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DEVELOPMENT OF SESAME CULTIVARS FOR NORTHERN AUSTRALIA

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FOR NORTHERN AUSTRALIA

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SUSTAINABLE AGRICULTURE

THE DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES IS COMMITTED TO THE PRINCIPLES AND PRACTICES OF SUSTAINABLE AGRICULTURE

Definition:

Sustainable agriculture is the use of practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities.

Principles:

1. Agricultural productivity is sustained or enhanced over the long term.
2. Adverse impacts on the natural resource base of agricultural and associated ecosystems are ameliorated, minimised or avoided.
3. Harmful residues resulting from the use of chemicals for agriculture are minimised.
4. The nett social benefit (in both dollar and non-dollar terms) derived from agriculture is maximised.
5. Agricultural systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

FOREWORD

This project was supported by Rural Industry Research and Development funds

DEVELOPMENT OF SESAME CULTIVARS FOR NORTHERN AUSTRALIA

(i) Summary:

Commercial sesame production in the Northern Territory over the past 6 years has proven the crop to be well adapted and economically viable. Grain merchants have been seeking additional supplies of sesame but expansion of production has been constrained due to plant genetic impurity of seed and unavailability of effective registered herbicides.

During the last 3 years numerous sesame genotypes have been evaluated over a range of cropping areas in the Northern Territory. A new high yielding sesame genotype that is less susceptible to lodging and disease has been identified and its seed multiplication has commenced. Adoption of the new sesame cultivar will be completed by the 1994/95 season.

Concurrently 2 herbicides, metolachlor and trifluralin, were evaluated for their suitability and effectiveness at weed control in sesame. Both herbicides will achieve limited use registration for application on sesame in the Northern Territory during 1993/94 season. Preparation of a submission to the Australian Agricultural and Veterinary Chemicals Council is underway.

(ii) Background:

Australia imports $8 million per year of sesame. Sesame is well adapted to the semi-arid tropics and an embryonic industry has been established in the Northern Territory.

However the current commercial cultivar contains numerous phenological and physiological off-types. The variation in the maturity of these off-types makes the decision of when to harvest difficult, and exacerbates harvesting losses. However some of these 'off-types' have desirable characteristics, eg. higher yield potential and disease tolerance, which if selected would provide superior genetic material which would assist in developing a the sesame industry in northern Australia.

Weeds can cause serious yield and quality losses in sesame. Prior to 1990 alachlor was used for weed control but it has now been withdrawn from the market. Since there are no herbicides registered for use in the Northern Territory it is important for the development of the industry that suitable herbicides be identified and registered.

(iii) Objectives:

(a) To identify and multiply pure sesame genotypes suitable for northern Australia.

(b) To identify herbicides for weed control in sesame and undertake the appropriate steps to register these products in the Northern Territory.

(iv) Introductory technical information:

Cultivar improvement

A description of the current commercial sesame cultivar (Yori 77) and the improvements selected for in the new superior genotype are detailed in Table 1 (page 12). Criteria marked with an asterix were given high priority for selection.

The new lines were assessed on the following criteria:

1. *Seed yield*

   The new superior genotype needs to produce a 10% increase in seed yield compared to Yori 77.

2. *Seed quality*

   The new superior genotype must maintain (and possibly improve) seed quality. Seed quality regulates unit value of the seed. Yori 77 generally produces export quality seed for the most demanding market, Japan. High quality seed is generally also needed for the confectionary trade.

3. *Plant morphology*

   The new superior genotype requires to be more suitable for mechanised agriculture, more efficient in seed production and better adapted to Northern Territory cropping practices. The new superior genotype should also be less prone to seed losses through shattering.

4. *Resistance to pest, diseases and lodging*

   The new superior genotype must be less susceptible to pests, diseases and lodging.

Weed control

A legal requirement for herbicide use by farmers is that the herbicide be approved for that use by the National Registration Authority. This requires data collected from experiments carried out at different sites in different years. Since the potential herbicide market is small, chemical companies will not do this work which means chemical weed control in sesame is predicated on DPIF doing the work.

