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ALTERNATIVE CROPS RESEARCH REPORT SESAME, PIGEON-PEA, GUAR

1986-87 AND 1987-88 WET SEASON KATHERINE

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PART 1

1986-87 WET SEASON

INTRODUCTION
The main aim of Crop by Environment Experiment (1983/84 - 1985/86) was to collect basic data on the performance of fourteen crops in three environments, and to elucidate which crops are likely to be most suitable for each area, Douglas Daly, Katherine and Daly Waters.

This research project has concluded that four crops, pigeon-pea, sesame, millet and guar, are suitable alternative crops for the drier southern regions of the Northern Territory.

It was decided to initiate research into sesame, pigeon-pea and guar in the 1986-87 wet season.

SESAME
Sesame (*Sesamum indicum*) is a crop suited to the hot, dry topics. Once established it can tolerate periods of drought but is not tolerant of water logging. Sesame is not exacting in soil requirements but prefers well drained light textured sils.

Research will commence with evaluation of sesame cultivars found to have potential in a similar environment (ie, Kununurra). The influence of sesame plant population and weed development on seed yield will also be investigated, while the search for a replacement herbicide for alachlor will initially be in the form of a metolachlor pot experiment. Monitoring of commercial crops will provide background information on current yield losses at harvest and the status of the Northern Territory sesame crops.

PIGEON-PEA
Pigeon-pea *(Canjanus canjan)* is a perennial which has a number of advantages over other grain legume crops. These include drought tolerance, lodging and shattering resistance and perenniality which allows the possibility of ratoon crops. Disadvantages however include susceptibility to water logging and yield loss due to insects.

Research into pigeon pea will include observations on potential cultivars from the University of Queensland Pigeon Pea Research program, and the influence of plant population and time of sowing on pigeon pea seed yield.

GUAR
Guar (*Cyamposis tetragonoloba*) is a summer growing annual grain legume with excellent drought resistance. Guar grows between 1.0 to 3.0m tall. Plant types can vary from single-stemmed to profusely branching.

The highest quality seed is produced in areas where rainfall ranges from 600 to 900mm. Prolonged wet weather during maturity results in seed discolouration making it less attractive for gum processing. Guar research will focus on cultivar observations and the influence of time of sowing on seed yield.

2.1 SESAME CULTIVAR EVALUATION IN THE 1986-87 WET SEASON

2.1.1 ABSTRACT

A range of sesame cultivars were evaluated at Katherine Rural College (K.R.C.) in 1986/87, wet season.

Cultivars Teras 77 and Hnan Dun produced the highest seed yields of 532 and 523 kg/ha respectively. Yields followed phenology with the earlier maturing cultivars producing the higher yields. Yields for all cultivars were depressed due to low populations, late plantings and a short wet season.

2.1.2 INTRODUCTION

Sesame is considered a potential crop for the Northern Territory. Previous research has concentrated on determining the areas best suited to growing sesame and possible agronomic strategies. Cultivar assessment has been negligible.

Extensive cultivar evaluation has been undertaken in the Ord River Irrigation Area (ORIA) during 1981/82 and 1982/83 wet seasons. Nine cultivars (white seeded) best suited for culinary trade market and one dark seed cultivar were selected from the ORIA work for initial research in the Northern Territory.

Characteristics of a sesame ideotype suitable for the Northern Territory include:

a) Maturity by late April for crops planted in early January.
b) Rapid height and minimal branch development.
c) Resistance/tolerance to sesame leaf roller, (*Antigastra catalaunalis*).
d) Rapid, compact capsule maturation.
e) Semi-dehiscent capsules.
f) White seeds of high oil content.
g) High yielding.
h) Lodging resistance.

2.1.3 MATERIALS AND METHODS

2.1.3.1 Seasonal conditions

The 1986/87 season was characterised by average rainfall for December and January and well above average rainfall for February. The wet season ended in the last days of February. (Table 2.1.1) Soil type was a Fenton clay loam which had been sown to sorghum the previous season. Prior to that, the area was a buffel grass paddock (Sesame Appendix).

2.1.3.2 Design, Treatments and Management

Experimental design was a split plot with 2 row spacings (main plots) and 10 cultivars (subplots). Row spacings were 18cm and 36cm. Cultivars included Teras 77, Turen, Hnan Dun, Pachequino Selection, Pachequino, Yori 77, Maporal, Aceitera, Black Seed and Palmetto. There were 3 replications. Plot size was 6 rows by 5.2m. The sesame seed was sown with a cone-seeder at 1-2 cm depth. Cultivar germination was variable and seeding rate was adjusted in order to obtain a plant population of 200×10^3 plants/ha.

The area was fertilised with single-superphosphate at 250kg/ha (approx. 23kg/ha N), on 24 December. The herbicide Lasso® (alachlor) was applied at 4L/ha on 18 December for grass control.

This experiment was sown on the C9 paddock of the D.P.P. research area at K.R.C. on 16 January, 1987. The insecticide Lorsban 500 EC® (chlorpyrifos) was sprayed at 2L/ha on 19 February to control seed harvesting ants.

Leaf roller and Heliothis caterpillars were controlled throughout the season with various insecticides. The cultivars were sprayed with Lorsban @ 2L/ha on 22 March and Ambush® (permethrin) @ 0.2L/ha on 27 March and Thiodan (endosulfan) on 6 April.

2.1.3.3 Recordings and Data Collection

During the season, phenological data were recorded. These included date of first flower, date of 50% of plants flowering, date of physiological maturity (95% of capsules yellow) and date of harvest maturity (95% of capsules brown).

Sesame cultivars were rated on 2 occasions for susceptibility to leaf roller damage. A score of 0 implied no symptoms and 5 that the entire plot was affected.

At physiological maturity, 10 plants were selected for yield component analysis. Height, height of lowest capsule, number of capsules/plant and weight of seed/plant were measured. From this data, length of stem used for capsule set and number of capsules/cm of stem used for capsule set were calculated.

At maturity, plant population and seed yield were recorded by harvesting the centre four rows by 3m from each plot. A $0.5m^2$ quadrat was vacuumed from within this area to determine seed loss due to shattering after capsule dehiscence. Samples were threshed and cleaned and yields recorded. Sub-samples were set aside for 100 seed weight, oil and germination determinations.

2.1.4 RESULTS AND DISCUSSION

Two plots in replicate 3 with 18cm row spacing were destroyed due to Gramoxone (paraquat) drift on 3 February 1987.

Sesame plants at random throughout the experiment displayed symptoms of 2,4-D damage during mid February. The symptoms were evident for 2 to 3 weeks. The 2,4-D herbicide had been sprayed more than 1km away.

2.1.4.1 Phenology

The ten cultivars could be divided into 3 maturity groups, early, mid and late on the basis of phenology.

Physiological maturity for early, mid and late was determined to be between 79-82 days, 89-90 days and greater than 102 days respectively.

With the exception of Maporal and Black Seed, all cultivars produced their first flower by day 35 after sowing (d.a.s.), 50% of plants were flowering by the 44th d.a.s. and had completed flowering by the 63 d.a.s. (Table 2.1.2).
The reason for the early cessation of flowering was the abrupt end to the wet season which induced conditions unsuitable for continued growth and flowering.

There was no significant affect of row spacing on phenology.
The time between physiological maturity and harvest maturity for early, mid and late cultivars was approximaqtely 1, 3 and 5 weeks respectively.

2.1.4.2 Yield Components

Cultivars grown with a 36cm row spacing were significantly taller than those grown with 18cm row spacing. This was probably due to greater availability of soil moisture for the crop planted with 36cm row spacing. There was no significant effect of row spacing on height of lowest capsule, number of capsules/plant or weight of seed/plant for the average of cultivars (Table 2.1.3).

Phenotypic expression of cultivars is presented in Table 2.1.4.

Three components of the sesame ideotype suitable for mechanical harvesting are

a) long capsule set stem length (C.S.L)

b) a large number of capsules within this region

c) The lowest capsule not being too low (not less than 20cm from the ground)

Sesame cv. Pachequino was used as the commercial standard for these characteristics.

None of the cultivars set their capsules less than 28cm from the ground. However, Maporal, Aceitera and Black Seed set their capsules too high up the stem (greater than 70cm).

Teras 77 and Turen set capsules significantly closer to the ground than did Pachequino.

Teras 77, Turen, Hnan Dun and Pachequino Selection, all had significantly longer capsule set length (CSL) than Pachequino.

No cultivar produced more capsules per centimetre of CSL than Pachequino.

Cultivars Teras 77, Turen, Hnan Dun, Pachequino Selection, Yori 77 and Pachequino all had suitable characteristics for mechanical harvesting.

Three cultivars, Black seed, Maporal and the Pachequino Selection were severely affected by the disease *Macrophomina phaseolina.*

2.1.4.3 Plant Population

There was no significant difference in plant population at harvest for row spacing or cultivars (Table 2.1.5). The average population was 149 x 10^3 plants/ha.

2.1.4.4 Seed Yield

Row spacing had no significant effect on seed yield (Table 2.1.6). Average cultivar yield was 344kg/ha with cultivars Teras 77 and Hnan Dun giving the highest yields of 532 and 523kg/ha respectively. Yields followed phenology with the earlier maturing cultivars producing the higher yields. Yields for all cultivars were depressed due to low populations, late sowing and an early end to the wet season.

2.1.4.5 Germination

Row spacing did not affect seed germination but there was a significant difference in germination between dehiscent cultivars and non-dehiscent cultivars (Table 2.1.8).

Threshing of sesame capsules requires accurate setting of the threshers concave and cylinder. Seed is easily damaged as microscopic cracks in the seed coat are sufficient to affect its germination.

Dehiscent sesame cultivars are more readily threshed than non-dehiscent cultivars. Cultivar Palmetto (non-dehiscent type) required 3 passes through a small sample thresher to extract all the seed from the capsules. The affect of this on seed germination was detrimental (Table 2.1.8).

Germination percentage for cv. Hnan Dun was low (77%) however there was 18% fresh ungerminated seed indicating possible seed dormacy.

2.1.4.6 Resistance to Sesame Leaf Roller

Caterpillars of sesame leaf roller (*Antigastra catalaunalis*) roll up and web together young leaves at the top of the plants with silk. They feed inside the rolled up mass. In addition to leaf damage the caterpillars also feed on flowers and bore into the capsules. The end result is severe defoliation and yield loss. Cultivars, Black Seed and Hnan Dun, appeared to be the least susceptible to Sesame leaf roller while cultivars Aceitera and Palmetto were the most susceptible (Table 2.1.7). Similar observations were recorded for these sesame cultivars when grown in Kununurra, W.A. (Eagleton, G. et al unpublished).

2.1.4.7 Hundred seed weight

There was no effect of row spacing on hundred seed weight, however there were significant differences between cultivars (Table 2.1.9).

Cultivar, Maporal, produced the lightest seed of 0.24g/100 seed with the Pachequino Selection the heaviest seed weight being 0.32g/100 seed.

2.1.4.8 Oil Content

Average sesame seed oil content was 53.5% with the highest from cv. Pachequino Selection (56.5%) and the lowest from the Black seed with (49.6%). (Table 2.1.10)

CONCLUSION

Three cultivars indicated that they had potential for growing in the Northern Territory, these were Hnan Dun, Yori 77 and Pachequino.

Yori 77 was similar to Pachequino in all characteristics except seed yield with the former producing the higher yields.

The major advantages of Hnan Dun over Pachequino were a higher seed yield, earlier maturity and resistance to leaf roller.

Further research is required to investigate the effect of wider row spacing (eg 64cm) on these 3 cultivars. Detailed research of cultivar differences in capsule dehiscence and seed quality in relation to time of harvesting should also be studied.

Table 2.1.1: Monthly rainfall (November - May) for 1986/87 wet season at Katherine Rural College.

MONTH	**SEASON 1986/87**	**LONG TERM AVERAGE**
November	56.0	83.3
December	155.5	191.6
January	207.6	228.6
February	327.2	210.2
March	0.0	162.7
April	2.0	32.8
May	0.0	5.1
Total	748.4	914.3

[1] Long term average for Katherine

Table 2.1.2: Phenology of the sesame cultivars

CULTIVAR	DAYS AFTER SOWING FOR THE FOLLOWING EVENTS				
HARVEST	FIRST FLOWERS	50% PLANTS FLOWERING	COMPLETION FLOWERING	P.M.	HARVEST
EARLY					
Teras 77	31	34	62	80	86
Turen	31	35	61	82	87
Hnan Dun	32	36	64	82	91
MID					
Pach. Sel.	34	39	63	90	111
Pachequino	35	42	63	90	111
Yori 77	34	41	62	89	114
LATE					
Maporal	39	51	88	102	136
Aceitera	34	49	63	119	154
Black Seed	45	51	96	136	155
Palmetto	33	37	61	104	156
LSD (5%) =	1	1	2	3	4
CV (%)	2.8	2.8	2.3	2.0	2.7

P.M. = Physiological Maturity

Table 2.1.3: Effect of row spacing on sesame yield components

	ROW SPACING			
	18cm	36cm	LSD (5%)	CV (5%)
Plant Height (cm)	111	118	4.7	1.2
Height of Lowest capsule (cm)	62	63	3.8	1.7
Number of capsules/plant	40	47	12.8	8.4
Weight of Seed/Plant (g)	3.7	4.1	1.8	13.1

Average over 10 cultivars

Table 2.1.4: Physical characteristics of sesame cultivars[1]

CULTIVAR	PLANT HEIGHT (cm)	HEIGHT OF LOWEST CAPSULE (cm)	WEIGHT OF SEED/PLANT (g)	LENGTH OF CAPSULE SET REGION	NUMBER OF CAPSULES/PLANT
Teras 77	104	28	5.2	76	56
Turen	113	34	4.5	79	50
Hnan Dun	121	60	5.4	61	43
Pach. Sel.	136	67	5.6	69	50
Pachequino	102	63	4.7	39	48
Yori 77	108	68	6.1	40	59
Maporal	126	98	1.0	28	20
Aceitera	115	73	1.1	42	18
Black Seed	148	103	3.3	45	56
Palmetto	71	35	1.9	46	35
LSD (5%) =	9	7	1.8	9	14
CV (%) =	6.9	9.1	39.3	15.3	27.3

[1]Averaged for both row spacings.

Table 2.1.5: Harvest populations of (* 1000/ha) sesame

CULTIVARS	**ROW SPACING**	
	18 cm	36 cm
Turen	218	127
Maporal	193	132
Yori 77	185	127
Teras 77	200	104
Black Seed	161	133
Palmetto	160	134
Hnan Dun	201	92
Pachequino	155	131
Pachequino Sel.	180	101
Aceitera	156	108
MEAN	181	119
LSD (5%) =	58	
CV (%) =	21.0	

Table 2.1.6: Effect of row spacing on sesame cultivar seed yields (kg/ha at 4% moisture)

CULTIVAR	**ROW SPACING**		**MEAN**
	18 cm	**36 cm**	
Teras 77	474	591	532
Hnan Dun	443	603	523
Yori 77	357	591	474
Pachequino Sel.	400	467	433
Turen	404	457	430
Pachequino	332	450	390
Maporal	142	227	184
Black Seed	218	147	182
Palmetto	139	194	166
Aceitera	115	119	117
Mean	302	385	
LSD (5%) =	130		
CV (%) =	22.3		

Table 2.1.7: Observations of cultivar resistance to Sesame Leaf Roller.

RATING: 0 = resistance 5 = No resistance
Average for 6 plots

CULTIVAR	1ST OBSERVATION 22 MARCH	2ND OBSERVATION 26 MARCH	AVERAGE OF BOTH OBS.
Black Seed	1.2	0.0	0.6
Hnan Dun	1.2	0.3	0.7
Maporal	2.5	1.3	1.9
Turen	2.0	2.3	2.2
Pachequino Sel	2.7	2.7	2.7
Teras 77	2.1	3.0	2.6
Pachequino	2.5	3.5	3.0
Yori 77	2.3	3.9	3.1
Aceitera	3.0	4.7	3.9
Palmetto	3.3	5.0	4.2
LSD (5%) =	1.2	0.8	-
CV (%) =	44.1	24.6	-

Table 2.1.8: Sesame seed germination

CULTIVAR	GERMINATION[1] %
Dehiscent capsules	
Turen	95
Teras 77	94
Aceitera	93
Yori 77	91
Maporal	90
Pachequino	89
Black Seed	80
Pachequino Sel.	79
Hnan Dun	77[2]
Non dehiscent capsules	
Palmetto	56
LSD (5%)=	10
CV (%)=	7.7

1 Seed collected at harvest maturity
2 An additional 18% fresh ungerminated seed.

Table 2.1.9: Sesame hundred seed weights

CULTIVAR		100 SEED WEIGHT (g at 4% moisture)
Pachequino Sel		0.32
Hnan Dun		0.32
Palmetto		0.29
Yori 77		0.29
Teras 77		0.27
Pachequino		0.27
Turen		0.25
Black Seed		0.25
Aceitera		0.25
Maporal		0.24
LSD (5%)	=	0.02
CV (%)	=	6.7

Table 2.1.10: Sesame seed oil content

CULTIVAR	OIL CONTENT %
Hnan Dun	55.7
Pachequino Sel.	56.5
Teras 77	55.8
Pachequino	53.7
Turen	54.3
Maporal	*
Yori 77	53.0
Aceitera	*
Palmetto	49.7
Black Seed	49.6

* Not Available

2.2 PLANT POPULATION AND HERBICIDE STUDIES WITH SESAME IN THE 1986/87 WET SEASON

2.2.1 ABSTRACT

An observation experiment was conducted in the 1986/87 wet season to study the effect of plant population and herbicides on the control of weeds in sesame.

Sesame cultivar Pachequino, was established at populations of 350, 490, 910 and 1 740 x 10^3 plants/ha with half of each plot sprayed with Sertin (sethoxydim) @ 1 L/ha. Two other observation plots were established at 490 x 10^3 plants/ha. These plots were sprayed with either Dual (metolachlor) @ 1L/ha or Treflan (trifluralin) 1 L/ha.

Application of Sertin or Treflan resulted in a seed yield increase of approximately 200 kg/ha.

2.2.2 INTRODUCTION

Sesame is a new crop to the Northern Territory with commercial production commencing in 1984-85.

Chemical control of grasses and pigweed in the commercial situation has been with Lasso (alachlor). During late 1986 Lasso was withdrawn from the market. This initiated a review of literature and a dry season pot trial was sown in search for alternative herbicides.

Australian literature indicated that Treflan and Dual would be suitable as pre-emergent herbicides.

One other possible approach to weed control was the combination of a low herbicide rate with a high sesame population. The low rate of herbicide retards weed establishment sufficiently for sesame plants to successfully compete with the emerging weeds.

All herbicides were applied at low rates to reduce possible phytotoxic effects.

