend was not obvious in the Gordon trials on Jarrah, which further indicates that there may be a low level of nitrogen available at a time when the seedling were active or nitrogen has little effect on mortality of Jarrah. The latter is more likely as trials in Poole 25km south of Pemberton by Strelein (unpublished) also showed no evidence of mortality from varied levels of nitrogen on Jarrah seedlings. Here survival was in excess of 90 percent for treatments including the unfertilised controls.

TABLE 2.A

Survival of Jarrah seedlings with different fertilisers and treatment levels for soil types

BLOCK SOIL TYPE	TREATMENT	FERTILISER TYPE	HEIGHT cms		SURVIVAL %	
Yellow Podsol	Raked	Agras 1	143		80	
		Agras 2	96		62	
		Potato E	77	*105*	70	*71*
	Raked & Sprayed	Agras 1	138		46	
		Agras 2	97		78	
		Potato E	120	*118*	30	*51*
	Cleared	Agras 1	110		62	
		Agras 2	-		-	
		Potato E	106	*108*	62	*62*
				111		*61*
Red podsol	Raked	Agras 1	130		34	
		Agras 2	117		26	
		Potato E	158	*135*	32	*31*
	Raked & Sprayed	Agras 1	114		14	
		Agras 2	196		28	
		Potato E	108	*139*	20	*21*
	Cleared	Agras 1	123		30	
		Agras 2	100		38	
		Potato E	155	*126*	60	*43*
				133		*32*

TABLE 2.B

Survival of Jarrah seedlings with different fertilisers and treatment levels for soil types

BLOCK Soil Type	TREATMENT	FERTILISER TYPE	HEIGHT cms		SURVIVAL %	
Black Gravel	Raked	Agras 1	124		78	
		Agras 2	121		68	
		Potato E	105	*117*	80	*75*
	Raked & Sprayed	Agras 1	84		72	
		Agras 2	92		64	
		Potato E	112	*96*	88	*75*
	Cleared	Agras 1	170		80	
		Agras 2	150		78	
		Potato E	140	*153*	78	*79*
				122		*76*
Laterite	Raked	Agras 1	165		90	
		Agras 2	185		82	
		Potato E	187	*179*	82	*85*
	Raked & Sprayed	Agras 1	148		72	
		Agras 2	225		80	
		Potato E	162	*178*	72	*75*
	Cleared	Agras 1	211		81	
		Agras 2	211		88	
		Potato E	260	*227*	84	*84*
				195		*81*

TABLE 2.C

Survival of Jarrah seedlings with different fertilisers and treatment levels for soil types

BLOCK Soil Type	TREATMENT	FERTILISER TYPE	HEIGHT cms		SURVIVAL %	
Sand Depress'n	Raked	Agras 1	36		68	
		Agras 2	136		16	
		Potato E	79	*83*	48	*44*
	Raked & Sprayed	Agras 1	60		74	
		Agras 2	56		8	
		Potato E	72	*63*	50	*44*
	Cleared	Agras 1	57		34	
		Agras 2	45		46	
		Potato E	65	*56*	54	*45*
				67		*44*
Sand Gully	Raked	Agras 1	46		68	
		Agras 2	43		44	
		Potato E	53	*47*	40	*51*
	Raked & Sprayed	Agras 1	34		60	
		Agras 2	43		78	
		Potato E	44	*40*	50	*63*
	Cleared	Agras 1	120		40	
		Agras 2	129		60	
		Potato E	100	*116*	72	*57*
				68		*57*

TABLE 2D

Survival of Jarrah seedlings with different fertilisers and treatment levels for soil types

Loams

BLOCK Soil Type	TREATMENT	FERTILISER TYPE	HEIGHT cms		SURVIVAL %	
Depositional Loams	Raked	Agras 1	47		68	
		Agras 2	97		24	
		Potato E	72	*72*	28	*43*
	Raked & Sprayed	Agras 1	90		60	
		Agras 2	63		16	
		Potato E	90	*81*	18	*31*
	Cleared	Agras 1	46		40	
		Agras 2	79		16	
		Potato E	44	*56*	20	*25*
				70		*33*

As with the fertilisers, no perceivable difference in survival was observed from the three vegetative treatments. This is probably due in much that all three treatments were initially very successful in eliminating scrub competition within all blocks. All blocks were clear of vegetation for 3 years and several still have little plant vegetation present after eight years.