(v) Research methodology:

Cultivar improvement

Single plants which exhibited desirable morphological characteristics were selected from local sesame crops; progeny from these plants were further selected to obtain uniform lines which were then evaluated; later the best of these lines were compared with Yori 77 at 3 sites representing the range of environments in which sesame is grown in the Northern Territory. The sites were Douglas Daly Research Farm (DDRF), Katherine Research Station (KRS) and Western Creek Station (WC). Site and soil fertility data is presented in Figure 2 (page 22) and Table 2 (page 13), and Table 3 (page 13) respectively.

Experimental design was a randomised complete block with 4 replications. Plot size was 8 rows x 5.0 m, with the row spacing 32 cm. The evaluation of the superior genotypes was conducted over 3 years, 1990/91 (91), 1991/92 (92) and 1992/93 (93) wet seasons. Environmental data is presented in Table 4 (page 14). The sesame genotypes were assessed on the four criteria mentioned in section (v).

A list of sesame genotypes and years of evaluation are presented in Table 5 (page 15). Any genotype discarded during this experiment was replaced by a new field selection.

All sites were conventionally prepared. Fertiliser and herbicide applications are presented in Tables 6 and 7 (page 16) respectively. Experiments were sown on the first suitable rainfall event in January. Dates of sowing are present in Table 7. Plants were thinned at 14 days after sowing (DAS) to an intra-row spacing of 10 cm (an equivalent to 300 000 plants/ha). Insects were controlled with applications of endosulphan @ 2.0 L/ha when required.

Weed control

Experiments were conducted at DDRF and KRS similar to those described above. That is, they were randomized complete blocks with 3 or 4 replicates, sown with the same machinery and grown in the same seasons. Treatments were as follows:
1990/91 KRS: 0, 1, 2, and 4 L ha^{-1} of Dual® (720 g L^{-1} metolachlor).
1991/92 KRS, DDRF: 0, 1, 2, and 4 L ha^{-1} of Dual® and trifluralin (400 g L^{-1} trifluralin); 1.6, 3.2, and 6.4 L ha^{-1} Yield® (125 g L^{-1} each of trifluralin and oryzalin).

1992/93 KRS:
Crop treatments:
- Crop only
- Weed only
- Unweeded
- Weeded for 25 days after planting
- Weeded for 33 days after planting

Herbicide treatments:
- Dual® (720 g L^{-1} a.i.)
  - 1 L ha^{-1}
  - 2 L ha^{-1}
  - 4 L ha^{-1}
- Trifluralin (400 g L^{-1} a.i.)
  - 1 L ha^{-1}
  - 2 L ha^{-1}
  - 4 L ha^{-1}

Trifluralin CR® (260 g L^{-1} a.i.)
1 L ha^{-1}
2 L ha^{-1}
4 L ha^{-1}

The crop treatments were included to study weed/crop competition.

(vi) **Results:**

Seasonal conditions

1990-91: At all sites, the 1990-91 season was characterised by good land preparation rains in November and December. This was followed by twice the monthly mean rainfall for January and February with a very low rainfall for March. Average rainfall were recorded for April (Table 4). Total rainfall at Douglas Daly, Katherine and Western Creek was 1257 mm, 1244 mm and 1034 mm respectively. Soils, were generally saturated for the months of January and February.

1991-92: At all sites, the 1991-92 season was characterised by very poor land preparation rains in November and December. In January the lack of suitable rainfall events for sowing sesame meant that the experiments were established with irrigation at Douglas Daly and Katherine. The Larrimah site was not sown. Average rainfall figures were recorded for February and were well below average rainfall for the rest of the wet season. Total rainfall at Douglas Daly, Katherine and Western Creek was 850 mm, 623 mm and 350 mm respectively (Table 4).

1992-93: At Douglas Daly and Katherine, the 1992-93 wet season was characterised by very good land preparation rains in November and December. At all sites for January, the lack of suitable rainfall events for sowing meant that the experiments were sown in late January. Rainfall for the end of January and February was above average. There were only isolated storms in March. Rainfall at Larrimah was isolated and well below average.

Total rainfall at Douglas Daly, Katherine and Western Creek Station was 1132 mm, 902 mm and 523 mm respectively (Table 4). These three seasons could be summarised as favourable, very poor and poor for sesame production.