2.2.3 MATERIALS AND METHODS

2.2.3.1 Seasonal Conditions

Total rainfall for the 1986/87 season was well below the long term mean at 720 mm.

Distribution varied considerably, with a below average rainfall in December and above average rainfall in February. There was an abrupt end of the wet season at the close of February (Table 2.2.1).

Soil type was a Fenton clay loam which had been rested under forage sorghum for 2 years (Sesame Appendix). The research site had well established populations of native *Sorghum sp, Trianthema portulacastrum, Portulaca oleracea* and *Alysicarpus vaginalis*.

2.2.3.2 Design, Treatments and Management

Experimental design was a randomised complete block with four sesame populations 350, 490, 910 and 1740 x 10^3 plants/ha. There were three replications. The plots were split in half. One half been sprayed with Sertin @ 1 L/ha, the other half having no weed control. Two other plots were established, one at either end of the RCB. Both plots were established with 490 x 10^3 plants/ha. One plot was sprayed with Dual @ 1 L/ha and the other with Treflan @ 1 L/ha.

Total plot length was 31.5m, sub-plots Sertin and no Sertin, 15.75m long, each. The plots sprayed with Dual and Treflan were 31.5m long. Seven rows or sesame each 32cm apart, were sown on each plot.

The observation areas was fertilised with single superphosphate @ 250kg/ha (approx. 23kg/ha of both phosphorus and sulphur) on the 22 December 1986.

The day before sowing urea was incorporated at 130kg/ha (approx. 60kg/ha of nitrogen).

On 5 January, 1987 Treflan was applied by hand boom spray and immediately incorporated. Conditions were cool and dry at the time of herbicide application. Sesame seed, cultivar Pachequino was then sown using a small plot combine.

Dual was applied pre-emergence by hand boom spray.

Fourteen days after sowing (d.a.s.) Sertin @ 1 L/ha was applied post emergence by a boom spray.

The trial was irrigated 1, 8 and 13 d.a.s., each of 20mm, to ensure establishment.

The experiment was sprayed three times at 22, 23 and 77 d.a.s. with Lorsban @ 2L/ha to control insect pests.

2.2.3.3 Recordings and Data Collection

Dry matter production was measured on three dates being 4, 6, and 8 weeks after sowing. On each occasion a sample comprising 1.0m x 1.6m (centre five rows) was taken from each sub-plot. All the above ground plant material was collected and later divided into sesame, grasses and pigweed/buffalo clover. These components were dried separately and dry weights recorded. The dry material was then ground and set aside to determine nitrogen and phosphorus concentration.

At maturity plant populations were recorded by counting number of plants in 1.0m x 1.6m (centre five rows), one quadrat per sub-plot. These same quadrats were also used to determine seed yield. Seed that shattered onto the ground was collected by a vacuum cleaner from a 0.5m^2 quadrat. Harvested samples were threshed and cleaned. Both harvest seed and shatter seed were added together to determine potential yield.

Sub samples were taken to determine 100 seed weight, oil content and germination percentage.

2.2.4 RESULTS AND DISCUSSION

2.2.4.1 Plant Population

The application of Sertin and Dual @ 1 L/ha may have reduced sesame populations by approximately 70,000 plants/ha (Table 2.2.2).

2.2.4.2 Hand Harvested Yield

The application of Sertin or Treflan resulted in an increase in seed yield of approximately 200kg/ha (Table 2.2.3).
The lowest population produced the highest seed yields because moisture was the most limiting factor in crop development during the 1986/87 wet season.

Taking plant population into account, the application of Dual @ 1 L/ha to control grasses probably did not give an increase in seed yield (Figure 1).

The plot treated with Treflan produced higher seed yields than those treated with Sertin, at equivalent populations.

2.2.4.3 Germination

Herbicides had no effect on the germination of sesame seed with the average germination for all treatments was 73% (Table 2.2.4).

2.2.4.4 Hundred Seed Weights

Herbicides had no effect on sesame 100 seed weights with average 100 seed weight for all treatments being 0.31 grams (Table 2.2.5).

2.2.4.5 Oil Content

Herbicides has no effect on sesame seed oil content with the average oil content for all treatments being 48.3% (Table 2.2.6).

BIOMASS

2.2.4.6.1 Sesame and total weeds

After an early period of low production of dry matter sesame rapidly develops a large biomass after the 4th week from sowing (Table 2.2.7). Until the 4th week weed species are able to compete successfully with the establishing sesame crop.

There was only minimal differences in biomass produced at 490,000 and 1740,000 plants/ha indicating that sesame readily compensates for variations in population (Table 2.2.8).

Application of a herbicide reduced total weed biomass, which allowed sesame plants to develop a larger biomass (Table 2.2.9).

2.2.4.6.2 Total weeds, grasses, pigweed and buffalo clover

The biomass for pigweed, buffalo clover and grass reached their peak at 6 weeks after sowing of the sesame experiment (Table 2.2.10). This grass biomass peak was due to the summer grasses completing their growth and commencing anthesis.

Visual observation indicated that pigweed rapidly established itself as the primary weed in the first 4-6 weeks, while buffalo clover was slower in establishing itself. Pigweed was heavily predated by insect larvae after canopy closure. Buffalo clover then replaced pigweed as the major weed after 7-8 weeks. Both pigweed and buffalo clover were rapidly shaded out by the sesame canopy after 12 weeks from sowing.

2.2.4.6.3 Influence of herbicides in weed control

Dual proved to be successful in controlling both broadleaf species, pigweed and buffalo clover (Table 2.2.11). As expected other herbicides did not influence the growth of these weeds.

For the control of grass weeds Sertin was more successful than Dual or Treflan (Table 2.2.11).

Dual was te most successful herbicide in controlling both pigweed and native *Sorghum sp.* in a sesame crop.

2.2.4.6.4 Influence of sesame plant population in weed control

There is a trend for higher sesame plant populations (490,000 and above) to be more successful at suppressing weeds especially for the first 6 weeks crop growth (Table 2.2.12). The low sesame population prior to the 4th week after sowing enabled the weeds to more rapidly establish themselves.

However, after 6 weeks of crop growth, the biomass developed by the 350,000 plants/ha treatment became effective in smothering the weeds.

2.2.4.7 Nutrient Levels in Weed Biomass

Levels of nitrogen and phosphorus of the weed biomass below a sesame crop with no herbicide treatment peaked around 17kg/ha and 4kg/ha respectively (Table 2.2.13). This peak concurred with the largest weed biomass at 6 weeks.

The division of nutrients between grasses and pigweed/buffalo clover parallels the proportions of their respective biomass. At 6 weeks after planting, two thirds of all the nutrients found in the weed biomass are associated with the pigweed/buffalo clover biomass.

Nutrient uptake of both the sesame crop and weeds at 8 weeks after planting was 73kg/ha of nitrogen and 16kg/ha of phosphorus of which 56kg N and 13kg P was taken up by the sesame biomass.

2.2.5 CONCLUSIONS

Observations indicated that Treflan may be a replacement herbicide for Lasso. The cost of Sertin would make its use for grass control an expensive operation, unless spot sprayed.

Further field research is required to determine the effect of Dual and Treflan on weeds and sesame yield. This study should also include the latest formulation for Lasso (experimental), Fusilade and Stomp at low rates of application. Present sesame recommendations are for an establishment population of 300,000 plants/ha. Which should be satisfactory when combined with a Dual or Treflan herbicide application.

Table 2.2.1: Mean monthly rainfall (November-May) for 1986/87 wet season and long term mean at CSIRO Katherine.

MONTH	RAINFALL 1986/87 (mm)	LONG TERM MEAN (mm)
November	62.8	83.3
December	52.8	191.6
January[1]	262.3	228.6
February	340.4	210.2
March	2.0	162.7
April	0.0	32.8
May	0.0	5.1
TOTAL	720.3	914.3

[1] Includes 66.2mm of irrigation

Table 2.2.2: Effect of herbicide on harvest plant population of sesame (* 1000/ha).

PLANT POPULATION (thousands)	350	490	910	1740	Av
TREATMENT					
Sertin	240	532	544	681	499
No Herbicide	290	396	667	954	577
Dual		325			
Treflan		540			

Table 2.2.3: Effect of herbicide on hand harvested sesame seed yield (kg/ha)

PLANT POPULATION (thousands)	350	490	910	1740	Av.
TREATMENT					
Sertin	1294	833	758	98	980
No Herbicide	1091	663	635	755	778
Dual		979			
Treflan		1212			

Table 2.2.4: Effect of herbicide on sesame seed germination (%)

PLANT POPULATION (thousands)	**350**	**490**	**910**	**1740**	**Av.**
TREATMENT					
Sertin	73	71	75	68	72
No Herbicide	75	76	72	72	74
Dual		69			
Treflan		78			

Table 2.2.5: Effect of herbicide on sesame hundred seed weight (g)

PLANT POPULATION (thousands)	350	490	910	1740	Av.
TREATMENT					
Sertin	0.32	0.32	0.32	0.31	0.32
No Herbicide	0.32	0.31	0.31	0.32	0.32
Dual		0.31			
Treflan		0.31			

Table 2.2.6 Effect of herbicide on sesame seed oil content (%)

PLANT POPULATION (thousands)	**350**	**90**	**910**	**10740**	**Av.**
TREATMENT					
Sertin	48.8	50.7	46.6	47.8	48.4
No Herbicide	49.3	50.4	50.5	48.8	49.8
Dual		47.7			
Treflan		47.3			

Table 2.2.7 Sesame and weed biomass at 4, 6 and 8 weeks after sowing.

WEEK	**4**	**6**	**8**
Sesame biomass (kg/ha)	687	1868	4237
Total weed biomass (kg/ha)	642	939	816

Table 2.2.8 Effect of plant population on sesame biomass at 8 weeks after sowing.

PLANT POPULATION (thousands)	350	490	910	1740	Av
Sesame biomass (kg/ha)	3636	4667	4084	4563	4237

Table 2.2.9 Effect of herbicide on sesame and weed biomass.

	SESAME BIOMASS[1] (kg/ha)	**TOTAL WEED BIOMASS (kg/ha)**
HERBICIDE		
Sertin	2738	678
No herbicide	2127	909
Dual	2827	197
Treflan	2576	547

[1] Sesame population of 490 x 10^3 plants/ha.

Table 2.2.10 Pigweed and grass biomass at 4, 6 and 8 weeks after sowing.

WEEK	4	6	8
Pigweed biomass (kg/ha)	596	727	627
Grass biomass (kg/ha)	46	212	189

Table 2.2.11 Pigweed and grass biomass at 4,6 and 8 weeks after sowing

WEEK	4	6	8
Pigweed biomass (kg/ha)	596	727	627
Grass biomass (kg/ha)	46	212	189

Table 2.2.12 Effect of herbicide on pigweed and grass biomass

	SESAME (490,000 plants/ha)		
	PIGWEED & BUFFALO CLOVER BIOMASS (kg/ha)	**GRASS BIOMASS (kg/ha)**	**TOTAL WEED BIOMASS (kg/ha)**
HERBICIDE[1]			
Sertin	676	2	678
No Herbicide	557	352	909
Dual	148	49	197
Treflan	451	96	547

[1] averaged 3 sample dates.

Table 2.2.13 Sesame and weed biomass for various sesame populations at 4, 6 and 8 weeks after sowing.

SAMPLE DATE	**BIOMASS (kg/ha)**			
• 4 WEEK				
PLANT POPULATION (thousands)	350	490	910	1740
Sesame biomass	521	547	599	911
Total weeds biomass	657	581	464	510
• 6 WEEK				
Sesame biomass	1563	1875	1771	1740
Total weeds biomass	1392	966	1039	1092
• 8 WEEK				
Sesame biomass	3729	3958	3292	3771
Total weed biomass	1248	1182	803	786

Table 2.2.14 Levels of nitrogen and phosphorus in sesame and weeds at 4, 6 and 8 weeks after sowing.

NUTRIENT LEVEL			
WEED SPECIES	**WEEK**		
	4	6	8
Total weed biomass (kg/ha)	553	1122	1005
Weight of N	11.4	16.3	-
Weight of P	1.9	3.4	-
Clover biomass (kg/ha)	465	739	627
Weight of N	9.7	10.8	*
Weight of P	1.6	2.1	*
Grass biomass (kg/ha)	88	383	378
Weight of N	1.8	5.5	*
Weight of P	0.3	1.3	*
Sesame biomass (kg/ha)	645	1966	3688
Weight of N	14.3	29.5	56.1
Weight of P	2.4	6.0	12.6

NOTE: All figures averaged for population for sesame plots receiving no herbicide treatment.

* Samples lost.

2.3 EFFECT OF METOLACHLOR (DUAL®) ON SESAME SEEDLINGS

2.3.1 INTRODUCTION

Alachlor, Lasso® has been used in sesame crops as a pre-emergent herbicide for the control of summer grasses and pigweeds in the Northern Territory.

The withdrawal of alachlor from the market initiated research into alternative herbicides. Metolachlor (Dual®) at application rates less than 2 L/ha was known not to induce visible damage to sesame plants and provided at least temporary control of grasses and pigweed.

As a result of these observations, a study was initiated to evaluate the effect of metolachlor on sesame seedlings.

2.3.2 METHOD

Experimental design was a pot trial arranged in a Latin Square. Metolachlor was applied pre-emergent at rates equivalent to 0, 1, 2, 4 and 8 L/ha. Sesame seedlings of cv. Yori 77 were thinned 7 days after sowing to 7 plants/pot. Number of established seedling/pot and seedling fresh weight were recorded 21 days after sowing.

2.3.3 RESULTS AND DISCUSSION

Metolachlor applied at 8 L/ha significantly reduced the number of establishing sesame plants from 6 to 2 plants/pot (Table 2.3.1). Seedling development was reduced with increasing rates of herbicide application (Table 2.3.1). Average plant weight was reduced from 1.54g (no herbicide) to 0.21g (8 L/ha metolachlor). Visual assessment indicated that application rates of up to 2 L/ha metolachlor produced only a temporary set back to plant growth.

Table 2.3.1 Effect of metolachlor on sesame seedlings at 21 days after sowing.

RATE OF METOLACHLOR APPLICATION (L/HA)	AVERAGE NUMBER OF PLANTS/POT	AVERAGE PLANT WEIGHT (g)
0	7.6	1.54
1	6.6	1.20
2	7.0	1.05
4	5.8	0.71
8	2.4	0.21
LSD (5%) =	1.8	0.39
CV (%) =	22.7	29.9

Various studies have demonstrated the potential for weed control using the smothering approach of a high plant population without prejudicing crop yield.

Hence, one possible way for weed control in sesame is the combination of a low application rate of metolachlor and a higher sesame population. The herbicide sufficiently retarding weed establishment for the sesame plants to successfully compete for moisture and light.

Future research is continuing along these lines.

2.4 MONITORING THE HARVEST OF COMMERCIAL SESAME CROPS - 1986/87

2.4.1 INTRODUCTION

Previous research has shown that sesame is a potential alternative crop for the Northern Territory.

Once the crop has been established, it can tolerate short periods of dry weather but will not tolerate excessively wet conditions. Sesame generally prefers well drained sandy loam soils. Crops have been successfully grown in the Katherine and Douglas-Daly districts. However, current sesame harvesting practices, plus the large number of off types (tall, early or late maturing plants), and the dehiscent nature of cv. Pachequino result in major yield losses during harvesting.

Seven farmers planted 492 ha of sesame in the 1986/87 wet season (Table 2.4.1). During harvesting, these crops were monitored for field and harvesting seed losses.

2.4.2 METHOD

During harvesting all sesame crops were sampled for the following losses (Figure 2.4.1):

i) The amount of seed on the ground before the harvester enters the crop.

ii) The amount of seed on the ground after harvesting due to the cutter bar action vibrating the plant at harvest.

iii) The amount of seed on the ground after harvesting due to the seed in the capsules passing through the harvester.

For each of these samplings 3 quadrats, each $1m^2$ were used to determine seed quantities. The field samples were dry and wet sieved to remove foreign material, oven dried then weighed.

All sesame crops harvested were delivered to ADMA depot for cleaning and bagging. The primary sample from the processed seed was sub-sampled for various determinations, which included germination %, hundred seed weight, plumpness (bushel), purity and moisture content.

2.4.3 RESULTS

Due to the small number of field observations taken, the sample mean should not be taken as an absolute measure but as indication of what was happening during harvesting (Table 2.4.2).

Field losses prior to harvesting ranged between 81-288kg/ha. These losses were due to seed shattering from the dehiscent capsules with wind and rain action.

Sesame seed losses due to the vibrating action of the cutter bar on contacting the sesame crop ranged between negligible and 262kg/ha.

The seed lost in the capsules passing through the harvester also ranged from negligible to 41kg/ha.

Total amount of sesame seed left in the field due to mechanical action ranged from 20-303kg/ha.

Potential economic yields for sesame crops grown in the Northern Territory during the 1986/87 were as high as 985kg/ha (Table 2.4.3). Note, potential economic yield includes seed lost to ground before harvesting. Characteristics of sesame seed harvested are presented in Table 2.4.4.

2.4.4 DISCUSSION

The present sesame harvesting practice is to allow the crop to reach a harvest maturity of at least 95% capsules brown (capsules generally dehisced) before commencing harvesting. This practice prevents the 'tainting' of the seed by plant sap and green vegetative material. However it also results in the farmer losing large amounts of seed to the shattering effect of wind and rain on the dehisced capsules.

An efficient and effective harvester entering a sesame crop at harvest maturity loses only a small percentage of total seed lost through mechanical action. Ineffective harvesters will lose greater amounts of seed during harvesting.

Harvesting earlier would reduce losses due to the shattering effect of wind and rain. However the harvester would have to be very effective in screening off all green vegetative and capsule material to prevent taining of the seed. The sesame seed may also require drying to reduce seed moisture levels for safe storage.

2.4.5 CONCLUSION

Future research is required to investigate the dehiscent losses in relation to the degree of crop maturity at harvest. Comparison with a range of cultivars is needed to assess if there are any differences in these seed losses.

Table 2.4.1 Sesame crops 1986-1987 wet season

REGION	FARMER (FARM)	RAINFALL (mm)	AREA[1] (ha)	SPOT YIELD[2] (kg/ha)	AVERAGE[2] YIELD (kg/ha)
Douglas Daly	M. Dawes (Kymbyehants)	972	60	*	250
Douglas Daly	T. Flake (Narwunjuke)	N.A	40	*	15
Douglas Daly	Mick and Duncan (Ruby Downs)	1055	212 (Pach.)	720	574
			80 (Yori 77)	*	147
Katherine	J. Scholz (Cutta Cutt)	730	40	530	370
Katherine	B. Sellars (Carbeen Pk)	977	5	*	240
Katherine	S. Denniss (Dry River)	958	30	420	300
Katherine	B. Utley (Sunday Creek)	823	25	530	470

1 Sesame cv. Pachequino was planted at all farms except Ruby Downs.
2 Yield figures quoted at 4% moisture.

Table 2.4.2 Sesame field and harvesting losses.