The survival varied markedly between blocks (soil types). The variation in survival is attributed primarily to poor drainage. This is particularly evident in the sand depression, deposition loams and to some extent yellow podsols, where localised areas of waterlogging occurred throughout the blocks.

The sand gully, yellow podsol and deposition loam blocks were badly inundated by water. The sand gully was flooded due to its low topographic position allowing pools to form in the depressions. Where as the yellow podsol and depositional loam was flooded due to depressions caused by mechanical disturbance in the soft sandy soils. These blocks had areas where plants were submerged for periods up to 8 weeks or longer. The high mortality in these areas is almost certainly due to waterlogging . Davidson and Tay (1985) in pot trials found jarrah seedlings to be sensitive to waterlogging. They concluded that occlusions of the xylem vessels in the tap roots and to some extent the stems by tyloses was the main cause of seedlings wilting. The proportion of vessels with tyloses increase with the duration of waterlogging. The duration of their trials was considerably shorter than the period of flooding which occurred in the Gordon trials.

The red podsols though well drained had high mortality, the cause of deaths was Botrytis fungi present in the seedling trays at time of planting. Many seedlings were either dead or wilting at time of fertilising and only 36 percent of plants had survived by the time of initial assessment at 12 months, reducing to 33 percent at 2 years. It is unknown why none of the other sites experienced losses to seedlings as did the red podsols. No record of seed lots were taken and the probable cause was not investigated.

The laterite and black gravel blocks were located in ridge top sites and were well drained. These sites had survival rates commensurate with normal operation plantings. Laterite had 81 percent survival and the black gravel 76 percent.

GROWTH

The early growth rates of Jarrah have shown considerable variation between soil types (table 3). Most of the variation is a result of establishment on poor and inadequately drained soils. This is particularly evident in the sands and Depositional loam. The lateritic soils which have good drainage recorded reasonable growth rates in excess of a meter per year. The podsols though poor having poor survival also recorded growth levels similar to the lateritic gravels.

TABLE 3.

Jarrah seedling growth rates for soil type, treatment and fertiliser type

SOIL TYPE	TREATMENT				FERTILISER			
YELLOW PODSOL	108	114	108	*110*	131	97	96	*108*
RED PODSOL	136	149	131	*139*	124	134	147	*135*
BLACK GRAVEL	116	97	153	*122*	127	123	118	*123*
DEPOSITIONAL LOAM	79	81	56	*72*	69	82	68	*73*
LATERITE	179	180	227	*195*	175	207	205	*196*
SAND DEPRESSION	64	64	54	*61*	50	67	71	*63*
SAND GULLY	47	40	114	*67*	59	71	71	*67*
	104	*103*	*120*	*109*	*105*	*112*	*110*	*109*
	raked	raked sprayed	cleared		ag1	ag2	pot	E

* Analysis using Duncans multiple range test.

Height growth was similar within the treatments and within the fertilisers. There are only small differences in treatment 3 , the cleared plots, which performed better on two sites , laterite and sand gully p>.05) than the raked, raked and sprayed treatments. The fertiliser treatments showed little significant difference within the sites.

The height growth recorded in the Gordon trials are comparative with other trials in planted Jarrah seedlings. Kimber (unpublished) at Inglehope recorded growth in the order of 1 metre per year on cleared ploughed lateritic gravels. Strelein (unpublished) Poole had mean growth in the order 1 metre at age 2 years.

GROWTH HABITS

The growth habits were recorded at age 3 years in terms of vigour, form and stem dynamics. Vigour was used to describe the stage of development of the Jarrah seedling from incipient advance growth to a dynamic shoot (table 4.). Three categories for vigour were recorded, dynamic, incipient and lignotuberous-coppice (Abbott and Loneragan, 1984).

1. Dynamic shoots have a well defined leader among the surrounding multiple shoots with the single dominant vigorous stem about 1-1.5 metres high .

2.Incipient shoots lack any definite leading stem and are usually bushy multi-stemmed plants less than 1 metre high.

3. Lignotuberous-coppice or seedling coppice are older than 1 year single stemmed with lignotuber present.

TABLE 4.

Percentage of dynamic shoots, incipient advance growth and lignotuberous coppice at age 3 years.