Cultivar improvement

Data collected from the WC site was not included in the seed yield analysis of the new genotypes due to the experiment not being sown in 1991 and poor establishment in 1993.

Selection criteria

1. *Seed yield*

Statistical analysis of two combinations of sites/years/genotypes are presented in Tables 8 and 9 (pages 19 and 20).

All the new sesame genotypes evaluated demonstrated significantly higher yields than the commercial cultivar Yori 77. There was no significant difference in seed yield for the genotypes Y1:44, Y5:83, PA:45 and PB:64. Generally the more drought tolerant cultivars developed larger seed yields, Hnan Dun > Pachequino > Yori 77. Seed yield ranged between 1065 kg/ha and 1579 kg/ha.

2. *Seed quality*

Seed quality data is presented in Tables 10 and 11.

2.1 *1000 seed weight*

All the new sesame genotypes developed larger seed that Yori 77. Seed weight ranged between 2.9 to 3.2 g/1000 seeds for Hnan Dun, Pachequino and Yori 77, while the 1000 seed weight for the remaining genotypes ranged between 3.2 g to 3.5 g/1000 seeds. Seed weight greater than or equal to 3.2 g/1000 seed is required for the largest sesame importer - Japan.

2.2 *Oil content*

Seed oil content for all sesame genotypes ranged between 53.0% - 54.7%. No genotype developed oil contents greater than 55.0% which is considered ideal for oil extraction.

2.3 *Seed colour*

All genotypes produced white seed except Hnan Dun which generally produced greyish to brownish white seed. Bright white seed is preferred by the processors of sesame.

2.4 *Seed palatability*

All genotypes produced reasonable, nutty tasting seed. Hnan Dun was generally more acceptable, while Y5:83 generally develop a slightly musty after-taste.

2.5 *Seedling vigour*

Radicle extension at 48 hours was used as an indication of the genotypes ability to give good crop establishment since vigorous root development increases the chance of survival of the emerging seedling. Radicle extension was most vigorous in Yori 77 with a root length of 14-16 mm. The genotypes Y5:83 and PA:45 developed the smallest radicles after 48 hours, being only 9-11 mm.

2.6 *Germination at harvest*

The current commercial cultivar, Yori 77 produces seed with less than 10% dormancy, while the other sesame genotypes produced seed that range up to 40% dormancy. Seed dormancy at harvest is a desirable characteristic as it prevents seed from germinating in the capsule on the event of a late storm at maturity. This percentage of dormancy decreases as the seed ages during storage.

3. *Plant morphology*

Plant morphology data is presented in Tables 10 and 11 (pages 19 and 20).

3.1 *Plant height*

The current commercial cultivar, Yori 77, was the shortest in stature, being 116-127 cm tall. The other genotypes were up to 6 cm taller, though all were less than 150 cm in height. Cultivars greater than 150 cm in height make mechanical harvesting more difficult.

3.2 *Height of lowest capsule*

The new genotypes being evaluated for the height of lowest capsule ranged between Yori 77 (71-77 cm) and Hnan Dun (62-72 cm). Height of lowest capsule reflected time to first flower, with early flowering genotypes developing capsules closest to the ground. Capsules set lower on the stem allow a greater percentage of the stem for setting capsules and higher yield potential.

3.3 *Branches per plant*

Both Yori 77 and Hnan Dun exhibit a branching habit while the remaining genotypes were characterised as single-stem types for plant densities of 300 000 plants/ha. Branching is a desired characteristic for a shorter flowering period, high seed yield and evenness of maturity.

3.4 *Capsule length*

All sesame genotypes developed longer capsules than Yori 77 (24.4 mm), while Hnan Dun produced the longest capsule, 28.0-28.9 mm. A longer capsule reflects increased seed set per capsule.

3.5 *Capsule width*

The sesame cultivar Yori 77 developed capsules with the narrowest width (5.5 mm). Capsule width reflects seed size, that is genotypes with large seed having wider capsules. For genotypes with similar seed size, a narrow capsule width is preferred as it produces a 'tight' seed fit within the capsule which restricts seed losses from shattering.