	SESAME SEED LOSSES (kg/ha, o% moisture)			
FARM	BELOW CROP BEFORE HARVESTING	DUE TO CUTTER BAR ACTION	LOST IN TRASH	TOTAL FIELD AND HARVESTING LOSSES
Ruby Downs				
cv. Pachequino	198.7	10.3	10.1	219.1 (27.3)[2]
cv. Yori 77	141.0	-19.0[1]	4.1	145.1 (Nil)
Cutta Cutt	287.8	262.2	41.2	591.2 (60.0)
Dry River	100.3	147.7	14.7	262.7 (45.8)
Carbeen Park	81.3	63.4	-1.7 (a)	144.7 (37.1)
Sunday Creek	*	*	41.3	299.3 (38.3)

1 A negative result due to sampling error.

2 Figures within paratheses are seed losses in percentages of potential economic yield.

* Not recorded.

Table 2.4.3 Potential economic yields for sesame on commercial forms for 1986/1987 season.

FARM	**POTENTIAL ECONOMIC YIELD (NO FIELD AND HARVESTER LOSSES) (kg/ha at 4% moisture)**
Ruby Downs	
cv. Pachequino	802
cv. Yori 77	293
Cutta Cutt	985
Carbeen Park	390
Dry River	573
Sunday Creek	781

Table 2.4.4: Sesame seed characteristics

FARMER	GERMINATION %	HUNDRED SEED WEIGHT (g) (4% moisture)	PLUMPNESS -BUSHEL (4% moisture)	PURITY %	MOISTURE %
Ruby Downs					
cv. Pachequino	80	0.280	48.5	99.3	3.7
cv. Yori 77	68	0.257	47.4	98.6	4.7
Kymbyehants	48	0.230	46.8	97.1	3.8
Narwunjuke	30	0.259	45.8	98.6	4.1
Cutta Cutt	69	0.282	48.5	99.5	3.8
Carbeen Park	58	0.237	46.2	97.8	3.6
Dry River	82	0.315	47.0	98.6	3.8
Sunday Creek	76	0.294	47.6	99.1	4.0

2.5 SESAME APPENDIX: Soil nutrient analysis

	EXPERIMENT	
	CULTIVAR	**HERBICIDE AND POPULATION**
Cond.	0.03	0.04
pH	6.1	7.1
Avail. P	12.0 ppm	10.0 ppm
Avail. K	124.0 ppm	322.0 ppm
Avail. Ca	457.0 ppm	781.0 ppm
Avail. Mg	61.0 ppm	215.0 ppm
Avail. S	7.0 ppm	less 5.0 ppm
Avail. Cu	2.9 pp	1.7 ppm
Avail. Zn	11.2 ppm	1.1 ppm

3.1 EFFECT OF POPULATION ON SYNCHRONY OF FLOWERING, DEPTH OF CAPSULE DEVELOPMENT AND YIELD OF PIGEON-PEA

3.1.1 ABSTRACT

Pigeon-pea cv. Hunt was sown at five populations 100, 200, 400, 500 and 800 x 10^3 plants/ha in a experiment on Fenton clay loam soil at C.S.I.R.O. in the 1986/87 wet season.

There was no significant effect of plant population on seed yield, synchrony of flowering and depth of capsule development. However, the following trends emerged. Pigeon-pea seed yield and 100 seed weight decreased with higher populations due to moisture stress while flowering was more synchronous at higher plant populations.3.1.2

INTRODUCTION

Pigeon-pea has been considered a potential crop for the Northern Territory especially between Katherine and Daly Waters.

Queensland research has identified various problems in growing high yielding pigeon-pea crops in dry regions similar to Katherine.

a) Pigeon-peas exhibit slow establishment during the initial 4 weeks of growth, therefore weed competition is a problem. However high densities of pigeon-pea will smother the weeds.

b) In low density crops, pigeon-pea branches profusely with flowering occurring in a less synchronous manner. The result may cause problems in both insect control and synchrony of capsule maturity at harvest.

c) Low crop densities are generally associated with low yields. Queensland research suggests for semi-arid conditions, rainfed crops should be planted at densities of 200,000 plants per hectare. This being a compromise between too rapid use of water and the loss of synchrony in capsule maturity.

Consequently, in the 1986/87 wet season an experiment was designed to identify a suitable plant population for pigeon-pea crops grown south of Katherine.

Row spacing was 36 cm due mainly to commercial planter specifications.

3.1.3 MATERIALS AND METHODS

3.1.3.1 Seasonal Conditions

The 1986/87 wet season was characterised by well below average December rainfall and above average rainfall for February. The wet season ended in the last days of February (Table 3.1.1).

The soil type was a Fenton clay loam which had produced forage sorghum for 2 years (Pigeon Pea Appendix).

3.1.3.2 Experimental Design

Experimental design was a randomised complete block with five pigeon-pea populations of 100, 200, 400, 500 and 800 x 10^3 plants/ha. There were 3 replications.

The research area was fertilised with single superphosphate at 250 kg/ha (approximately 23 kg/ha P and S), on December 22, 1986.

All plots were 5.2m long, 6 rows each 36 cm apart. Sowing was with a cone-seeder at a depth of 2 - 3 cm. Pigeon-pea cv. Hunt seed was inoculated with Cowpea (Group I) inoculum. The experiment was planted on 5 January, 1987.

Design, Treatments and Management

Irrigation was applied 3 times,each of approximately 20 mm on 6, 13 and 18 January to ensure pigeon-pea establishment.

Several herbicide sprays were required during the season to control weeds. Roundup CT (glyphosate) plus boost was applied at 1.6 L/ha as a pre-emergent. Basagran (bentazone) was applied twice, 1 L/ha and 2 L/ha on the 19th January and 6th February, respectively. Grass weeds were controlled with Fusilade 212 (fluazifop), application rate of 0.75 L/ha on 28th February.

Heliothis caterpillars were controlled by 3 applications of insecticide. The first Lorsaban (chlorpyrifos) 2 L/ha on 22

March, the second Ambush (permethrin) 0.2 L/ha on the 28 March and the third, Thiodan (endosulfan) 2 L/ha on the 6 April.

3.1.3.3 Recording and Data Collection

During the season phenological data was recorded, date of 50% of plants flowering and date of completion of flowering.

Light interception was recorded weekly with a line quantum sensor between 25 and 74 d.a.s. Two 10 second readings/plot were taken between the hours of 11 and 1 o'clock. Each reading having 2 components, an above canopy and a ground level measurement.

Weed biomass was measured 45 d.a.s. (19 February). A sample comprising the centre inter row space by 1.0 m was taken from each plot. All above ground plant material was collected, dried and weights recorded.

At maturity, plant population and yield was recorded by harvesting the centre 4 rows by 3 m from each plot. Samples were threshed and cleaned and yields recorded. Sub-samples were set aside for 100 seed weight determinations.

Ten plants were selected from the end of the plots for yield component analysis. Plant height and height of lowest capsules were recorded.

3.1.4. RESULTS AND DISCUSSION

3.1.4.1 Phenology

Phenological data is presented in Table 3.1.2.

Pigeon-pea population did not significantly affect the time to 50% of plants flowering and completion of flowering. However there was a trend for plots with higher plant populations to flower later.

The higher plant populations also tended to exhibit a more synchronise flowering pattern (Table 3.1.3). The advantage of a short period of flowering is in control of insects. The shorter the flowering period the fewer insecticide applications required.

3.1.4.2 Plant population

Plant populations at harvest are shown in Table 3.1.4. Note, there was no significant difference between populations harvested for planting rates equivalent to 400 and 500 x 10^3 plant/ha.

3.1.4.3 Light interception

Important light interception measurements for the various pigeon-pea populations are presented in Figures 3.1.5. An increase in plant population resulted in a decrease in time to 50% max. light interception (T5MAX) and maximum light interception (TMAX). Maximum light interception ranges from 90% at 53 d.a.s. for 100,000 plants/ha to 100% at 47 d.a.s. for 800,000 plants/ha.

3.1.4.4 Seed yield

There was no significant differences between seed yields for various plant populations (Table 3.1.6). However there was a trend for the higher populations to produce lower seed yields. This was due to higher levels of moisture stress at the higher populations.

3.1.4.5 Pigeon-pea hundred seed weight

Pigeon-pea seed weight was significantly affected by plant population. The heaviest seed was produced by plants at the lowest population. The lightest seed by plants at the highest population (Table 3.1.7). Again, moisture stress at the higher populations reduced seed weights.

3.1.4.7 Depth of capsule development in pigeon pea canopy

In high density pigeon-pea crops, capsule development is usually confined to upper and exterior regions of the canopy. The advantage of this being the reduction in the distance that insecticides have to penetrate to be effective against capsule boring caterpillars (Heliothis). In this experiment, depth of capsule development was not significantly affected by plant population (Table 3.1.8).

3.1.4.8 Weed biomass

There was no significant difference in the weed biomass developed below the canopies for the various plant populations at 49 d.a.s. (Table 3.1.9). This was probably due to the too early assessment of the effect of canopy closure on weed biomass development.

However a trend for lower weed biomass under higher pigeon-pea populations was apparent. Visual assessment indicated the weed biomass rapidly decreased with maturity of crop.

3.1.5 CONCLUSIONS

Higher pigeon-pea plant populations tend to exhibit a more synchronise flowering habit, produce lower seed yields and smaller seed. There was no significant plant population effect on control of weeds or depth of capsule development at 49 d.a.s. With more favourable weather conditions seed yield and seed size would improve. The use of more replications would have allowed significant differences in depth of capsule development and weed biomass below various canopies to be measured.

If further population research is to continue the lower population range (100-250 x 10^3 plants/ha) should be considered. This should be combined with the affect of row spacing (18, 36 or 54 cm) on seed yield.

TABLE 3.1.1: Mean monthly rainfall (Nov. - May) for 1986/87 wet season and long term mean at CSIRO Katherine.

MONTH	RAINFALL 1986/87 (mm)	LONG TERM MEAN (mm)
November	62.8	83.3
December	52.8	191.6
January	262.3 (a)	228.6
February	340.4	210.2
March	2.0	162.7
April	0.0	32.8
May	0.0	5.1
TOTAL	720.3	914.3

(a) Includes 66.2 mm of irrigation.

TABLE 3.1.2: Phenology of pigeon-pea cv. Hunt at various populations

	POPULATION (thousands)					
PHENOLOGICAL EVENT (d.a.s.)	100	200	400	500	800	LEVEL OF SIGNIFICANCE (5%)
50% of Plants Flowering	63	63	45	75	88	NS
Completion of Flowering	98	97	101	100	106	NS

TABLE 3.1.3: Effect of pigeon-pea population on synchrony of flowering.

	POPULATION (thousands)				
	100	200	400	500	800
NUMBER OF DAYS OF FLOWERING	35	34	27	26	17

TABLE 3.1.4: Established pigeon-pea populations.

	POPULATION (thousands)				
Planted	100	200	400	500	800
Harvest	157	238	479	499	772

TABLE 3.1.5: Effect of pigeon-pea population on light interception

LIGHT INTERCEPTION PLANT POPULATION (thousands)	T5MAX[1] (d.a.s.)	TMAX[2] (d.a.s)	MAXLT[3] (%)
100	35.5	52.5	90
200	33.5	53.2	98
400	31.0	45.5	98
500	27.5	47.0	100
800	16.5	46.5	100

[1] T5MAX = time to 50% maximum light interception
[2] TMAX = time to maximum light interception
[3] MAXLT = maximum light interception

TABLE 3.1.6: Effect of pigeon-pea plant population on seed yield

POPULATION (thousands)	100	200	400	500	800	LEVEL OF SIGNIFICANCE
Yield (kg/ha)	900	829	772	608	549	N.S.

TABLE 3.1.7: Effect of pigeon-pea plant population on 100 seed weights.

POPULATION (thousands)	100	200	400	500	800
Hundred seed weight (g)	8.2	8.1	8.0	7.8	7.4
LSD (5%) = 0.2					
CV (%) = 1.4					

TABLE 3.1.8: Effect of pigeon-pea plant population of capsule development.

POPULATION (thousands)	100	200	400	500	800	LEVEL OF SIGNIFICANCE
Depth of capsule development (cm)	27	28	31	31	30	N.S.

TABLE 3.1.9: Effect of pigeon-pea density on weed biomass at 49 d.a.s.

Population (thousands)	100	200	400	500	800	LEVEL OF SIGNIFICANCE
Weed biomass (kg/ha)	516	514	289	248	78	N.S.

3.2 PIGEON-PEA VARIETY OBSERVATIONS IN THE 1986/87 WET SEASON

3.2.1 ABSTRACT

Twenty-four pigeon-pea varieties were evaluated at CSIRO Katherine during the 1986/87 wet season.

All varieties commenced flowering between 56 and 64 days after sowing. Average plant height and height of lowest capsules for varieties tested was 145 cm and 112 cm respectively.

Varieties QPL 702 and QPL 67 gave the highest seed yields of 1067 kg/ha and 1002 kg/ha, respectively. Variety QPL687 produced the lowest seed yield of 403 kg/ha. All pigeon pea seed produces in the Northern Territory was lighter then their Queensland counterparts.

3.2.2 INTRODUCTION

Pigeon-pea has been considered a potential crop for the Northern Territory especially between Katherine and Daly Waters.

Queensland research has identified higher yielding and more export acceptable varieties. Consequently, an observation experiment was design to monitor the performance this material in the Katherine environment. Characteristics of a pigeon pea ideotype suitable for the Northern Territory include:

a) High seed yields and heavy seed weights
b) White seed
c) Thin testar for easier milling
d) Short plant stature, 1.2 m tall
e) Capsules borne at the top of the canopy
f) Flowering and capsule development synchronised

3.2.3 MATERIALS AND METHOD

3.2.3.1 Seasonal Conditions

The 1986/87 wet season was characterised by well below average December rainfall, and well above average rainfall for February. The wet season ended in the last days of February (Table 3.2.1).

Soil type was a Fenton clay loam which has produced forage sorghum for 2 years (Pigeon Pea Appendix).

3.2.3.2 Design, Treatments and Management

Experimental design was 24 plots laid in 6 blocks of 4 varieties with plot size being 6 rows, each 36 cm apart, by 5.3 m. Sowing was with a cone seeder at a depth of 2 - 3 cm. Seed germination was variable and seeding rate was adjusted in order to obtain a population of 250,000 plants/ha. Seed was inoculated with Cowpea (group I) inoculum.

The observational area was fertilised with single- superphosphate at 250 kg/ha (approx. 23 kg/ha P and S) on 22 December, 1986. The experiment was sown on 5 January, 1987.

Irrigation was applied 3 times each of approximately 20 mm on 6, 13 and 18 January, to ensure establishment. Several herbicide sprays were required during the season to control weeds. Roundup (Glyphosate) plus boost was applied 1.6 L/ha as a pre-emergent. Basagran (bentazone) was applied twice, 1 L/ha and 2 L/ha on the 19th January and 6th February respectively. Grass weeds were controlled with Fusilade 212 (fulazifop), application rate of 0.75 L/ha on 28th January.

Heliothis caterpillars were controlled by 3 applications of insecticide. The first, Lorsban (chlopryrifos), 2 L/ha on 22 March, the second Ambush (permethrin) 0.2 L/ha on the 28 March and the third, Thiodan (endosulfan) 2 L/ha on the 6th April.

3.2.3.3 Recording and Data Collection

During the season phenological data was recorded. In particular, date of first flower, date of 50% plants flowering, date of completion of flowering, date of physiological maturity (95% of capsules brown) and date of harvest.

At maturity, plant population and seed yield was recorded by harvesting the centre 4 rows by 3 m from each plot. Samples were threshed and cleaned and yields recorded. Sub-samples were set aside for seed colour and 100 seed weight determinations.
Ten plants were selected for yield component analysis with plant height and height of lowest capsule being recorded.

Varieties were visually rated for Heliothis damage to immature capsules.

3.2.4 RESULTS AND DISCUSSION

3.2.4.1 Phenology

Phenological data is presented in Table 3.2.2.

All varieties produced their first flower between 56 and 64 days. Three varieties, QPL 787, QPL 1003 and QPL 1004 were very slow in reaching 50% of plants flowering (approximately 99 days).

Completion of flowering ranged between 96 and 116 d.a.s. except for QPL 503 which need 125 days. Varieties Hunt, Quantum and QPL 969 were the earliest to be harvested at 141 days. The last varieties to be harvested were QPL 752, QPL 1003 and QPL 1004.

3.2.4.2 Plant population

Harvest populations ranged between 192,000 and 317,000 plants/ha. The average population was 219,000 plants/ha (Table 3.2.3).

3.2.4.3 Seed Yield

Pigeon pea seed yields ranged between 403 kg/ha, QPL687 and 1067 kg/ha, QPL702. The new commercial cultivar Quantum produced a higher yield than cultivar Hunt, 890 kg/ha and 726 kg/ha respectively. The average yield for all varieties harvested was 728 kg/ha (Table 3.2.3).

3.2.4.4 Plant Height and Height of Lowest Capsule

Varieties ranged in plant height between 120 cm and 162 cm. The average variety height being 145 cm. The lowest capsules were set between 82 cm and 130 cm, the average being 112 cm (Table 3.2.4).

3.2.4.5 Seed Colour

Pigeon pea seed colours varied from creamy to dark brown (Table 3.2.5). All seed was paler than their Queensland counterparts.

3.2.4.6 100 Seed Weight

Hundred seed weights varied between 12.4 and 7.0 grams for QPL702 and QPL67 respectively. Cultivars Hunt and Quantum seed weights were 7.8 and 8.1 grams respectively.

3.2.4.7 Heliothis Capsule Damage

A visual rating of Heliothis damage to capsules indicated that QPL67 was the least susceptible while QPL752 was the most susceptible (Table 3.2.5).

CONCLUSION

Pigeon-pea variety QPL 702 was the most promising variety under observation. It produced a higher seed yield and heavier seed of a paler colour when compared to cv. Quantum the current commercial variety in Queensland.

Further research is required, possibly under irrigation, with high fertiliser inputs situation to determine the economic potential of variety QPL702 at Katherine.

TABLE 3.2.1: Mean monthly rainfall (November - May) for 1986-87 wet season and long term mean at CSIRO Katherine

MONTH	RAINFALL 1986/87	
	MEAN (mm)	LONG TERM (mm)
November	62.8	83.3
December	52.8	191.6
January [1]	262.3	228.6
February	340.4	210.2
March	2.0	162.7
April	0.0	32.8
May	0.0	5.1
TOTAL	720.3	914.3

[1] Includes 66.2 mm of irrigation

TABLE 3.3.2: Phenology of pigeon-pea varieties in 1986 - 87 wet season.