	RAKED	RAKED SPRAYED	CLEARED		
DYNAMIC	58	62	69	*63*	AGRAS 1
	72	65	72	*70*	AGRAS 2
	59	54	60	*58*	POTATO E
	63	*60*	*67*	*64*	
INCIPIENT	40	36	27	*34*	AGRAS 1
	28	35	26	*30*	AGRAS 2
	40	46	40	*42*	POTATO E
	36	*39*	*35*	*35*	
LIG-COPPICE	2	28	4	*11*	AGRAS 1
		1	2	*1*	AGRAS 2
	1	1	1	*1*	POTATO E
	1	*10*	*2*	*4*	

The extreme variability of the different sites makes it difficult to determine any real significance between treatments. Agras 2 has a marginally better percentage of dynamic shoots but as it has less nitrogen than Agras 1 and more than Potato E with identical levels of phosphorous then the differences are more probably due to site variability than fertiliser effect. Similarly the vegetative treatments show little significant differences.

The percentage of dynamic shoots overall was 63 percent at three years which compares favourably with the Inglehope, trials near Dwellingup where 50 percent had recorded dynamic shoots at 2 years and 95 percent by 5 years. While the Poole trials recorded from 30 to 50 percent with dynamic shoots at age two years .

Seedling form was measure used to record stem straightness. Stems were recorded as straight, wandering, kinked and coppice (Table 5.).

Straight stems were stems with obvious good form, free of any defects with straight shoots.

Wandering stems were stems with abnormal form usually greater than 20 percent displacement - probably nutrient related.

Kinked stems were displaced, commonly at branch nodes, due usually to grazing or insect attacks.

Coppiced stems were stems arising from the lignotuber where the original stems have either died or been removed.

Overall 95 percent of seedlings were straight, 3 percent were wandering, and 1 percent were kinked and coppiced

TABLE 5.

Percentage Jarrah seedling form

	RAKED	RAKED	CLEARED	
STRAIGHT	97	95	94	AGRAS 1
	92	98	94	AGRAS 2
	92	95	98	POTATO E
WANDERING	2	4	5	AGRAS 1
	6	2	5	AGRAS 2
	3	3		POTATO E
KINKED	1	1	1	AGRAS 1
	1		1	AGRAS 2
	1			POTATO E
COPPICE		1		AGRAS 1
	1	2	1	AGRAS 2
	4	2	1	POTATO E

Most trees were found to be straight. Even the multi stemmed and moribund trees had straight stems. The high level of straight stems recorded is probably a function of the young age at which this measurement was taken. Recent visits to the trail have given an impression that this figure would not be as large if remeasured.

A measure of stem numbers showed 47 percent of trees had single stems, 20 percent were double stemmed, 31 percent were multi-stemmed and 2 percent had ramicorn stems present. Like tree straightness assessment of stem numbers was done at a time when the Jarrah seedlings were not sufficiently advanced to adequately determine this parameter confidently. In this case it is possible that the number may increase as many stems were still at advance growth stage and would have developed further into trees with single or multiple shoots. Table 6, shows the relative scores for stem numbers for each treatment.

TABLE 6.

Percentage of jarrah trees with single stems.

	RAKED	RAKED SPRAYED	CLEARED		
SINGLE STEMS	50	54	54	*53*	AGRAS 1
	43	47	45	*45*	AGRAS 2
	40	42	45	*42*	POTATO E
	44	*48*	*48*	*47*	
DOUBLE STEMS	14	14	17	*15*	AGRAS 1
	23	19	21	*21*	AGRAS 2
	23	26	21	*23*	POTATO E
	20	*20*	*20*	*20*	
MULTI STEMMED	36	30	26	*26*	AGRAS 1
	32	31	31	*31*	AGRAS 2
	32	27	32	*32*	POTATO E
	33	*29*	*30*	*31*	
RAMICORN	1	2	2	*2*	AGRAS 1
	2	3	2	*2*	AGRAS 2
	5	4	2	*4*	POTATO E
	3	*3*	*2*	*3*	

From his Jarrah trails Kimber 1983 observed that the form of planted seedlings were generally poor, even at high densities (10,000 plus spha). He hypothesized that attacks by cossid moths was a possible cause of poor form and recorded frequent multiple stemming. Strelein, in the Poole trials, recorded 50 to 60 percent of all seedlings at 2yr old as single stemmed which relates closely with results of this trial. It would appear that Jarrah seedlings at age 2 or 3 years have a reasonable percentage of seedlings with single stems which is not maintained as they develop due to some unknown factor. This may be insect attack as indicated by Kimber or even fungal or may be nutrient related. A re-assessment of this trial would almost certainly show an increase in multiple stems as recent inspection of the areas have given a general impression of poor form and a higher level of multiple stems than recorded previously.