3.6 *Apex gap of capsule*

Two genotypes Yori 77 and Y1:44 tended to dehisce less due to a smaller apex gap than the other genotypes evaluated. A smaller gap assists in minimising seed shattering losses. Apex gap of the capsule ranged between 6.6 mm and 7.8 mm.

3.7 *Seed weight/capsule weight ratio*

All genotypes produced higher seed weight/capsule weight ratios than Yori 77. Seed weight/capsule weight ratios ranged between 49.7% and 55.1%. The higher the ratio the more efficient the genotype is in distributing assimilate between seed and capsule wall.

3.8 *Harvest index*

All genotypes developed a higher harvest index than Yori 77. Harvest index ranged between 28.4% and 34.5%. The higher the harvest index the more efficient the genotype in distributing assimilates between vegetative and reproductive growth.

3.9 *Days to 50% plants flowering*

All genotypes reached 50% of plants flowering before Yori 77. Hnan Dun was always first to flower at 36-37 DAS.

4. *Resistance to diseases, insects and lodging*

The main diseases that attack sesame in the Northern Territory are the leaf diseases, *Corynespora cassiccola* and *Cercospora sesami* while the main insect pest is *Antigastra catalaunalis*. Data on resistance for the genotypes are presented in Tables 10 and 11.

4.1 *Diseases*

Three sesame genotypes Yori 77, Hnan Dun and Y5:83, were generally susceptible to leaf diseases. The genotypes Y1:44 and PB:64 were the least susceptible.

4.2 *Insects*

Susceptibility to capsule damage by insects ranged from extensive, (29% capsules damaged) for Pachequino to minimal, (8% capsules damaged) for Hnan Dun.

4.3 *Lodging*

The current commercial cultivar is very susceptible to lodging, while the other genotypes were not as susceptible to lodging.

<u>Weed control</u>

The important points with respect to herbicide use are their effects on the crop and their residual levels. In 1990/91, applications of Dual® from 1 to 4 L ha^{-1} had no effect on crop growth or seed yield and no chemical residues were detected in seed or stover. Levels up to 0.02 mg kg^{-1} were detected in the soil from the 2 and 4 L ha^{-1} treatments.

Results for seasons up to 1992/93 are shown in tables 12 to 17 (pages 23 to 25) and figure 2 (page 22).

(vii) Discussion:

Cultivar improvement

The development of a new sesame cultivar for northern Australia required that four criteria be met, namely, seed yield, seed quality, plant morphology and resistance to diseases, insects and lodging. Both seed yield and seed quality directly affect farm income, that is total crop value and unit value of sesame respectively. Seed quality characteristics were set to export standards to meet the requirements of the world's largest market (Japan). Plant morphological characters provide selection criteria for improved seed yield. Harvest index is the most important because of its high heritability and close relationship to seed yield. Morphological characters also affect mechanical harvesting and lodging.

The current commercial cultivar, Yori 77, has a potential seed yield of 1000-1200 kg/ha of export quality seed, (with its seed size generally a little too small for export). It's harvestability could be improved by reducing height at which the capsules are developed, however a major constraint to growing Yori 77 in northern Australia is its susceptibility to lodging and leaf diseases.

The new sesame genotype selected for northern Australia has incorporated some improvements in all four criteria. The genotype selected was Y1:44. Potential seed yields have been increased significantly, ie. up to 37% even under poor seasonal conditions. Seed quality has also been improved with an increase in seed size. The genotype PB:64 was discarded due to its small seed size in comparison to the other genotypes reviewed. The new genotype has maintained seed oil content, a white seed testa and palatablity similar to Yori 77. The genotype Y5:83 was discarded due to its greyish appearance and off flavour giving musty after-taste.

Radicle development in the new genotypes was found to be not as vigorous as Yori 77 but were not serious enough to be of economic importance, all genotypes except Yori 77 exhibited a high percentage of dormancy. Neither characteristic was considered critical to the selection of a new sesame genotype.

The other genotypes evaluated were generally 6 cm taller than Yori 77 and exhibited a single stem plant type at plant population pressures of 300 000 plants/ha. A branching plant type which is shorter in stature is considered ideal for mechanical harvesting and they generally have a shorter maturation period which reduces the risk of seed loss. The increased plant height of the new genotype is not considered to be so tall as to make mechanical harvesting difficult.