VARIETY	PHENOLOGY DAYS AFTER SOWING				
	FIRST FLOWER	50% OF PLANTS FLOWERING	COMPLETION OF FLOWERING	P.M.	HARVEST
Hunt	60	66	96	132	141
Quantum	62	68	114	133	141
QPL 702	62	69	98	148	162
QPL 17	56	63	98	137	149
QPL 67	58	86	114	154	164
QPL 131	60	71	116	138	154
QPL 297	61	68	98	136	148
QPL 503	58	71	125	139	155
QPL 511	63	71	111	133	145
QPL 574	59	72	115	138	154
QPL 687	59	71	116	134	146
QPL 717	57	69	110	136	148
QPL 752	57	69	97	170	170
QPL 753	58	67	112	137	149
QPL 787	64	97	105	132	141
QPL 892	64	71	113	150	162
QPL 914	60	71	97	170	170
QPL 927	59	68	97	133	145
QPL 929	60	70	112	149	162
QPL 969	62	72	105	131	141
QPL 992	59	66	110	136	148
QPL 1003	62	100	115	170	170
QPL 1004	61	100	114	150	170
QPL 1061	63	71	113	149	162

P.M = PHYSIOLOGICAL MATURITY

TABLE 3.2.3: Plant population and seed yield of pigeon-pea varieties in 1986 - 87 wet season

VARIETY	HARVEST POPULATION (1000's)	YIELD (kg/ha)
Hunt	192	726
Quantum	192	890
QPL 702	317	1067
QPL 17	208	791
QPL 67	211	1002
QPL 131	236	950
QPL 297	192	701
QPL 503	204	981
QPL 511	208	552
QPL 574	231	432
QPL 687	259	403
QPL 717	204	584
QPL 752	197	652
QPL 753	206	704
QPL 787	227	564
QPL 892	206	491
QPL 914	194	651
QPL 927	227	734
QPL 929	243	943
QPL 969	213	768
QPL 992	255	766
QPL 1003	208	471
QPL 1004	231	837
QPL 1061	285	823
AVERAGE	219	728

TABLE 3.2.4: Plant height and height of lowest capsule for pigeon-pea varieties in 1986 - 87 wet season

VARIETY	HEIGHT[1] (cm)	HEIGHT OF LOWEST Capsule[1] (cm)
Hunt	140	106
Quantum	132	107
QPL 702	120	82
QPL 17	135	96
QPL 67	149	110
QPL 131	162	118
QPL 297	145	113
QPL 503	144	114
QPL 511	141	117
QPL 574	142	117
QPL 687	146	124
QPL 717	148	114
QPL 752	144	108
QPL 753	140	113
QPL 787	156	130
QPL 892	162	127
QPL 914	156	119
QPL 927	142	104
QPL 929	151	114
QPL 969	147	116
QPL 992	128	102
QPL 1003	146	114
QPL 1004	150	112
QPL 1061	144	112
AVERAGE	145	112

1 Average for 10 plants.

TABLE 3.2.5: Seed colour, seed weight and visual estimation of Heliothis capsule damage of pigeon-pea variety

VARIETY	SEED COLOUR	100 SEED WEIGHT (g)	HELIOTHIS DAMAGE[1]
Hunt	Brown	7.8	3.0
Quantum	Light Brown	8.1	2.0
QPL 702	Creamy	12.1	3.0
QPL 67	Dark Brown	7.0	0.5
QPL 131	Creamy Brown	10.1	1.0
QPL 1004	Creamy	10.1	1.0
QPL 969	Light Brown	9.4	1.0
QPL 892	Light Brown	8.8	1.0
QPL 687	Light Brown	9.4	1.0
QPL 1061	Light Brown	9.6	1.5
QPL 1003	Creamy	10.3	1.5
QPL 914	Light Brown	8.0	1.5
QPL 927	Light Brown	8.5	1.5
QPL 787	Creamy Brown	9.9	1.5
QPL 17	Brown	6.6	2.0
QPL 929	Brown	8.1	2.0
QPL 503	Brown	8.0	2.0
QPL 992	Dark Brown	9.5	2.5
QPL 753	Very Light Brown	9.1	3.0
QPL 574	Light Brown	8.6	3.0
QPL 297	Light Brown	10.3	3.0
QPL 717	Brown	7.7	3.5
QPL 752	Dark Brown	10.1	4.0
QPL 511	Creamy	10.2	4.0

1 *Heliothis sp.* damage to immature capsules

0.0 = No damage
5.0 = Severely damaged

3.3 **PIGEON PEA APPENDIX:** soil nutrient analysis

Cond.	0.04
pH	7.1
Avail. P	10 ppm
Avail. K	322 ppm
Avail. Ca	781 ppm
Avail. Mg	215 ppm
Avail. S	less than 5 ppm
Avail. Cu	1.7 ppm
Avail. Zn	1.1 ppm

4.1 EFFECT OF TIME OF SOWING ON GUAR cv. PHD1

4.1.1 ABSTRACT

The effect of time of sowing on Guar cv. PHD1 was evaluated on sandy clay loam soil at C.S.I.R.O. in the 1986/87 wet season. Guar was sown on 3 occasions, the 4, 16 and 29 January.

Guar seed yield and plant height was significantly reduced at the last time of planting, due to lack of moisture with the abrupt end to 1986/87 wet season. Seed yields and plant height ranged from 1329 kg/ha and 103 cm tall for the first time of sowing to 204 kg/ha and 38 cm tall for the last sowing.

Seed quality for all 3 planting dates was excellent. This was due to low humidity and lack of rainfall as the crop matured.

4.1.2 INTRODUCTION

Guar is considered a potential crop for Katherine to Daly Waters region of the Northern Territory. Previous research has concentrated on variety evaluation, and the most suitable region for guar development.

Recently there has been approaches by Australian Gum Products to develop a guar industry south of Katherine. This has initiated renewed research activities into guar.

In the 1986/87 wet season two experiments were implemented to refresh guar seed stocks and provided experience for staff not familiar with the crop. This experiment was designed to evaluate the effect of time of sowing on seed quality and yield of guar.

4.1.3 MATERIALS AND METHODS

4.1.3.1 Seasonal Condition

The 1986/87 wet season was characterised by above average December rainfall and below average rainfall for February. The wet season finished in the last days of February. Details are presented in Table 4.1.1.

Soil type was Venn sandy clay loam (Guar Appendix)

4.1.3.2 Design, Treatments and Management

Experimental design was randomised complete block with 3 times of sowing; 4, 16 and 29 January. There were 3 replications. Plot size was 6 rows, each 36 cm apart, by 5.2m long. Sowing was with a cone-seeder at a depth of 2.5 cm. The seeding rate was equivalent to 300,000 plants/ha with the seed being inoculated with rhizobium, Cowpea (Group I).

The experimental area was fertilised with single superphosphate at 250 kg/ha and Crop King 8:4:8 at 200 kg/ha, on December 19 and 22 respectively (approximately 16, 30, 16 and 25 kg/ha of N, P, K, and S).

The experiment was sown on the C.S.I.R.O. Venn sandy clay loam research site on 4 January, 1987.

The weed, *Tarvine Boerhavia diffusa*, was controlled manually as required while Fusilade 212 was applied at 0.75 L/ha for grass control on 2 February. A follow up spray of Sertin% 1.25 L/ha was applied on 13 February.

Insects, *Riptortus serripes* were controlled by spraying Thiodan% 2 L/ha on 4th April.

4.1.3.3 Recordings and Data Collection

During the season phenological data were recorded. These include date of first flower, date of 50% plants flowering, plant date of completion of flowering and date of physiological maturity.

At maturity, plant population and seed yield were recorded by harvesting the centre 4 rows by 3 m from each plot. Samples were threshed and yields recorded. Sub samples were set aside for 100 seed weight determinations and visual assessment of seed quality.

Ten capsules were selected from lower racemes to determine number of seeds per capsule.

4.1.4 RESULTS AND DISCUSSION

In hindsight manual control of *Tarvin Boerhavia diffusia* was not required. The caterpillar of a Hawk moth sp. provided excellent biological control.

4.1.4.1 Phenology

All relevant data is presented in Table 4.1.2.

Guar planted on 4 January was significantly later in producing its first flower than the other two times of sowing. The average time taken for all TOS to produce their first flower was 25 days while all sowing dates reached 50% of plants flowering by 30 days after sowing.

All sowing dates were significantly different in the time taken to complete flowering and to reach physiological maturity (Table 4.1.2). However taking into account the various times of sowing all treatments tended to converge on the same date of completion of flowering and the same date of physiological maturity, 27 March and 20 April respectively (Table 4.1.3).
The reason being, the end of rainfall in the last days for February induced moisture stress. This forced all time of sowing to cease flowering by the 1st week of April and reach physiological maturity by the 3rd week of April.

4.1.4.2 PLANT POPULATION

There was no significant differences between the plant populations recorded for the different time of sowing (Table 4.1.4). The average guar population was 340,000 plants/ha.

4.1.4.3 SEED YIELD

The seed yield for the 3rd TOS was significantly lower than for the earlier sowing dates (Table 4.1.4). The yield reduction was caused by the lack of crop growth due to with inadequate levels of soil moisture.

The average seed yield for guar cv. PHD1 for the first 2 sowing dates was 1160 kg/ha, while the seed yield for the 3rd sowing date was 204kg/ha.

4.1.4.4 YIELD COMPONENTS

4.1.4.4.1 Plant Height

Guar planted on the 29 January was significantly shorter than guar planted at earlier dates (Table 4.1.5). This was due to moisture stress inhibiting plant growth 4 weeks after crop establishment. The average plant height for guar cv. PHD1 for the first 2 sowing dates was 91cm, while plant height for the 3rd sowing date was 38cm.

4.1.4.4.2 Height of Lowest Capsule

There was no significant difference between treatments for the height of lowest capsule (Table 4.1.5). The average height of the lowest capsule was 9 cm above the soil surface.

4.1.4.4.3 Number of Seed/Capsule and Hundred Seed Weight

There was no significant difference in the number of seeds per capsule and 100 seed weight for the different time of sowing (Table 4.1.5). Guar cv. PHD1 produced an average of 6 seeds/capsule with an average oven dry 100 seed weight of 2.9 grams.

4.1.4.5 SEED QUALITY

Visual assessment of guar seed produced for all 3 sowing dates indicated that the seed was of excellent quality, white spherical and of average size. The excellent seed quality was due to the lack of rainfall and high humidities as the capsules matured.

4.1.5 CONCLUSIONS

Later plantings of guar resulted in lower seed yields and shorter plants being produced. This effect was exaggerated by the shortness of the wet season. Height of lowest capsule and seed size were not influenced by planting date. High quality seed was produced by all sowing dates due to lack of end of season rainfall.

The interaction of yield, seed quality and time of sowing should be further investigated, under more reasonable wet season conditions. Earlier sowing dates than 4 January should be considered.

TABLE 4.1.1: Monthly rainfall (November - May) for 1986/87 wet season at CSIRO, Blain site

MONTH	SEASON 1986/87 (mm)	LONG TERM AVERAGE[1] (mm)
November	65.0	83.3
December	96.2	191.6
January	249.0	228.6
February	183.2	210.2
March	0.0	162.7
April	0.0	32.8
May	0.0	5.1
TOTAL	593.4	914.3

[1] Long term average for CSIRO

TABLE 4.1.2: Phenology of guar cv. PHD1 for various times of sowing.

	DAYS AFTER SOWING			
TIME OF SOWING	**FIRST FLOWER**	**50% OF PLANTS FLOWERING**	**COMPLETION FLOWERING**	**P.M.[1]**
4 Jan	27	31	83	104
16 Jan	25	30	70	94
29 Jan	24	30	66	82
LSD (5%) =	1	1	2	4
CV (%) =	1.6	1.9	1.2	1.9

[1] P.M. = physiological maturity

TABLE 4.1.3: Effect of moisture stress on date of completion of flowering and physiological maturity of guar cv. PHDI.

TIME OF SOWING	**DATE OF COMPLETION OF FLOWERING**	**P.M.[1]**
4 January	27 March	17 April
16 January	27 March	20 April
29 January	4 April	20 April

[1] P.M. = physiological maturity.

TABLE 4.1.4: Effect of sowing date on seed yield guar cv. PHD1.

	TIME OF SOWING				
	4 Jan	**16 Jan**	**29 Jan**	**LSD (5%)**	**CV (%)**
Population (1000's)	342	352	326	136	17.7
Yield (kg/ha)	1329	991	204	562	29.5

TABLE 4.1.5: Effect of TOS on yield components of guar cv. PHD1

YIELD COMPONENTS	**TIME OF SOWING**				
	4 Jan	**16 Jan**	**29 Jan**	**LSD (5%)**	**CV (%)**
Height (cm)	103	79	38	27	16.3
Height of Lowest Capsule (cm)	10.7	8.3	8.5	2.7	13.1
No. of Seeds per Capsule	5.1	7.0	5.3	4.6	35.0
Hundred Seed Weight (oven dry g)	3.0	3.0	2.6	0.7	10.1

4.2 GUAR VARIETY OBSERVATIONS IN THE 1986 - 87 WET SEASON

4.2.1 ABSTRACT

Eleven guar varieties were re-evaluated at C.S.I.R.O. Katherine in the 1986/87 wet season.

Varieties Selection 3 and FS277 produced the highest seed yields of 1162 and 1002 kg/ha respectively. No varieties exceeded 127 cm in height due to the early end of the wet season.

4.2.2 INTRODUCTION

Guar is considered a potential crop for Katherine to Daly Waters region of the Northern Territory. Previous research has been extensive and included variety evaluation, optimum time of sowing and fertiliser research.

Approaches by Australian Gum Products to develop a guar industry south of Katherine, has initiated renewed research into guar.
This experiment was designed to re-evaluate a range of varieties.

4.2.3 MATERIALS & METHODS

4.2.3.1 Seasonal Conditions

The 1986/87 wet season was characterised by above average December rainfall and below average rainfall for February. The wet season finished on the last days of February. Details are presented in Table 4.2.1.

Soil type was Venn sandy clay loam (Guar Appendix).

4.2.3.2 Design, Treatment and Management

Experimental design was randomised complete block with 10 varieties and 3 replications. A single plot of an additional variety was planted January 17 for seed multiplication. Plot size was 6 rows, each 36 cm apart, by 5.2 m long. Sowing was with a cone-seeder at a depth of 2 cm. Seed germination was variable hence seeding rate was adjusted in order to obtain a population of 300,000 plants/ha. The seed was inoculated with Cowpea (Group I), rhizobium.

The experimental area was fertilised with single superphosphate at 250 kg/ha and Crop King 8:4:8 at 200 kg/ha, on December 19 and 22 respectively (approximately 16, 30, 16 and 25 kg/ha of N, P, K, and S). This experiment was sown on the Venn site of the CSIRO on 4 January, 1987.

The weed, *Tarvine Boerhavia diffusa*, was controlled manually. Fusilade 212 was applied at 0.75 L/ha for grass control on 2 February. A follow up spray of Sertin 1.25 L/ha was applied on 13 February.

The insect, *Riptortus serripes*, was controlled by spraying Thiodan at 2 L/ha on 4 April.

4.2.3.3 Recordings and Data Collection

During the season various phenological data was recorded. In particular date of first flower, date of 50% of plants flowering, date of physiological maturity (95% of capsules brown) and date of harvest (95% plus of capsules brown and dry).

At maturity plant population and seed yield were recorded. Yield was determined by harvesting the centre 4 rows by 3 m from each plot. Samples were threshed and cleaned and yields recorded. Sub-samples were set aside for hundred seed weight determinations.

Ten plants were selected from the remaining plot to measure yield components. On each plant the following were recorded; plant height and height of lowest capsule. Ten capsules were selected from the lower racemes and number of seeds counted.

4.2.4 RESULTS AND DISCUSSION

In hindsight manual control of *Tarvine Boerhavia diffusia* was not required. The caterpillar of a *Hawk moth sp.* provided an excellent biological control.

Poor seedling vigour caused the three selections and the variety ECR67 to be replanted on the 13 and 21 January.

Individual plant development within plots was variable for the first two months of experiment. Sampling of plants suggested that the variability may have linked to nodulation. This was surprising considering that the guar seed was inoculated. The guar seedling also having access to a 'starter' nitrogen.

Ken Jackson (D.P.I., Qld.) suggested that this variability may have also been associated with the slow development of mycorrhizal relationships (personal communication).

Because of the large variation in establishment dates for the guar varieties, statistical analysis has not been attempted. The results are presented as the mean of 3 replications, (1 replication of AG111). For this reason the results should be viewed with caution as valid comparisons for any characteristic is not possible. However, some interesting points have emerged and are worthy of discussion:

4.2.4.1 PHENOLOGY

Most varieties had produced their first flower by 28 days after sowing. Within another 7 days, fifty percent of all plants for that variety were flowering (Table 4.2.2).

Completion of flowering and physiological maturity varied according to maturity type. The early finish to the wet season probably resulted in a shorting in the number of days to physiological maturity.

4.2.4.2 PLANT POPULATIONS

Plant populations at harvest were variable. They ranged between 167,000 plants/ha for NC70 and 348,000 plants/ha for AG111 (Table 4.2.3). The variation in populations may be attributed to the incidence of *Macrophomina phaseolina*. killing guar seedlings. The average population for the experiment was 235,000 plants/ha.

4.2.4.3 SEED YIELD

Highest seed yields were recorded for variety FS227 and Selection 3, 1162 kg/ha and 1002 kg/ha respectively. Seed yield for PHD1 were disappointing considering seed weights per plant indicated that 1000 kg/ha plus were to be expected. However PHD1 in the time of sowing experiment did yield 1329 kg/ha for the 4 January planting date. Excluding AGIII and ECR67, (the last two planting dates) the average variety yield was 951 kg/ha.

4.2.4.4 YIELD COMPONENTS

4.2.4.1. Plant Height

With the exception of AG111, all varieties were generally of medium height. Their height ranged between 91 and 127 cm. AG111 was short in stature at 72 cm.

Moisture was the limiting factor in growth during the 1986/87 wet season with the naturally tall varieties were unable to express their normal stature (Table 4.2.4).

4.2.4.2 Height of Lowest Capsule

The height of the lowest capsule ranged between 7 and 13 cm (Table 4) with capsules set less than 15 cm from the ground are generally inaccessible to the harvester.

4.2.4.3 Number of Seed/Capsule

The number of seed/capsule ranged between 3.3 for AG111 to 8.7 for CP177 while PHD1 recorded an average of 4.6 (Table 4.2.4)

4.2.4.4 Hundred Seed Weight

Range in the oven dry 100 seed weight was between 2.7 and 3.4 grams with PHD1 recording only 3.0 grams/100 seed.