CONCLUSION AND RECOMMENDATIONS.

The Jarrah development trials have shown that artificial establishment of Jarrah seedlings is achievable particularly on lateritic gravels and podsolic soils. Although low mortality was observed in the podsol soils, reasonable height growth resulted. This was also concluded in other trials on Jarrah seedlings (Strelein unpublished). The sand soils were found to be more difficult to establish jarrah seedlings as mortality was low and generally subsequent height growth is poor. The sand soils are recognised as difficult to rehabilitate and perhaps jarrah is not the species best suited for these sites. In these sites Jarrah rarely occurs naturally due to there high moisture characteristics and are more usually inhabited with Blackbutt (Eucalyptus patens), Paperbark (Melaleuca pressiana) and occasionally Bullich (Eucalyptus megacarpa) or Flooded Gum (Eucalyptus rudis).

This trial was established in an area which had poor natural regeneration and had been treated several years previously. The trial could be useful as an alternative technique to burning. The site establishment through raking to mineral earth with a rake blade bulldozer was successful in producing a scrub free environment for planting. Perhaps the inclusion of ripping and planting on rip lines may increase establishment success and promote better early development of seedlings and to some extent may have reduced waterlogging. The removal of competition is essential in successful regeneration and Jarrah has also shown a need for good drainage therefore site preparation should meet these requirements.

The application of different fertilisers was inconclusive in this trial, however it is often quoted that any fertiliser is better than no fertiliser in promoting early growth of seedlings. Jarrah trials in Poole have shown increased growth with all fertilisers compared with unfertilized controls, those fertiliser with P/N ratio's 1:1 or 2:1 were better than those fertilised with just phosphorous alone (Strelein unpublished). Many authors have reported an interaction between nitrogen and phosphorous. Foth 1978 reported when phosphate fertiliser is placed with nitrogen in the soil, a greater uptake of phosphate occurs. The lack of response in this trial between the three fertilisers is probably due partly to the combined effect of several factors other than just fertiliser combinations or elements. Moisture and temperature as well as timing and placement are important elements in the final outcome in fertiliser response. Finally due to the low solubility of phosphorous, phosphate supply to the plants depends more on the size of root systems, density of its root hairs and soil diffusion than any other nutrient (Russell 1973). Therefore faster growing plants or plants with large active root systems will uptake more phosphate than plants with poorly developed roots.

It would be advantageous to remeasure this trial to observe the form of the Jarrah saplings. The trial is now in its eighth year and is at a stage where form can be adequately seen. I feel there is little benefit to be gained in further assessing the sites for comparative growth data due to the poor survival of some of the sites though growth is easily measured if other parameters are to be recorded. There has been some interest shown in treating Jarrah plots with poor form to see if subsequent shoots arising from the lignotuber have improved form. Parts of this trial may prove useful for these ends. Due to the trial having poor survival in several replicates then perhaps little more useful information is obtainable from this trial in terms of establishment.

REFERENCES

ABBOTT, I and LONERAGAN, O. (1986). The ecology of Jarrah Eucalyptus marginata in the Northern Jarrah Forests of Western Australia. Bulletin 1, Department of Conservation and land Management, Perth, Western Australia.

DAVIDSON, E.M. and TAY, F.C.S. (1985) The effect of waterlogging on seedlings of Eucalyptus marginata. The New Phytologist, 101, 743-753.

FOTH, H.D. (1978) Fundamentals or soil science. Wiley, New York.

KIMBER P.C. (1983) In proc. Jarrah workshop, Manjimup, March 1983, Forests Department of Western Australia.

MASON, M.G. (not dated), Nitrogenous fertiliser for cereal Production. Bulletin 3992, Department of agriculture, Western Australia.

RUSELL, E.W. (1973) Soil conditions and plant growth. 10th edition, Longman, London.