All the new genotypes flowered earlier than Yori 77 and hence set their capsules closer to ground. This allows plants to partition more assimilate to reproductive development than vegetative growth compared to Yori 77. The earlier time to flowering also allows a better fit between phenology and available growing season.

The new genotypes developed longer capsules that were slightly wider than Yori 77. The increased capsule width reflected an increase in seed size. All the sesame genotypes evaluated were dehiscent types, developing a similar apex gap as Yori 77. No genotypes had capsule characteristics that would minimise seed losses.

The sesame genotype Y1:44 was selected in preference to PA:45 due to its earlier flowering.

Weed control

Biomass and seed yield: Results in tables 12 to 15, and figure i, showed that metolachlor had no significant effect on seed yield and, in general, reduced the mass of grass weeds. It could safely be used, as Dual, up to 2 L ha^{-1}. Trifluralin, on the other hand, showed evidence of serious crop damage with no weed control, particularly on the sandy soil at DDRF (tables 13 and 14). Figure I, from the 1992/93 season illustrates the difference between the action of Trifluralin and Dual. The Dual, and Trifluralin CR points all lie on the regression line whereas the Trifluralin points all lie well below the line showing that Trifluralin, in contrast to the other 2 herbicides, has upset the mutually exclusive relationship between crop and weeds. Thus, Dual appears to be the safest and most reliable herbicide to use. Trifluralin CR requires further evaluation.

Herbicide residues: Residual levels in soil and seed are shown in tables 16 and 17. The only detectable level of metolachlor in seed was in 1992/93 at 4 L Dual ha^{-1}. Since this rate is much higher than would be used in practice residual levels in seed will not be a problem. Metolachlor levels in soil increased with increasing rate of application, but are quite low and pose no environmental problem. We intend to get approval from the Chemical Safety Unit of the Department of Health, Housing, Local Government & Community services for a Maximum Residue Limit (MRL) before approaching the NRA for an off-label permit. Trifluralin residues in seed were not detected at any rate of application of Trifluralin or Trifluralin CR. Trifluralin MRL's exist for oil seeds. Since our residues were less than these we intend to make application for an off- label permit. As with metolachlor, trifluralin residues in soil increase with increasing rate of application. The residues from Trifluralin CR are lower than those from Trifluralin because of the lower rate of active constituent applied.

(viii) Implications and recommendations:

Cultivar improvement

Farming areas in the semi-arid tropics of Western Australia and Northern Territory are expected to benefit from the release of this new genotype and there is a possibility it may be grown else where in Australia. The immediate benefit to the farmers in the Northern Territory will be increased and more stable farm income, through increased seed yield, quality, and yield stability.

The current area of sesame production in the Northern Territory is 200 ha valued at $100 000 while the value of Australian sesame imports is estimated at $8 million pa. It is anticipated that sesame production in northern Australia could expand within the next 5 years to 1000 ha, involving 5-8 producers and be valued at approximately $650 000 pa.

As initial commercial seed stocks of the new sesame cultivar will be produced by the DPI&F, and made available to industry at reasonable prices the availability and cost of seed will not be an impediment to widespread adoption of the new cultivar.

The new cultivar does not have the characteristics that minimise seed loss as the crop matures and pre-harvest losses may reach 40% of the total yield. New sesame breeding lines are available with capsule characteristics that would significantly reduce pre-harvest seed losses. A new project to breed lines with better capsule characteristics with recently identified cultivar selections has been supported by RIRDC.

Weed control

Adequate, cost effective weed control is fundamental to successful cropping systems. Our current work has merely identified herbicides that may be used to control mainly grass weeds in conventional tillage systems. With the trend towards minimum and no-till systems new herbicides need to be evaluated since neither metolachlor nor trifluralin perform well in these systems. In addition, there is a growing need for herbicides effective on broad leaf weeds. Since there is an environmental need to minimize herbicide use our recommendation for the future would be to continue the search for suitable herbicides for use on sesame, and to incorporate them into an integrated weed management package, a process which requires a knowledge of weed biology, herbicide effectiveness, economic loss due to weeds and, of course, research support and time.