4.2.5 DISCUSSION

Criteria currently used in selecting the ideal guar variety for mechanical harvesting are,

i) High seed yields.
ii) The height of the crop is 1.5m.
iii) The lowest capsule is greater than 15 cm above the ground.
iv) Seed produced is large, white and spherical.
v) The seed should have a high gum content
vi) Disease resistance especially to *Alternateria cucumeria*.

Previous research indicated that cv. PHD1 was the most suitable variety the Northern Territory conditions. The major constraint on other possible varieties was plant height (ie. too tall). During the 1986/87 wet season crop stature was not a problem due to below average rainfall and early finish of the wet season. However it was very obvious that varieties CP177, CP380, FS277 and ECR67 would have exceed height restrictions if rain had fallen in March, 1987. AG111 maybe a little too early maturing therefore did not grow tall enough to develop a large yield. Variety NC70 could be discarded due to its small seed size.

Future variety work, if any, should be left to comparisons between PHD1 and the Selections and possibly a promising line from previous work by K. Jackson, D.P.I. Queensland.

4.2.6 CONCLUSION

The experiment provided valuable experience to staff not familiar with guar. However seed stocks were not re-freshed as substantially as hoped. Therefore further seed multiplication should be considered.

TABLE 4.2.1: Monthly rainfall (November - May) for 1986/87 wet season at CSIRO, Blain site, Katherine.

MONTH	SEASON 1986/87 (mm)	Long Term Average[1] (mm)
November	65.0	83.3
December	96.2	191.6
January	249.0	228.6
February	183.2	210.2
March	0.0	162.7
April	0.0	32.8
May	0.0	5.1
TOTAL	593.4	914.3

[1] Long term average for CSIRO, Katherine.

TABLE 4.2.2: Phenology of guar varieties in 1986 - 87 wet season

		DAYS AFTER SOWING			
PLANTING DATE	VARIETY	FIRST FLOWER	50% OF PLANTS FLOWERING	COMPLETION OF FLOWERING	P.M.[1]
4 Jan '87	CP177	28	37	98	112
	CP380	29	40	90	108
	FS277	27	35	84	110
	MSS1	27	33	88	108
	NC70	28	36	84	110
	PHD1	26	32	86	104
13 Jan '87	SEL3	29	36	88	101
	SEL20	30	36	88	99
	SEL36	26	32	79	95
17 Jan '87	AG111	26	31	94	101
21 Jan '87	ECR67	29	36	76	94

[1]. P.M. - Physiological maturity.

TABLE 4.2.3: Seed yields and plant populations for guar varieties in 1986-87 wet season

DATE PLANTED	VARIETY	POPULATION (1000's)	YIELD (kg/ha)
4 Jan '87	CP177	246	866
	CP380	275	841
	FS277	214	1002
	MSS1	184	797
	NC70	167	794
	PHD1	239	682
13 Jan '87	SEL3	200	1162
	SEL20	213	609
	SEL36	205	854
17 Jan '87	AG111	348	547
21 Jan '87	ECR67	295	865

TABLE 4.2.4: Yield components for guar varieties in 1986 - 87 wet season.

DATE	VARIETY	PLANT HEIGHT (cm)	HEIGHT OF LOWEST CAPSULE (cm)	NUMBER OF SEED/ CAPSULES	OVEN DRY 100 SEED WEIGHT (g)
4 Jan '87	CP177	127	13	8.7	2.9
	CP380	104	11	7.0	3.1
	FS277	123	13	7.9	3.3
	MSS1	91	9	6.8	3.1
	NC70	99	8	7.5	2.9
	PHD1	111	8	4.6	3.0
13 Jan '87	SEL3	96	8	8.3	3.4
	SEL20	113	8	7.9	2.8
	SEL36	102	11	7.9	3.0
17 Jan '87	AG111	72	7	3.3	2.7
21 Jan '87	ECR67	105	12	8.2	2.8

4.3 GUAR APPENDIX: soil nutrient analysis

Cond.	0.01
pH	6.7
Avail. P	less than 5 ppm
Avail. K	44 ppm
Avail. Ca	240 ppm
Avail. Mg	33 ppm
Avail. S	less than 5 pm
Avail. Cu	0.6 ppm
Avail. Zn	0.7 ppm

Introduction

There has been substantial research in identifying crops which are possible alternatives to maize, soybean, mungbeans and sorghum for the Northern Territory.

One crop that has shown potential for the drier Katherine region is sesame. Intensive sesame research was initiated in the 1986/87 wet season. Research included cultivar, herbicide and plant population trials. Conclusions of this work, plus monitoring of commercial crops and suggestions by various sesame farmers provided the directions of this year's work. These directions include restoration of pure seed lines, sesame population by row spacing studies, fertiliser and herbicide trials, and time of sowing and harvesting experiments.

Six projects were implemented to provide answers to some of the farmers most pressing problems.

2. General Methods

2.1 Seasonal Conditions

The 1987/88 wet season started with favourable rains in November and December. January rainfall was well below average, while February rainfall returned to normal. The wet season finished during the first week of March (Table 3.1.1).

Soil type was a Fenton clay loam which produced forage sorghum the previous season (Table 3.1.2).

2.2 Fertiliser Application

Prior to sowing on 26 December 1987, the experimental area was fertilised with single superphosphate @ 240kg/ha (approx. 22kg/ha and 24kg/ha of phosphorus and sulphur respectively).

2.3 Weed Control

Dual @ 0.75 L/ha was applied by boomspray on the evening of December 31, 1987. Soil conditions were moist but cloddy at the time of application.

2.4 Insect Control

Insects were controlled as required throughout the season with Lorsban @ 0.90 L/ha. The plots were sprayed 3 times, 59, 76 and 84 d.a.s.

Table 3.1.1: Monthly rainfall (mm), November - May 1987/88 wet season at CSIRO, Katherine

MONTH	SEASON 1987/88 (mm)	LONG TERM AVERAGE[1] RAINFALL (mm)
November	145.8	83.3
December	206.0	191.0
January	82.8	228.6
February	214.3	210.2
March	22.3	162.7
April	2.4	32.8
May	0.0	5.1
TOTAL	673.6	914.3

[1]Long term average for CSIRO, Katherine

Table 3.1.2: Sesame and Pigeon Pea research site - soil nutrient analysis.

	CSIRO	DDRF
Cond.	0.05	-
pH	6.6	6.2
Avail. P	14 ppm	23 ppm
Avail. K	293 ppm	100 ppm
Avail. Ca	1030 ppm	470 ppm
Avail. Mg	209 ppm	43 ppm
Avail. S	5.8 ppm	17 ppm
Avail. Cu	2.4 ppm	1.0 ppm
Avail. Zn	0.7 ppm	

3.1 RESTORATION OF PURE SESAME CULTIVARS

3.1.1 INTRODUCTION

A wide range of sesame plant types are presently found in commercial crops in the Northern Territory this variation provides scope for selection of new sesame lines. This variation also delays harvesting of the crop until the late maturing types defoliate. The end result is farmers lose large amounts of seed from shattering due to wind and rain action on the dehisced capsules.

In the 1987/88 wet season, "reference" seed material of sesame cultivars Hnan Dun, Yori 77 and Pachequino was planted. These observation plots were used to identity cultivar characteristics which will enable future restoration of pure (uniform) commercial seed stocks.

3.1.2 MATERIALS AND METHOD

3.1.2.1 Design and Management

The sesame cultivars Hnan Dun, Yori 77 and Pachequino were sown in unreplicated observation plots on January 5, 1988. All plots consisted of 2 rows, 20 m long with 36 cm between rows.

Plants were thinned to an intra-row space of 14 cm (equivalent to 200,000 plants/ha), within 3 weeks of sowing.

Urea @ 130 kg/ha (approx. 60 kg/ha of nitrogen) was hand spread on January 14, 1988.

Supplementary irrigation, 10 mm, was applied 9 d.a.s. to assist crop establishment.

3.1.2.2 Recordings and Data Collection

Dates of various phenological occurrences were recorded. These included date of first flower, date of 50% plants flowering, completion of flowering and date of physiological maturity (95% of capsules yellow).

Floral characteristics recorded were the presence or absence of extra-floral nectaries, and the presence or absence of purple spots on the inner lower surface of the tubular - campanulate corolla (ie., the throat of the flower).

Sesame cultivars were rated for susceptibility to the caterpillar stage of Sesame Leaf Roller *(Antigastra catalaunis)* and a leaf disease, Large Leafspot *(Cercospora sesamicola)*.

At physiological maturity, 30 plants were selected for recording of morphological characteristics. These included plant height, number of effective branches, height of lowest capsule, node number of lowest flower scar or capsule, number of capsules on central stem and number of whorls of capsules.

From this data, length of stem used for capsule set (C.S.L.), number of capsules/cm of stem used for pod set and number of capsules/whorl were calculated.

Also recorded at physiological maturity was the cultivars susceptibility to lodging from wind.

Harvested material was air-dried, threshed and seed was set aside for 100 seed weight, seed colour and germination determinations.

3.1.3 RESULTS

Morphological characteristics of sesame cultivars Hnan Dun, Yori 77 and Pachequino are presented in Table 3.1.3 and observations of the Katherine Local sesame on the Katherine farms are included in Table 3.1.4.

3.1.4 DISCUSSION

Sesame cultivar Hnan Dun can easily be distinguished from Pachequino and Yori 77 on plant structural characteristics, ie. multiple branching, alternate capsules and yellow nectaries at each whorl. Restoration of Hnan Dun is well underway, however, within the plant type there is a range of maturing types which require separation.

Separating Yori 77 from Pachequino can be accomplished by using branching habit and more conclusively the presence or absence of purple spots on the inner lower surface of the flower.

Pachequino tends to be single stem and has a speckled throat, whereas yori branches and does not have a speckled throat.

Dates for phenological events and seed characteristics do not provide reliable means of separating these sesame types.

The Katherine Local sesame can easily be distinguished from the commercial types. Firstly the Katherine Local sesame has multiple branches, and is generally spindly with minimal leaves. Secondly, by the time commercial sesame crops are planted the Katherine Local sesame have taken advantage of the December rains and are flowering profusely.

Seed characteristics are obviously different, with the Katherine Local seed having a rough black seed coat texture while Yori and Pachequino have a white smooth, seed coat.

TABLE 3.1.3: Morphology of sesame cultivars Hnan Dun, Yori 77 and Pachequino.

CHARACTERISTICS	HNAN DUN	YORI 77	PACHEQUINO
a) Phenology (days after sowing)			
. First Flower	28	31	32
. 50% plants flowering	38	41	40
. Completion of flowering	74	72	68
. Physiological maturity	87	93	90
b) Floral Structure			
. Nectaries	Yes	No	Possible?
. 'Speckled Throat'	Yes	No	Yes
c) Resistance to			
. Leaf Roller	Yes	No	No
. Large Leaf Spot	No	No	Marginal
. Lodging	Yes	No	Marginal
d) Plant Structure			
. Plant Height (cm)	1222	128	118
. Height of lowest pod (cm)	53	69	53
. Capsule set stem length (cm)	69	59	65
. Number of Branches	2.4	1.8	0.2
. Node number of lowest capsule/flower scar	6	8	6
. Number of capsules	30	54	45
. Capsules/cm of stem	0.4	0.9	0.7
. Number of whorls of Capsules	15	15	14
. Capsules/whorl	2	4	3
e) Seed			
. Colour	Cream	White	White
. Texture	Smooth	Smooth	Smooth
. 100 seed weight (g)	0.29	0.31	0.28
. Germination, normal %	74.0	69.7	23.7
. Fresh ungerminated %	0.0	0.0	62.7
f) Accession Number	83009	85608	85609

TABLE 3.1.4.: MORPHOLOGY OF KATHERINE LOCAL SESAME.

CHARACTERISTICS	KATHERINE LOCAL
a) Phenology (days after sowing)	
. First Flower	33
b) Foral Structure	
. Nectaries	Yes
. 'Speckled Throat'	Yes
c) Resistance to	
. Leaf Roller	Yes
. Large Leaf Spot	N.R.*
. Lodging	Yes
d) Plant Structure	
. Plant height (cm)	131
. Height of lowest capsule (cm)	86
. C.S.L. (cm)	45
. Number of branches	3.8
. Node number of lowest capsule/flower scar	11
. Numbers of capsules	21
. Capsules/cm of C.S.L.	0.5
. Capsules of whorls of capsules	13
. Capsules/whorl	2
e) Seed	
. Colour	Black
. Texture	Rough
. 100 seed weight (g)	0.22
. Germination, normal %	0.0
. Fresh ungerminated %	95.0

*N.R. - Not recorded in 1987/88 wet season.

3.2 EFFECT OF SESAME POPULATIONS AND ROW SPACINGS ON WEED CONTROL AND SEED YIELD

3.2.1 ABSTRACT

Sesame cultivar Yori 77 was sown at four row spacing - 16, 32, 48 and 64 cm - and three plant populations - 100 000, 200 000 and 300 000 plants/ha in an experiment on Fenton clay loam at C.S.I.R.O. Katherine in the 1987/88 wet season. Weed biomass was measured 44 days after sowing. At physiological maturity, 94 days after sowing, sesame population and yield were measured.

Weed biomass decreased with increasing sesame plant population and decreasing row spacing. The lowest weed biomass of 997 kg/ha was recorded for a sesame population of 300,000 plants/ha sown in 16 cm rows. While the highest weed biomass (1508 kg/ha) was found in sesame with a population of 100,000 plants/ha in 64 cm rows.

Sesame seed yield was not influenced by plant population, average seed yield being 1519 kg/ha. Highest yields were found in plots with 48 cm row spacing, while the lowest yields were recorded in plots with 16 cm row spacing.

3.2.2 INTRODUCTION

Weeds commonly encountered in a sesame crop include summer grasses and pigweed. Sesame farmers rely heavily on herbicides and tillage for weed control. Weed control could be improved by the use of the sesame crop itself to smother the weeds. However plant populations suitable for smothering the weeds may not coincide with minimising risk to local drought, and optimum population for maximum sesame yield.

Current Northern Territory sesame recommendations to ensure maximum yield are to establish a population of 300,000 plants/ha, at no specific row spacing. Sesame population research in 1986/87 measured the highest yield at 290,000 plants/ha on 32 cm row spacing.

A marked response in seed yield to plant population was recorded by A. Tiangtrong Qld, 1984. Sesame populations of 400,000 plants/ha, 16 cm row spacing produced the highest seed yield. However, there was no yield plateauing at this population. Plant populations of 200,000 plants/ha using a 33 cm row spacing are recommended by G. Schrodter, 1986.

From Western Australia, the ideal plant population is 350,000 plants/ha (G. Eagleton, 1986). Possible plant arrangements included 2 rows on 91 cm ridges, 4 rows to a 1.5 m bed and 4 to 6 rows on a 1.82 m bed.

A study was initiated in 1987/88 wet season to evaluate the effects of different sesame plant populations and row spacings on the smothering of weeds and sesame yield at Katherine Northern Territory.

3.2.3 MATERIAL AND METHODS

3.2.3.1 Design, Treatments and Management

Experimental design was a randomised complete block with four row spacings - 16, 32, 48 and 64 cm - and three plant populations - 100 000, 200 000 and 300 000 plants/ha. There were four replications.

All plots were 2.5 m long. There being 4, 5, 7 and 13 rows for the 64, 48, 32 and 16 cm row spacings respectively.

Sesame cultivar Yori 77 was sown with a small plot combine on January 10, 1988. Plants were thinned to their appropriate populations and row spacings on January 22, 1988.

Urea @ 130 kg/ha (approx. 60 kgN/ha of nitrogen) was hand spread on February 17, 1988.

Supplementary irrigation was applied to maintain the experiment, with 10 mm in January, 23 mm in February and 32 mm in March, 1988.

3.2.3.2 Recordings and Data Collection

Sesame and weed biomass were sampled 44 days after sowing. The centre 2, 3, 4 and 7 rows x 0.5 m were sampled for the 64, 48, 32 and 16 cm row spacing respectively for sesame biomass. A quadrat, 1.0 m x 0.5 m, was sampled for weed biomass from this area.

At physiological maturity, 94 days after sowing, sesame population and seed yield were measured. The centre 2, 3, 4 and 7 rows x 1.0 m were sampled for the 64, 48, 32 and 16 cm row spacings respectively. The number of plants were recorded, and samples set aside to sun dry. These were later threshed and seed weight recorded. A sub sample was set aside for 100 seed weight determination.

3.2.4 RESULTS

3.2.4.1 Weed Biomass at 44 D.A.S.

3.2.4.1.1 Plant Population Effects - Increasing plant population decreased weed biomass (Table 3.2.1). There was no significant difference between the 200,000 and 300,000 sesame plant/ha treatments on weed biomass.

3.2.4.1.2 Row Spacing Effects - The two narrower row spacing significantly decreased weed biomass but there was no significant difference in weed biomass between sesame planted at 48 cm and 64 cm. (Table 3.2.1)

3.2.4.1.3 Plant Population x Row Spacing Effects - There was no significant interaction between plant population and row spacing (Table 3.2.1). However there was a trend for the highest population at the narrower row spacing to produce the lower weed biomass.

3.2.4.2 Sesame Biomass at 44 D.A.S.

3.2.4.2.1 Plant Population Effects - Increasing plant populations produced increasing sesame biomass at 44 d.a.s. (Table 3.2.2).

3.2.4.2.2 Row Spacing Effects - There was no effect of row spacing on sesame biomass at 44 d.a.s. (Table 3.2.2).

3.2.4.3 Sesame Plant Population at Harvest

Mean harvested sesame plant populations were 110,000, 204,000 and 271,000 plants/ha. There was no effect of row spacing on plant population (Table 3.2.3).

3.2.4.4 Seed Yield

3.2.4.4.1 Plant Population Effects - There was no significant effect of plant population on sesame seed yield. The average seed yield was 1519 kg/ha (Table 3.2.4).

3.2.4.4.2 Row Spacing Effects - Sesame planted on 48 cm row spacings produced the greatest average yield of 1804 kg/ha, while 16 cm row spacings produced the lowest average yield of 1314 kg/ha (Table 3.2.4).

3.2.4.5 100 Seed Weight

There was no effect of plant population or row spacing on sesame 100 seed weight (Table 3.2.5). Average 100 seed weight was 0.29 gm.

3.2.4 DISCUSSION

Experimental results indicate that maximum smothering of weeds (mainly pigweed, *Trianthema portulacastrum*), can be achieved with high populations (200 - 300 thousand plants/ha) together with narrow row spacings.

The experiment also indicated that there is no seed yield advantage in 200 or 300 thousand plants/ha over 100,000 plants/ha. While sesame seed costs $1.00/kg and only requires

3 kg/ha to establish 300,000 plants/ha. There is no cost advantage in establishing lower population sesame crops. Hence 300,000 plants/ha will remain the recommended population.

As regards to row spacing, if sesame is to be row cropped, this experiment indicated that sesame in 16 cm row spacing was more successful in weed control. However, seed yields for such a crop were the lowest. Maximum yields were found in plots with 48 cm row spacing; 32 cm and 64 cm being less productive. Weed control, however, was ineffective at 64 cm row spacing. Hence the future recommendation for row cropped sesame will be for row spacing between 32 cm and 48 cm. This fits in favourably with current row planters which have a 36 cm spacing.

TABLE 3.2.1: Effect of sesame plant population and row spacing on weed biomass (kg/ha) at 44 days after sowing.

ROW SPACING (cm)	PLANT POPULATION (x 1000 plants/ha)			
	100	200	300	MEAN
16	1088	1083	997	1056
32	1441	1165	1018	1208
48	1428	1230	1338	1332
64	1508	1348	1281	1379
MEAN	1367	1207	1159	

Level of Significance:

Row Spacing = **, LSD (5%) = 151

Population = *, LSD (5%) = 131

Row Spacing x Population = Not significant

CV (5%) = 15.2

TABLE 3.2.2: Effect of sesame plant population and row spacing on sesame biomass (kg/ha) at 44 day after sowing.

ROW SPACING (cm)	PLANT POPULATION (x 1000 plants/ha)			
	100	200	300	MEAN
16	2447	2308	3201	2652
32	1617	2357	3465	2480
48	1824	3675	3076	2858
64	1896	2935	3121	2651
MEAN	1946	2819	3216	

Level of Significance:

Row Spacing = Not significant

Plant Population = **, LSD (5%) = 463

Row Spacing x Population = Not significant

CV (%) = 25.1

TABLE 3.2.3: Sesame plant populations (x 1000/ha) in the 1987/88 wet season.

ROW SPACING (cm)	PLANT POPULATION (x 1000 plants/ha)			
	100	200	300	MEAN
16	130	196	281	202
32	98	172	315	198
48	116	193	260	190
64	96	255	229	193
MEAN	110	204	271	

Level of Significance:

Row Spacing = Not significant
Plant Population = **, LSD (5%) = 23
Row Spacing x Population = **, LSD 5% = 47
CV (%) = 16.6

TABLE 3.2.4: Effect of sesame plant population and row spacing on sesame yield (kg/ha).

ROW SPACING (cm)	PLANT POPULATION (x 1000 plants/ha)			
	100	200	300	MEAN
16	1376	1421	1145	1314
32	1419	1580	1592	1531
48	1807	1755	1850	1804
64	1422	1503	1357	1427
MEAN	1506	1565	1486	1519

Level of Significance:

Row Spacing = **, LSD (5%) = 189

Plant Population = Not significant

Row Spacing x Population = Not significant

CV (%) = 15.6

TABLE 3.2.5: Effect of sesame population and row spacing on sesame hundred seed weight (g).

ROW SPACING (cm)	POPULATION (x 1000 plants/ha)			
	100	200	300	MEAN
16	0.30	0.29	0.29	0.29
32	0.29	0.30	0.29	0.29
48	0.30	0.29	0.29	0.29
64	0.30	0.30	0.30	0.30
MEAN	0.30	0.29	0.29	0.29

Row Spacing = Not significant

Population = Not significant

Row Spacing x Population = Not significant

CV (%) = 3.1

3.3 EFFECT OF TIME AND RATE OF APPLICATION OF NITROGEN FERTILISER ON SESAME SEED YIELD

3.3.1 ABSTRACT

The effect of different rates and times of application of nitrogen on the sesame growth and seed yield was studied on Fenton clay loam in the 1987/88 wet season.

Sesame cv. Yori 77 was sown with a basal application of either 0, 30, 60 or 120 kg/ha nitrogen. Two applications of 15 or 30 kg/ha were also applied pre or post flowering to the 30 and 60 kg/ha nitrogen treatments.

Though there was no significant response to nitrogen fertiliser, there was a trend for sesame biomass and seed yield to increase up to 60 kg/ha initial nitrogen. The first split application of nitrogen tended to further increase seed yield while the second depressed sesame seed yield.

3.3.2 INTRODUCTION

Due to the high cost of nitrogen fertilisers, it is essential to improve fertiliser efficiency and this may be obtained by the use of split applications. This management technique also offers the option of applying fertiliser according to the type of the wet season and supplying the nutrients when the crop requirements are high.

The objective of this experiment is to evaluate the effect of split application of nitrogen (urea) on sesame growth and yield under rainfed or supplementary irrigated conditions.

3.3.3 MATERIALS AND METHOD

3.3.3.1 Seasonal Conditions

The 1987/88 wet season started with initial good rains in November and December. January rainfall was well below average, while February rainfall returned to normality. The wet season finished at by the start of March (Table 3.3.1).

Soil type was a Fenton clay loam which had produced forage sorghum the previous season (Table 3.3.2).

3.3.3.2 Design, Treatments and Management

There were 2 experiments, the first grown under rainfed conditions and the second under supplementary irrigation.

In each experiment the design was a randomised completed block with 10 treatments and 2 replications.

Treatments details are presented in Table 3.3.3.

Sesame cv. Yori 77 was planted on 1 January 1988, at 300,000 plants/ha. All plots were 8 rows x 6.6 m long, row spacing was 36 cm.

Supplementary irrigation was applied to the second experiment 6 times commencing 35 d.a.s. with the last application at 64 d.a.s. Scheduling was based on evapotranspiration and available soil moisture (Sesame Appendix).

3.3.3.3 Recordings and Data Collection

Soil samples were taken @ 0-10cm, 10-30cm and 30-60cm depths from 0 and 60 N kg ha' plots prior to fertiliser application to determine available sulphur, nitrogen and total nitrogen.

Plant dry matter production was measured 52 d.a.s. An area of 6 rows x 1.0 m was sampled from each plot. The samples were dried at 60°C for 96 hours and dry weight recorded.

At physiological maturity plant population, sesame biomass and seed weight were measured by sampling 6 rows x 1.0 m'.

3.3.4 RESULTS AND DISCUSSION

3.3.4.1 BIOMASS

3.3.4.1.1 52 Days After Sowing

No significant differences were found in sesame biomass between the various nitrogen treatments for either experiments (Table 3.3.4).

Rainfed: The trend was for sesame to produce increasing levels of biomass with increasing levels of initial nitrogen application. However, the split application of nitrogen at 27 d.a.s. generally depressed sesame biomass production.

Irrigated: Results indicated a depression in sesame biomass production with increasing levels of nitrogen application. With the increased levels of soil moisture and the initial high levels of available nitrogen plus the application of nitrogen fertiliser may have raised soil nitrogen to too high a level and hence suppressed sesame growth. Treatment 3, 30-15-00, treatment produced the highest sesame biomass.

3.3.4.1.2 At Physiological Maturity

Rainfed: The trend was for sesame to produce increasing levels of biomass with increasing levels of initial nitrogen application, up to 60 kg/ha. Further applications of nitrogen generally depressed sesame biomass production.

Irrigated: There was significant differences in sesame biomass for nitrogen treatments (Table 3.3.5). A similar response curve to that of the rainfed experimetn for increasing levels of initial nitrogen application was found. The highest sesame biomass was produced from an initial nitrogen application of 60kg/ha; the first split application of nitrogen increased biomass production more than the second split application of nitrogen. Further application after the initial application of 60kgn/ha depressed biomass production.

3.3.4.2 PLANT POPULATION

For both experiments there was no significant difference in plant populations between treatments (Table 3.3.6). Average sesame population was 263,000 plants/ha and 251,000 plants/ha for the rainfed and irrigated experiments respectively.

3.3.4.3 SEED YIELD

Yields improved with higher applications of nitrogen; However in both experiments there was no significant effects of nitrogen application on sesame yield.due to the high initial levels of available nitrogen, which were more than adequate for crop growth. (Table 3.3.7).

Rainfed: For increasing levels of initial nitrogen, up to 60 kg/ha application, the trend was for increased sesame yields. An application of 120 kg N/ha produced a lower seed yield. The first split application of 30 kg N/ha increased seed yield while the second split application suppressed seed yield. The 15 kg N/ha split application produced the reverse effect. Inadequate soil moisture may have prevented significant expression of fertiliser efforts.

Irrigated: A similar response was found to initial nitrogen applications as that for the rainfed experiment. For an initial application of 30 kg N/ha the first additional application of nitrogen increased sesame seed yield while the second application suppressed sesame seed yield.
Additional split applications of nitrogen to the initial 60 kg N/ha only suppressed sesame seed production.

High levels of available soil nitrogen at planting plus high levels of initial and additional split applications of nitrogen probably induced too high levels which caused yield depression.

3.3.4.4 HARVEST INDEX

For both experiments there was no significant nitrogen effects on sesame harvest index (Table 3.3.8). Average harvest was 0.27 and 0.26 for the rainfed and irrigated sesame respectively.

3.3.5 FIELD IMPLICATION

The recommended fertiliser application of 60 kg N/ha should be maintained until further research can define the effect of various levels of initial available soil nitrogen. The advantages of a crop rotation with crop or pasture legumes for possible residual nitrogen effects is to be investigated on sesame growth and seed yield.

3.3.6 ACKNOWLEDGMENT

Special thanks to K. Thiagalingam for advice throughout the experiment.

TABLE 3.3.1: Monthly rainfall (mm), November - May, for 1987/88 wet season at C.S.I.R.O. Katherine

MONTH	EXPERIMENT		LONG TERM AVERAGE[1]
	RAINFED (mm)	IRRIGATED (mm)	
November	145.8	145.8	83.3
December	206.0	206.0	191.6
January	82.8	82.8	228.6
February	214.3	295.3	210.2
March	22.3	70.3	162.7
April	2.4	2.4	32.8
May	0.0	0.0	5.1
TOTAL	673.6	802.6	914.3

[1] Long term average of C.S.I.R.O. Katherine.

TABLE 3.3.2: Soil fertility - nutrient analysis

PRE FERTILISING	**SOIL DEPTH (cm)**		
	0 - 10	**10 - 30**	**30 - 60**
Cond.		0.04	0.03
pH	0.04	6.6	6.4
Avail. P (ppm)	7.1	Less 5	Less 5
Avail. K (ppm)	16	213	100
Avail. Ca (ppm)	268	1104	1030
Avail. Mg (ppm)	1344	169	162
Avail. Zn (ppm)	199	0.6	0.4
Avail. Cu (ppm)	1.7	3	1
Avail. S (ppm)	3	16	29
Total N (ppm)	8	546	259
Avail. N (ppm	721	41	28
	28		

TABLE 3.3.3: Treatment levels (kg N/ha) and times of urea application.

TREATMENT	TIME OF APPLICATION			
	SOWING	27 d.a.s.	52 d.a.s.	TOTAL
1	0	0	0	0
2	30	0	0	30
3	30	15	0	45
4	30	0	15	45
5	60	0	0	60
6	30	30	0	60
7	30	0	30	60
8	60	30	0	90
9	60	0	30	90
10	120	0	0	120

TABLE 3.3.4: Effect of nitrogen on sesame biomass (kg/ha) 52 days after sowing

TREATMENT	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
1	4767	6140
2	5563	5533
3	5251	6926
4	(a)	(a)
5	5857	5532
6	(a)	(a)
7	6313	5780
8	5037	5725d
9	(b)	(b)
10	6968	5691
AVERAGE	5720	5817
Level of significance	N.S.	N.S.

(a), (b): Treatments only partially implemented at 52 d.a.s.; treatment included into 2 and 7 and analysed accordingly.

TABLE 3.3.5: Effect of nitrogen on sesame biomass (kg/ha) at physiological maturity

TREATMENT	EXPERIMENT	
	RAINFED	**IRRIGATED**
1	4577	5103
2	5021	5267
3	4719	6201
4	5584	5889
5	4803	6483
6	4589	5649
7	5586	7120
8	5713	5115
9	5125	5707
10	5332	6974
AVERAGE	5105	5951
Level of significance	N.S.	**
LSD (5%) =	-	1116
CV (%) =	-	8.9

TABLE 3.3.6: Sesame populations (x 1000/ha) for the rainfed and irrigated nitrogen fertiliser experiments

TREATMENT	EXPERIMENT	
	RAINFED	**IRRIGATED**
1	280	238
2	282	238
3	262	241
4	252	285
5	259	248
6	278	234
7	264	273
8	273	241
9	245	269
10	234	245
AVERAGE	263	251
Level of significance	N.S.	N.S.

TABLE 3.3.7: Effect of nitrogen on sesame yield (kg/ha) in the 1987/88 wet season

TREATMENT	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
1	1355	1243
2	1316	1434
3	1198	1738
4	1524	1552
5	1400	1713
6	1382	1429
7	1596	2058
8	1644	1465
9	1423	1495
10	1494	2009
AVERAGE	1433	1614
Level of significance	N.S.	N.S.

TABLE 3.3.8: Effect of nitrogen on sesame harvest index in the 1987/88 wet season

TREATMENT	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
1	0.28	0.23
2	0.25	0.26
3	0.24	0.27
4	0.26	0.25
5	0.28	0.25
6	0.29	0.24
7	0.27	0.28
8	0.28	0.28
9	0.27	0.25
10	0.27	0.28
AVERAGE	0.27	0.26
Level of significance	N.S.	N.S.

3.4 EFFECT OF LATE SOWING OF SESAME ON SEED YIELD

3.4.1 ABSTRACT

The effect of time of sowing on seed yield for sesame grown at Douglas Daly was evaluated in the 1987/88 wet season. Sesame cv. Yori 77 was planted at 5 sowing dates ranging from December 30, 1987 to February 16, 1988.

Planting within the recommended sowing dates at Douglas Daly

gave a mean sesame yield of 1638 kg/ha. Extending the time of sowing by 4 weeks reduced yield to only 40 kg/ha.

3.4.2 INTRODUCTION

Current sowing recommendations for sesame to maximise both yield and seed quality is listed for Douglas Daly and Katherine in the crop Agnotes.
Specifically for cultivars Pachequino and Yori 77, for the Douglas Daly, it is desirable to sow before January 15 and no later than January 22. For the Katherine area, sowing 1 week earlier is advisable.

These recommendations are based on crop phenology and average wet season rainfall pattern. However, no experimental data is available to verify these recommendations.

This study was proposed to evaluate the effect of time of sowing on seed yield for sesame grown in the Douglas Daly region.

8.4.3 MATERIALS AND METHODS

8.4.3.1 Seasonal Conditions

Monthly rainfall for November and December was above average. From January to April monthly rainfall was approximately 60% of the expected average (Table 3.4.1.).

Soil type was a Venn, sandy clay loam.

3.4.3.2 Design, Treatments and Management

Experimental design was a randomised complete block with 5 dates of sowing and 3 replications. Plot size was 6 rows, each 36cm apart, x 5.1m long. Planting was with a cone seeder at a seeding rate in order to obtain a plant population of 200 000 plants/ha. The cultivar used was Yori 77.

Sowing dates were December 30 1987, January 12 and 22, February 2 and 16, 1988.

Prior to sowing, on December 19, 1987, the area was fertilised with single superphosphate with Cu, Mo, Zn at 200 kg/ha (approx. 16, 22, 2.4, 0.04 and 1.6 kg/ha of P, S, cu, Mo and Zn respectively). Potash was applied @ 30 kg/ha (15 kg K/ha).

Treflan @ 1.0 L/ha was applied by boomspray on the evening of December 24, 1987.

Urea @ 130 kg/ha (approx. 60 kg N/ha) was hand spread after each plot was sown.

Insects were controlled as required throughout the season with Lorsban @ 0.90 L/ha. The experiment was sprayed 4 times, approximately every 3 weeks after sowing.

3.4.3.3 Recordings and Data Collection

Dates of various phenological occurrences were recorded. These included date of first flower, 50% plants flowering, completion of flowering, physiological maturity (95% capsules yellow) and harvest maturity (95% capsules brown).

At maturity plots were hand harvested; plant population and seed weight were measured by sampling the centre 4 rows x 1.0m. Seed was collected for visual assessment of weather damage.

3.4.4 RESULTS

3.4.4.1 PHENOLOGY

Results are presented in Table 3.4.2.

3.4.4.1.1 First Flower:

Time to first flower tended to be earlier with later sowing dates. The exception was the 3rd sowing date (22 January) where flowering was probably delayed by moist overcast conditions.

First flower occurred between 27 and 38 d.a.s.

3.4.4.1.2 50% PLANTS FLOWERING:

Generally 50% plants were flowering within 6 days of the first flower for all sowing dates prior to February. After February, this difference extended to an average of 15 days.

3.4.4.1.3. COMPLETION OF FLOWERING:

For the first 2 sowing dates flowering was complete by 46 d.a.s. Sesame planted at later sowing dates responded to rains in late March - early April. Completion of flowering occurred as late as 75 d.a.s. for the 3rd time of sowing.

3.4.4.1.4 PHYSIOLOGICAL MATURITY:

Sesame planted at all sowing dates, except February 16, reached physiological maturity at 109 d.a.s. For the last sowing date, cooler weather delayed time to physiological maturity to 115 d.a.s.

3.4.1.5 HARVEST MATURITY:

Time to harvest maturity tended to be earlier with later sowing dates, except for the last sowing. Lack of moisture with later plantings shortened the period to harvest maturity, whereas cooler temperatures were the overriding control for the 5th time of sowing. Cool temperatures delaying time to harvest maturity.

3.4.4.2 PLANT POPULATION AT HARVEST

Average sesame plant population for the first four time of sowings was 169 000 plants/ha (Table 3.4.3). The last sowing date had a poor establishment with an average population of 67 000 plants/ha.

Though sesame populations were statistically different, biologically the various plant stands should have successfully compensated as regards effect on seed yield for population between 100 000 and 300 000 plants/ha.

3.4.4.3 SEED YIELD

Sesame seed yields were not significantly different for sowing dates December 30 and January 12 (Table 3.4.4). Yields for the next 2 dates, January 22 and February 2,were significantly lower than January 12, though similar to the earliest planting date December 30. the last sowing date, February 16, only just managed to produce some seed.

3.4.4.4 WEATHER DAMAGE

No visual differences in seed colour for all sowing dates due to a lack of rain after crop physiological maturity.

3.4.5 DISCUSSION

For the 1987/88 wet season sesame seed yields for treatments sown within the recommended period of sowing averaged 1638 kg/ha. Planting up to a fortnight later than 20 January resulted in seed yield reduction to 1083 kg/ha. Within a further fortnight sesame yield had been reduced to 40 kg/ha. This was partly associated with a significant loss of plants during establishment.

The trend is for a reduction in potential sesame yield of 50 kg/ha per day for crops sown later than January 20. These figures verify the Department's recommendations.

TABLE 3.4.1: Monthly rainfall (mm), November - May, for 1987/88 wet season at D.D.R.F.

MONTH	SEASON	LONG TERM AVERAGE[1]
November	205.8	105
December	187.6	149
January	171.4	273
February	194.1	306
March	151.0	284
April	18.3	34
May	0.0	5
TOTAL	931.2	1156

[1]Long term average for Douglas Daly Research Farm.

TABLE 3.4.2: Phenology of sesame cv. Yori 77 planted at various dates in the 1987/88 wet season.

PHENOLOGICAL EVENT (d.a.s.)	**TIME OF SOWING**				
	DEC 30	**JAN 12**	**JAN 22**	**FEB 2**	**FEB 16**
First Flower	34	30	38	29	27
50% Plants Flowering	40	36	44	42	43
Completion of Flowering	46	40	75	66	57
Physiological Maturity	109	110	109	103	115
Harvest Maturity	121	119	115	109	125

TABLE 3.4.3: Sesame populations (x 1000 plants/ha) for the various time of sowing in the 1987/88 wet season.

	TIME OF SOWING				
	DEC 30	**JAN 12**	**JAN 22**	**FEB 2**	**FEB 16**
POPULATION	123	211	190	153	67
Level of significance	**				
LSD (5%) =	59				
CV (%) =	21.0				

TABLE 3.4.4: Effect of sowing date on sesame seed yield (kg/ha).

TIME OF SOWING	YIELD (kg/ha)
Dec 30	1559
Jan 12	1718
Jan 22	1122
Feb 2	1045
Feb 16	40
Level of significance	**
LSD (5%)	582
CV (%)	28.5

3.5 EFFECT OF DELAYING SESAME HARVEST ON SEED YIELD

3.5.1 ABSTRACT

Sesame crops have been successfully grown in the Katherine and Douglas Daly districts of the Northern Territory. However, current harvesting practices and the dehiscent nature of commercial cultivars result in major yield loses before the seed reaches the grain depot. This experiment simulates the farmer practice of delaying harvest to minimise the risk of tainting of seed from sap and vegetative material. Observed seed loses over a 3 week period were 300 kg/ha. This information will encourage farmers to harvest earlier with suitable machinery.

3.5.2 INTRODUCTION

Sesame grown in the Northern Territory is normally ready for harvesting 90 - 120 days after sowing. Present cultivars, Pachequino, Yori 77 and Hnan Dun are all dehiscent types. At physiological maturity, leaves and stems change from green to yellow while the capsules ripen irregularly from the lower stem upward. As the capsule ripens it splits along the septa from top to bottom. If the mature plant is allowed to stand for some time prior to harvesting the crop will lose large amounts of seed through shattering from the effects of wind and rain.

This study proposes to evaluate sesame seed loses by delaying harvesting. This will provide research and extension staff with information to help encourage farmers to harvest at the correct time.

3.5.3 MATERIALS AND METHODS

3.5.3.1 Design, Treatments and Management

The sesame cultivars Hnan Dun, Yori 77 and a Yori 77 selection were sown on January 1, 1988.

Experimental design was a randomised complete block with 6 replications. Plot size was 8 rows x 5.1 m long, with a row spacing of 36 cm. Sowing was with a cone-seeder at a depth of 1 cm. Germination was variable and seeding rate was adjusted to obtain a plant population greater than 300,000 plants/ha. Plots were thinned to equivalent to 300,000 plants/ha within 2 weeks of sowing. Urea @ 130 kg/ha (approx. 60 kg/ha of nitrogen) was broadcast by hand on January 14, 1988.

3.5.3.2 Recordings and Data Collection

Plots were quadrats 4 times, each 1 week apart. Quadrats, 6 rows x 1.0 m, were hand harvested and number of plants recorded. The first harvest was 88, 90 and 90 days after sowing for hnan Dun, Yori 77 and Yori 77 selection respectively (Table 3.5.1). This date corresponded with approximately physiological maturity (95% of capsules yellow) for each cultivar. The samples were air dried for 7 days, threshed and seed weight and moisture content recorded.

3.5.4 RESULTS AND DISCUSSION

3.5.4.1 PLANT POPULATION

The sesame cultivars were not significantly different in plant population at harvest. Average number of plants/ha was 236,000 (Table 3.5.2).

3.5.4.2 SEED YIELD

Later harvest dates were associated with lower seed yields for all cultivars (Table 3.5.3). Approximately 300 kg/ha of seed was lost by each cultivar during the 3 weeks after crop physiological maturity.

3.5.4.2.1 Hnan Dun:

Seed losses were not significant until the 3rd harvest date, ie. 14 days after physiological maturity, (Table 3.5.2). Seed loses were 315 kg/ha.

3.5.4.2.2 Yori 77 and Yori 77 Selection:

Highest seed yields were recorded at physiological maturity; (Table 3.5.2). For the next 3 weeks lower yields were recorded but were not significantly different from each other. Reason for the plateauing in seed losses was that once seed from the apex of the capsule is lost, a more intensive disturbance (wind or rain) is required to dehisce seed, which did not occur during the research period.

TABLE 3.5.1: Harvest dates (d.a.s.) for the sesame cultivars.

HARVEST	HNAN DUN	YORI 77 AND YORI 77 SELECTION
1	88	90
2	95	97
3	102	104
4	109	111

TABLE 3.5.2: Sesame populations (x 1000/ha).

CULTIVAR	HARVEST				
	1	2	3	4	MEAN
Hnan Dun	251	238	241	239	242
Yori 77	258	214	223	205	225
Yori selection	241	246	249	229	241

Level of significance: Not significant

TABLE 3.5.3 Sesame seed yield (kg/ha) at four dates of harvest.

CULTIVAR	HARVEST			
	1	2	3	4
Hnan Dun	1484	1227 (17.3)[1]	1169 (21.2)[1]	1263 (14.9)
Yori 77	1623	1095 (32.5)	1359 (16.3)	1148 (29.3)
Yori selection	1410	1410 (24.6)	1053 (25.3)	1027 (27.2)

Level of significance: **
LSD (5%) comparing harvest within cultivar = 161
CV (%) = 10.8
[1] ( ) = % loss of seed

3.6 EFFECT OF HERBICIDE CONTROL OF PIGWEED AND SUMMER GRASS ON SEED YIELD OF SESAME UNDER RAINFED AND IRRIGATED CONDITIONS.

3.6.1 ABSTRACT

Chemical weed control in sesame has been re-investigated due to the withdrawal of alachlor from the market.

A sesame crop was established on a Fenton clay loam at CSIRO, Katherine in the 1987/88 wet season. Herbicides used to control pigweed and summer grass in this experiment included trifluralin, metolachlor, alachlor (new experimental formulation), pendimethalin and fluazifop, all at various rates.

Pendimethalin (0.660 kg a.i./ha) proved to be the most effective herbicide in total weed control while Alachlor (1.000 kg a.i./ha) and fluazifop (0.212 kg a.i./ha) were effective in controlling grasses.

No herbicide was effective in translating weed control into an significant increase in seed yield. This suggested, that where there were few weeds, pigweed does not seriously affect yield of sesame when grown at 300,000 plants/ha. Pigweed

being a prostrate plant does not compete effectively for light against sesame.

3.6.2 INTRODUCTION

Chemical weed control in sesame has been studied in Queensland and Western Australia. Alachlor applied pre-emergence was the most acceptable herbicide (Schrodter et al, 1984). However, alachlor was withdrawn from the market. Trifluralin, sethoxydim and pendimethalin also showed benefits when compared with alachlor in control of summer grass (Brachiaria sp and Digitaris ciliaris) and/or pigweed (Trianthema protulacastrum) (Eagleton 1986).

Herbicides used in this experiment included trifluralin, metolachlor, alachlor (new experimental formulation), pendimethalin and fluazifop, all at various rates. The treatments also include weed and weed free controls.

Two trials were established, the first under rainfed conditions and the second under supplementary irrigation. The objective of this experiment is to evaluate potential herbicides for weed control in sesame.

3.6.3 MATERIALS AND METHODS

3.6.3.1 Seasonal Conditions

The 1987/88 wet season started with initial good rains in November and December. January rainfall was well below average, while February rainfall returned to normal. The wet season finished at the beginning of March (Table 3.6.1).

3.6.3.2 Design, Treatments and Management

There were 2 experiments, the first grown under rainfed conditions and the second grown under supplementary irrigation.

In both experiments, the design was a randomised complete block with 2 replications and ten treatments.

Treatments and levels of application are indicated in Table 3.6.2.

Reason for 6 week and 20 week hand weeding treatment is that sesame generally takes 6 weeks to reach maximum foliage projected cover. From then on the sesame canopy is successfully competing for light with all plants of lower stature, especially pigweed. Hence in the commercial situation the herbicide needs only to be effective for those initial 6 weeks of crop growth.

The 20 week hand weeding treatment provides an environment where sesame is not competing with any weeds for moisture and light throughout the life of the crop.

Sesame cultivar Yori 77 was planted on 1 January 1988, at 300,000 plants/ha. All plots were 8 rows x 4.0m long with a row spacing of 36cm.

Urea @ 130 kg/ha (approx. 60 kg/ha of nitrogen) was broadcast by hand on 14 January 1988.

Supplementary irrigation was applied to the second experiment 6 times commencing 35 d.a.s. with the last application 64 d.a.s. Scheduling was based on evapotranspiration and available soil moisture (Sesame Appendix).

3.6.3.3 Recordings and Data Collection

At 42 d.a.s., sesame, pigweed and grass dry matter production was determined. The sample comprised the centre 4 rows x 1.0m for sesame and the 3 inter-row spaces for weed biomass. These were dried and dry weights recorded.

Within a week after physiological maturity, plant population and seed weight were measured by sampling the centre 4 rows x 1.0m. Plots were hand harvested.

3.6.4 RESULTS

3.6.4.1 Sesame dry matter production

There was no effect of herbicide on sesame dry matter production (Table 3.6.3), at 42 d.a.s. regardless of moisture regime.

3.6.4.2 Grass dry matter production

There was no effect of herbicide on grass dry matter production (Table 3.6.4) at 42 d.a.s., regardless of moisture regime. However, Alachlor (1.0kg a.i./ha) and Fluazifop (0.212kg a.i./ha) tended to be the most successful in controlling summer grass.

3.6.4.3 Pigweed dry mater production

3.6.4.3.1 Rainfed:

An application of Pendimethalin (0.66kg a.i./ha) significantly controlled pigweed development. Metolachlor (0.36kg a.i./ha), Alachlor (1.0kg a.i./ha) and Pendimethalin (0.33kg a.i./ha) reduce pigweed biomass, though not significantly. Fluazifop (0.212 kg a.i./ha) and Trifluralin (0.4 kg a.i./ha) did not affect pigweed levels (Table 3.6.5).

3.6.4.3.2 Irrigated

All herbicides, except Fluazifop (0.212 kg a.i./ha), were equally effective in controlling pigweed development (Table 3.6.5).

3.6.4.4 Total Weeds

3.6.4.4.1 Rainfed

Pendimethalin (0.33 and 0.66 kg a.i./ha) and Alachlor (1.0 kg a.i./ha) were the most effective herbicide in controlling weeds in a sesame crop.

3.6.4.4.2 Irrigated

Trifluralin (0.4 kg a.i./ha) and Alachlor (1.0 kg a.i./ha were effective in controlling weeds in sesame.

3.6.4.5 Plant Population

There was no significant population effects in both experiments (Table 3.6.3). Average population was 285,000 and 262,000 plants/ha for rainfed and irrigated experiments respectively.

3.6.4.6 Seed Yield

There was no significant response to weed control on seed yield in both the rainfed irrigated experiment (Table 3.6.7).

Average seed yield for the rainfed and irrigated experiment was 1616 kg/ha and 1803 kg/ha respectively.

3.6.5 DISCUSSION

Stomp and Lasso (new formulation) proved to be effective herbicides in controlling weed development in sesame crops. However, no herbicide was effective in translating weed control into a significant increase in sesame seed yield.

This suggested where pigweed is the major problem (and grass weeds being minimal) successful establishment of sesame will smother the weeds. Hence negating the effect of the herbicide. Further research is however required to determine herbicide effectiveness on summer grass in sesame.

TABLE 3.6.1: Monthly rainfall (mm), November - May, for 1987/88 wet season at CSIRO, Katherine.

MONTH	**EXPERIMENT**		**LONG TERM AVERAGE**[1]
	RAINFED (mm)	**IRRIGATED (mm)**	
November	145.8	145.8	83.3
December	206.0	206.0	191.6
January	82.8	82.8	228.6
February	214.3	295.3	210.2
March	22.3	70.3	162.7
April	2.4	2.4	32.8
May	0.0	0.0	5.1
TOTAL	673.6	802.6	914.3

[1]Long term average CSIRO, Katherine

TABLE 3.6.2: Treatments and levels of herbicide application.

HERBICIDE	**REGISTERED NAME**	**LEVEL OF APPLICATION (kg a.i./ha)**		
Pendimethalin (i)	Stomp	-	0.330	0.660
Metolachlor (ii)	Dual	0.360	0.720	-
Trifluralin (i)	Treflan	-	0.400	-
Alachlor (ii)	Lasso	-	-	1.000
Fluazifop (iii)	Fusilade	-	0.212	-
No herbicide	-			
Hand weeding until	6 weeks			20 weeks

TABLE 3.6.3: Effect of herbicide on sesame dry matter production (kg/ha) at 42 days after sowing.

TREATMENT	EXPERIMENT	
	RAINFED	IRRIGATED
1. Trifluralin 0.40 kg a.i./ha	2681	3531
2. Metolachlor 0.36 kg a.i./ha	2941	3328
3. Metolachlor 0.72 kg a.i./ha	3735	3172
4. Alachlor 1.00 kg a.i./ha	2737	3553
5. Pendimethalin 0.33 kg a.i./ha	2776	310
6. Pendimethalin 0.66 kg a.i./ha	2717	2285
7. Fluazifop 0.212 kg a.i./ha	2205	2467
8. Hand weed (6 weeks)	3425	3751
9. Hand weed (20 weeks)	3779	3543
10. No herbicide	2667	2277
AVERAGE	2916	2964
Level of significance	N.S.	N.S.

TABLE 3.6.4: Effect of herbicide on grass dry matter production (kg/ha) at 42 days after sowing.

TREATMENT	EXPERIMENT	
	RAINFED	IRRIGATED
1. Trifluralin 0.40 kg a.i./ha	246	163
2. Metolachlor 0.36 kg a.i./ha	121	165
3. Metolachlor 0.72 kg a.i./ha	0	196
4. Alachlor 1.00 kg a.i./ha	0	88
5. Pendimethalin 0.33 kg a.i./ha	83	197
6. Pendimethalin 0.66 kg a.i./ha	84	111
7. Fluazifop 0.212 kg a.i./ha	96	0
8. Hand weed (6 weeks)	0	0
9. Hand weed (20 weeks)	0	0
10. No herbicide	331	202
AVERAGE	135	127
Level of significance	N.S.	N.S.

TABLE 3.6.5: Effect of herbicide on pigweed dry matter production (kg/ha) at 42 days after sowing.

TREATMENT	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
1. Trifluralin 0.40 kg a.i./ha	1293	460
2. Metolachlor 0.36 kg a.i./ha	884	753
3. Metolachlor 0.72 kg a.i./ha	1110	921
4. Alachlor 1.00 kg a.i./ha	937	564
5. Pendimethalin 0.33 kg a.i./ha	750	581
6. Pendimethalin 0.66 kg a.i./ha	0	717
7. Fluazifop 0.212 kg a.i./ha	1909	1405
8. Hand weed (6 weeks)	0	0
9. Hand weed (20 weeks)	0	0
10. No herbicide	1395	2115
AVERAGE	992	979
Level of significance	*	*
LSD (5%)		
Between (10) and rest =	739	1082
Between rest =	906	1325
CV (%) =	45.5	59.8

TABLE 3.6.6: Effect of herbicide on total weed dry matter production (kg/ha) at 42 days after sowing.

TREATMENT	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
1. Trifluralin 0.40 kg a.i./ha	1539	624
2. Metolachlor 0.36 kg a.i./ha	1006	918
3. Metolachlor 0.72 kg a.i./ha	1100	1117
4. Alachlor 1.00 kg a.i./ha	937	652
5. Pendimethalin 0.33 kg a.i./ha	833	778
6. Pendimethalin 0.66 kg a.i./ha	84	828
7. Fluazifop 0.212 kg a.i./ha	2005	1405
8. Hand weed (6 weeks)	0	0
9. Hand weed (20 weeks)	0	0
10. No herbicide	1726	2317
AVERAGE	1058	1106
Level of significance	*	*
LSD (5%)		
Between (10) and rest =	774	1167
Between rest =	948	1429
CV (%) =	41.5	59.8

TABLE 3.6.7: Sesame population (x 1000 plants/ha) in the rainfed and irrigated herbicide experiments.

TREATMENT	EXPERIMENT	
	RAINFED	**IRRIGATED**
1. Trifluralin 0.40 kg a.i./ha	284.7	229.2
2. Metolachlor 0.36 kg a.i./ha	295.1	246.5
3. Metolachlor 0.72 kg a.i./ha	284.7	232.6
4. Alachlor 1.00 kg a.i./ha	274.3	256.9
5. Pendimethalin 0.33 kg a.i./ha	270.8	277.8
6. Pendimethalin 0.66 kg a.i./ha	277.8	312.5
7. Fluazifop 0.212 kg a.i./ha	305.6	270.8
8. Hand weed (6 weeks)	298.6	263.9
9. Hand weed (20 weeks)	284.7	281.3
10. No herbicide	280.1	258.1
AVERAGE	284.7	262.2
Level of significance	N.S.	N.S.

TABLE 3.6.8: Effect of weed control on seed yield (kg/ha).

TREATMENT	EXPERIMENT	
	RAINFED	**IRRIGATED**
1. Trifluralin 0.40 kg a.i./ha	284.7	229.2
2. Metolachlor 0.36 kg a.i./ha	295.1	246.5
3. Metolachlor 0.72 kg a.i./ha	284.7	232.6
4. Alachlor 1.00 kg a.i./ha	274.3	256.9
5. Pendimethalin 0.33 kg a.i./ha	270.8	277.8
6. Pendimethalin 0.66 kg a.i./ha	277.8	312.5
7. Fluazifop 0.212 kg a.i./ha	305.6	270.8
8. Hand weed (6 weeks)	298.6	263.9
9. Hand weed (20 weeks)	284.7	281.3
10. No herbicide	280.1	258.1
AVERAGE	284.7	262.2
Level of significance	N.S.	N.S.

3.7 SCREENING HERBICIDES FOR WEED CONTROL IN SESAME

3.7.1 ABSTRACT

New herbicides are being continually released for weed control in various temperate crops. Some of these herbicides may have potential use in the semi-arid tropics for control of summer grass and pigweed in sesame. The withdrawal of alachlor from the market has initiated research for alternative chemicals.

Two herbicides, Agil® and Lentagran® were investigated for phytotoxic effects on sesame. Agil did not effect sesame

seedling number or plant fresh weight. Application of Lentagran induced symptoms of leaf scorch on sesame seedling. Indications were that these sesame seedling would not have recovered from this damage.

3.7.2 INTRODUCTION

Alachlor has been used in sesame crops in the Northern Territory as a pre-emergent herbicide for the control of summer grass and pigweed.

The withdrawal of alachlor from the market initiated research into alternative herbicides. Part of this research included the screening of potential new herbicides for phytotoxic effects to sesame seedlings. Herbicides reviewed were Agil (a selective grass formulation) and Lentagran for broad leaf weed control.

3.7.3 METHOD

Experimental design was a pot trial arranged in a Latin square. Herbicides were applied post emergence (2nd true leaf stage, 23 days after sowing) at rates equivalent to 0, 1, 2, 4 and 8 L/ha. Sesame seedlings were thinned 14 days after sowing to 6 plants/pot. Number of established seedlings/pot and seedling fresh weight were recorded 31 days after sowing.

3.7.4 RESULTS

3.7.4.1 Agil

There was no effect of post emergent application of Agil on sesame seedling number or fresh plant weight (Table 3.7.1).

3.7.4.2 Lentagran

Sesame seedlings were affected by Lentagran (Table 3.7.2). Though numbers were not reduced at 31 days after sowing, seedling death would have occurred if the experiment had continued.

Seedling weights for all treatment levels, except 2 L/ha, were reduced compared to the control. Plants affected by Lentagran developed leaf scorch.

3.7.5 DISCUSSION

Agil did not induce phytotoxic symptoms in sesame. Hence future herbicide research will include Agil at various rates to determine its effectiveness to control local grass species. Another possibility to be evaluated is the use of Agil as a pre-emergent herbicide.

Lentagran induced phytotoxic symptoms in sesame. If Lentagran was to be included in future herbicide studies, application rates of less than 2L/ha should be used.

TABLE 3.7.1: Effect of Agil on sesame seedlings at 31 days after sowing

RATE OF AGIL APPLICATION (L/ha)	AVERAGE NUMBER OF PLANTS/POT	AVERAGE PLANT WEIGHT (g)
0	5.6	0.07
1	6.0	0.07
2	6.0	0.08
4	6.0	0.07
8	6.0	0.07
Level of significance	N.S.	N.S.

TABLE 3.7.2: Effect of Lentagran on sesame seedlings at 31 days after sowing

RATE OF AGIL APPLICATION (L/ha)	AVERAGE NUMBER OF PLANTS/POT	AVERAGE PLANT WEIGHT (g)
0	6.0	0.10
1	6.0	0.05
2	5.8	0.08
4	5.8	0.06
8	6.0	0.05
Level of significance	N.S.	*
LSD (5%) =	-	0.03
CV (%) =		37.3

3.8 REFERENCES

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3.9 SESAME APPENDIX

Irrigation scheduling for the irrigated sesame herbicide and fertiliser experiments.

Scheduling was based on daily recordings of rainfall and pan evaporation. Pan evaporation was converted by a crop factor to evapotranspiration. If the available soil moisture reached 104 mm/m of soil profile, approximately 25 mm of irrigation was applied.

Background information

1. Tippera clay loam with an available soil moisture of 139 mm/m of soil profile.

2. Sesame cv. Yori 77 reaches maximum light interception (maximum foliage projected cover) approximately 46 d.a.s. (Ninety percentage foliage cover occurring 35 d.a.s.)

3. Assuming evapotranspiration and foliage projected cover are linked, the following crop factors were used to modify evaporation.

DAYS AFTER PLANTING	CROP FACTOR
35 - 45	0.9
46 - 67	1.0

4. No supplementary irrigation was applied after 67 d.a.s.

IRRIGATION SCHEDULING SESAME - HERBICIDE & FERTILISER STUDY

DATE	D.A.S.	RAIN (irrigation) (mm)	PAN. EVAP. (mm)	CROP FACTOR	EVAPOTRANS (mm)	AVAILABLE SOIL MOIST. (mm/m)
4th February	Estimate from gravimetric moisture profiles					86.3
5th	35	(32.0)	3.9	0.9	3.50	114.8
6th	36	-	6.1	0.9	5.49	109.3
7th	37	48.0	7.1	0.9	6.39	139.0(f)
8th	38	-	6.0	0.9	5.40	133.6
9th	39	-	5.0	0.9	4.50	129.1
10th	40	36.0	5.9	0.9	5.31	139.0(f)
11th	41	53.2	1.4	0.9	1.26	139.0(f)
12th	42	49.4	7.0	0.9	6.30	139.0(f)
13th	43	1.4	5.0	0.9	4.50	139.0(f)
14th	44	-	1.8	0.9	1.62	137.4
15th	45	-	4.6	0.9	4.15	133.2
16th	46	-	5.7	1.0	5.70	127.5
17th	47	(10.0)	6.5	1.0	6.50	131.0
18th	48	-	5.9	1.0	5.90	125.1
19th	49	(14.0)	5.7	1.0	5.70	133.4
20th	50	18.6	7.3	1.0	7.30	139.0(f)
21st	51	2.4	7.4	1.0	7.40	139.0(f)
22nd	52		4.7	1.0	4.70	134.3
23rd	53		3.6	1.0	3.60	130.7
24th	54		5.8	1.0	5.80	124.9
25th	55		6.5	1.0	6.50	118.4
26th	56		6.4	1.0	6.40	112.0
27th	57		6.9	1.0	6.90	105.1
28th	58	(25.0)	5.8	1.0	5.80	124.3
29th	59		7.3	1.0	7.30	117.0
1st March	60		7.5	1.0	7.50	109.5
2nd	61		5.7	1.0	5.70	103.8
3rd	62	(20.0)	6.7	1.0	6.70	117.1
4th	63		6.5	1.0	6.50	110.6
5th	64		5.8	1.0	5.80	104.8
6th	65		5.0	1.0	5.00	99.8
7th	66	3.0	7.0	1.0	7.00	95.8
8th	67	(28.0)	5.5	1.0	5.50	118.3

(f) greater than field capacity.

4.1 POTENTIAL OF PIGEON PEA IN THE NORTHERN TERRITORY

4.1.1 ABSTRACT

Pigeon pea varieties, QPL 702, QPL 131, QPL 67 and cultivar Quantum were evaluated at CSIRO in the 1987/88 wet season.

Phenology of pigeon pea indicated QPL 702 was the earlier variety and QPL 67 the later variety. Generally 50% of pigeon pea plants were flowering 69 days after sowing and had complete flowering 95 days after sowing. For rainfed conditions in the 1987/88 season, average plant height and seed yield was 112cm and 590 kg/ha. Under supplementary irrigation average plant height and seed yield increased to 131 cm and 1494 kg/ha. Pigeon pea did not produce economically viable seed yields under rainfed conditions in the 1987/88 season. However, it is generally expected that in 4 out of 5 years rainfall would exceed 1987/88 rainfall total. The supplementary irrigated seed yield figures are the more appropriate as they reflect pigeon pea seed yield for an average wet season.

4.1.2 INTRODUCTION

Pigeon pea is considered a potential crop for the region between Katherine and Daly Waters. During the 1986/87 wet season research identified 3 potential varieties for the Northern Territory. They were QPL 702, QPL 313 and QPL 67. Characteristics used to select these varieties were seed yield, seed size and colour, and resistance to Heliothis caterpillars.

The economics of growing dry-land pigeon pea indicated that the break even yield for $220/tonne of seed is 1200 kg/ha. An irrigated crop would need to produce a higher yield cover to irrigation costs.

For the development of a pigeon pea industry to proceed these 3 potential cultivars would need to satisfy both the market requirements (large, spherical pale seed) and farm economics.

A study was initiated in the 1987/88 wet season to evaluate 3 experimental and 1 commercial variety under rainfed and supplementary irrigation conditions.

4.1.3 MATERIALS AND METHODS

4.1.3.1 Seasonal Conditions

The 1987/88 wet season started with initial good rains in November and December. January rainfall was well below average, while February rainfall returned to normality. The wet season finished in the 1st week of March (Table 3.1.1). Total rainfall for November to April was 673.6 mm. The probability of such a low rainfall occurring is 1 in 5 years.

4.1.3.2 Design, Treatments and Management

There were 2 experiments, the first grown under rainfed conditions and the second grown under supplementary irrigation.

In each experiment the design was a randomised complete block of 4 varieties with 4 replications. The varieties were QPL 702, QPL 131, QPL 67 and cultivar Quantum.

Plot size was 6 rows, each 36 cm apart by 1.5 m long. Sowing was with a cone seeder at a depth of 2 - 3 cm. Variety germination was variable and seeding rate was adjusted in order to obtain a plant population of 250,000/ha. Seed was inoculated with cowpea (group I) inoculum.

The experiment was sown on January 1, 1988.

Supplementary irrigation was applied 7 times commencing 9 d.a.s. with the last application 77 d.a.s. Scheduling was based on evapotranspiration and available soil moisture (Pigeon Pea appendix).

4.1.3.3 Recordings and Data Collection

Dates of various phenological occurrences were recorded. These included date of first flower, date of 50% plants flowering, completion of flowering and date of physiological maturity (95% of pods brown).

At physiological maturity, pigeon pea plant population and seed yield were measured by sampling the centre 6 rows x 1 m. Samples were threshed and sub samples set aside for 100 seed weight determinations.

Ten plants were selected for yield component analysis; plant height, height of lowest pod and number of pods were measured.

4.1.4 RESULTS

4.1.4.1 PHENOLOGY

QPL 702 was generally the earlier to flower while QPL 67 was later.

4.1.4.1.1 Rainfed:

Varieties were significantly different in time to 50% plants flowering and completion of flowering (Table 4.1.2). There was no difference in cultivar phenology for time to first flower and physiological maturity. First flower occurred 51 d.a.s. and physiological maturity was 121 d.a.s.

4.1.4.1.2 Irrigated:

Varieties were significantly different in time to first flower, 50% plants flowering and completion of flowering (Table 4.1.3). There was no difference in time to physiological maturity; average time to physiological maturity was 114 d.a.s.

4.1.4.2 PLANT POPULATION

4.1.4.2.1 Rainfed:

There was no variation in pigeon pea population between cultivars; average population was 189,000 plants/ha (Table 4.1.4).

4.1.4.2.2 Irrigated:

Variety QPL 131 was significantly lower in population than the other 3 varieties, by approx. 48,000 plants/ha (Table 4.1.4). This variation in population would not have influence QPL 131 yield as pigeon pea is able to successfully compensate for this difference. Average pigeon pea population was 193,000 plants/ha.

4.1.4.3 SEED YIELD

4.1.4.3.1 Rainfed:

There was no difference between cultivars in seed seed yield (Table 4.1.5). Average pigeon pea yield was 590 kg/ha.

4.1.4.3.2 Irrigated:

Quantum and QPL 702 yields were significantly higher than for the other 2 varieties (Table 4.1.5). Yields ranged from 1730 kg/ha to 1214 kg/ha for QPL 702 and QPL 131 respectively.

4.1.4.4 100 Seed Weight

Variety QPL 702 was significantly heavier than all other varieties in both experiments (Table 4.1.6). Average 100 seed weight for all varieties was 9.4 and 9.6 gm for the rainfed and irrigated experiments respectively.

4.1.4.5 Plant Structure

For both experiments, varieties were significantly different in plant height and height of lowest pod (Table 4.1.7 and 4.1.8).

Average plant height and height of lowest pod was 112 cm and 100 cm versus 131 cm and 112 cm for rainfed and irrigated experiments respectively. Average number of pods/plant was 13.0 and 28.6 for the rainfed and irrigated experiment. Varieties were not significantly different within each experiment (Table 4.1.7 and 4.1.8).

4.1.5 DISCUSSION

For the development of a pigeon pea industry to proceed, the cultivar chosen for Northern Territory conditions will need to have large, spherical pale coloured seed. This crop would need to produce at least 1200 kg/ha under rainfed conditions, and higher seed yields under supplementary irrigation.

This season, rainfall for November to April was 673.6 mm. Normally such a low rainfall figure occurs once in 5 years. Total "rainfall" for the supplementary irrigated experiment was 845.8 mm. This being just below average rainfall for Katherine. Hence, the seed yield figures for pigeon pea under supplementary irrigated conditions indicated a possible 'average' outcome of dry land pigeon pea cropping. Only QPL702 produced seed yields comparable to Quantum.

Quantum and QPL702 seed yields ranged between 1600 and 1700 kg/ha. This is 400 - 500 kg/ha greater than the require break even yield. The probability that these seed yields are obtained is 1 in 2 years.

TABLE 4.1.1: Monthly rainfall (mm), November - May, for 1987/88 wet season at CSIRO, Katherine

MONTH	EXPERIMENT		LONG TERM AVERAGE
	RAINFED	IRRIGATED	
November	145.0	145.0	83.3
December	206.0	206.0	191.6
January	82.8	131.8	228.6
February	214.3	240.3	210.2
March	22.3	120.3	162.7
April	2.4	2.4	32.8
May	0.0	0.0	5.1
TOTAL	673.6	845.8	914.3

[1]Long term average for C.S.I.R.O., Katherine

TABLE 4.1.2: Phenology (d.a.s.) of rainfed pigeon pea.

VARIETY	FIRST FLOWER	50% PLANTS FLOWERING	COMPLETION FLOWERING	PHYSIOLOGICAL MATURITY
Quantum	51	65	97	121
QPL 702	51	66	91	119
QPL 67	52	72	98	124
QPL 131	53	71	96	119
Level of significance	N.S.	*	*	N.S.
LSD (5%)	-	5	5	-
CV (%)	-	4.4	3.0	-

TABLE 4.1.3: Phenology (d.a.s.) of irrigated pigeon pea.

VARIETY	FIRST FLOWER	50% PLANTS FLOWERING	COMPLETION FLOWERING	PHYSIOLOGICAL MATURITY
Quantum	52	65	95	115
QPL 702	52	63	90	112
QPL 67	58	70	98	117
QPL 131	56	68	94	113
Level of significance	**	**	**	N.S.
LSD (5%)	2	2	2	-
CV (%)	2.6	1.9	1.5	-

TABLE 4.1.4: Pigeon pea population (x 1000/ha) for the rainfed and irrigated experiments

VARIETY	EXPERIMENT	
	RAINFED	IRRIGATED
Quantum	178	196
QPL 702	181	189
QPL 67	202	217
QPL 131	194	169
AVERAGE	189	193
Level of significance	N.S.	*
LSD (5%) =	-	30
CV (%) =	-	9.5

TABLE 4.1.5: Pigeon pea yield (kg/ha) for the rainfed and irrigated experiment

VARIETY	**EXPERIMENT**	
	RAINFED	**IRRIGATED**
Quantum	606	1643
QPL 702	648	1730
QPL 67	454	1390
QPL 131	653	1215
AVERAGE	590	1494
Level of significance	N.S.	*
LSD (5%) =	-	282
CV (%) =	-	11.6

TABLE 4.1.6: Pigeon pea 100 seed weight (g) for the rainfed and irrigated experiments

VARIETY	RAINFED	EXPERIMENT IRRIGATED
Quantum	8.9	9.1
QPL 702	10.8	11.1
QPL 67	8.7	8.9
QPL 131	9.2	9.2
AVERAGE	9.4	9.6
Level of significance	**	**
LSD (5%) =	0.7	0.8
CV (%) =	4.4	5.0

TABLE 4.1.7: Pigeon pea plant characteristics for rainfed experiment

VARIETY	PLANT HEIGHT (cm)	HEIGHT OF LOWEST POD (cm)	NUMBER OF PODS/PLANT
Quantum	107	97	14.9
QPL 702	97	86	9.6
QPL 67	118	106	11.6
QPL 131	126	110	15.8
AVERAGE	112	100	13.0
Level of significance	**	**	N.S.
LSD (5%) =	4	8	-
CV (%) =	2.3	38.4	-

TABLE 4.1.8: Pigeon pea plant characteristics irrigated experiment

VARIETY	PLANT HEIGHT (cm)	HEIGHT OF LOWEST CAPSULE (cm)	NUMBER OF PODS/PLANT
Quantum	132	114	28.9
QPL 702	109	88	32.1
QPL 67	14	123	25.8
QPL 131	140	122	27.8
AVERAGE	131	112	28.6
Level of significance	**	**	N.S.
LSD (5%) =	5	7	-
CV (%) =	2.1	16.9	-

4.2 PIGEON PEA APPENDIX:

Irrigation scheduling for the irrigated pigeon pea experiment Scheduling was based on daily recording of rainfall and pan evaporation. Pan evaporation was converted by a crop factor to evapotranspiration. When the available soil moisture reached 104 mm/m of soil profile, approximately 25 mm of irrigation was applied.

Background information

1. Fenton clay loam with an available soil moisture of 139 mm/m of soil profile.

2. Pigeon pea reaches maximum light interception (maximum foliage cover) approximately 64 d.a.s.

3. Assuming evapotranspiration and foliage cover are linked, the following crop factors were used to modify pan evaporation.

DAYS AFTER SOWING	CROP FACTOR
01 - 19	0.4
20 - 26	0.5
27 - 34	0.6
35 - 48	0.7
49 - 55	0.8
56 - 63	0.9
64 - 77	1.0

4. No supplementary irrigation was applied after 77 d.a.s.

DATE	D.A.S.	RAIN (IRRIGATION) (mm)	PAN EVAP. (mm)	CROP FACTOR	EVAPOTRANS (mm)	AVAILABLE SOIL MOIST. (mm/m)
16	46		5.7	0.6	3.99	130.5
17	47		6.5		4.55	126.0
18	48		5.9		4.13	121.8
19	49		5.7	0.8	4.56	117.3
20	50	18.6	7.3		5.84	130.0
21	51	2.4	7.4		5.92	126.5
22	52		4.7		3.76	122.8
23	53		3.6		2.88	119.9
24	54		5.8		4.64	115.2
25	55		6.5		5.20	110.0
26	56	(26.0)	6.4	0.9	5.76	130.3
27	57		6.9		6.21	124.1
28	58		5.8		5.22	119.0
29	59		7.3		6.57	112.3
1 March	60		7.5		6.75	105.5
2	61		5.7		5.13	100.4
3	62	(20.0)	6.7		6.03	114.4
4	63		6.5		5.85	108.5
5	64		5.8	1.0	5.80	102.7
6	65		5.0		5.00	97.7
7	66	3.0	7.0		7.00	93.7
8	67		5.5		5.50	88.2
9	68		6.2		6.20	82.0
10	69		7.0		7.00	75.0
11	70	(30.0)	6.7		6.70	98.3
12	71	(20.0)	6.6		6.60	111.7
13	72		6.8		6.80	104.9
14	73		8.0		8.00	96.9
15	74		6.7		6.70	90.2
16	75		7.5		7.50	82.7
17	76		7.0		7.00	75.7
18	77	1.2(28.0)	7.3		7.30	97.6