Table 1 Selection criteria, components and genotype characteristics

Selection criteria		Commercial cultivar Yori 77	New genotype
1.	Seed yield *	1200 kg/ha	>1350 kg/ha
2.	Seed quality		
	2.1 1000 seed weight *	2.9 g	>3.2 g
	2.2 oil content *	54.3%	>55%
	2.3 seed colour	white	bright white
	2.4 seed palatability *	good	good
	2.5 seedling vigour	vigorous	vigorous
	2.6 germination at harvest	fresh	dormant
3.	Plant morphology		
	3.1 plant height	116 cm	<150 cm
	3.2 height of lowest capsule *	70 cm	<70 cm
	3.3 branches/plant	1.5	2
	3.4 capsule length	23.4 mm	>23.4 mm
	3.5 capsule width	5.3 mm	<5.5 mm
	3.6 apex gap of capsule	6.4 mm	<6.4 mm
	3.7 seed weight/capsule weight ratio	47.7%	>47.7%
	3.8 harvest index *	28.5%	>28.5%
	3.9 50% plants flowering *	43 DAS	<43 DAS
4.	Resistance to		
	4.1 diseases * *(Corynespora cassiicola)*	susceptible	tolerant
	(Cercospora sesami)	susceptible	tolerant
	4.2 insects * *(Antigastra catalaunalis)*	susceptible	tolerant
	4.3 lodging *	susceptible	tolerant

* Criteria given high priority

Table 2 Location of experiments

Site	**Location**	**Soil type**
Katherine Research Station (KRS)	14° 28'S, 132° 18'E	Fenton clay loam
Douglas Daly Research Farm (DDRF)	13° 51'S, 132° 12'E	Venn sandy loam
Western Creek Station (WC)	15° 35'S, 133° 13'E	Oolloo clay loam

Table 3 Soil nutrient status at KRS, WC and DDRF

Soil analysis (0-15cm)									
		KRS			**WC**			**DDRF**	
Year	**91**	**92**	**93**	**91**	**92**	**93**	**91**	**92**	**93**
Cond (ms/cm)	0.07	0.13	0.14	0.03	0.05	0.05	0.04	0.04	0.04
pH	7.1	7.1	6.5	6.5	5.9	6.9	6.8	7.3	6.2
Avail. P (ppm)	9	16	17	26	13	12	18	21	8
Avail. K (ppm)	353	365	350	106	145	147	69	46	91
Avail. Ca (ppm)	1253	1800	1260	424	370	454	320	470	218
Avail. Mg (ppm)	277	375	290	55	50	63	52	69	36
Avail. S (ppm)	16	8	12	7	5	12	2	2	3
Avail. Cu (ppm)	4.7	3.5	3.8	0.5	1.2	1.1	1.0	1.0	0.3
Avail. Zn (ppm)	1.6	1.5	1.8	1.5	2.9	2.5	1.3	2.2	0.2
Avail. Mn (ppm)	93	5	17	32	9	20	36	10	37
Avail. B (ppm)	0.4	0.2	0.2	0.3	0.1	0.2	<0.1	<0.1	<0.2
Total (N) %	0.12	0.11	0.18	0.06	0.04	0.05	0.02	0.03	0.03

Table 4 Rainfall, maximum and minimum temperatures at Katherine, Larrimah and Douglas Daly

	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Monthly rainfall (mm)									
DDRF	90/91	121.4	209.0	455.2	358.0	26.2	86.8	0.0	1256.6
	91/92	39.2	80.1	210.1a	357.9	134.8	22.6	5.4	850.1
	92/93	123.1	171.6	390.3	389.2	59.5	0.0	0.0	1133.7
KRS	90/91	82.2	264.7	454.7	417.6	4.7	25.2	0.0	1244.1
	91/92	106.2	97.5	77.4b	248.8	56.8	13.9	22.8	623.4
	92/93	116.4	136.3	371.2	239.3	39.0	0.0	0.0	902.2
WC	90/91	11.9	155.5	284.5	506.5	17.0	58.5	0.0	1033.9
	91/92	6.7	4.8	102.0	109.0	29.0	0.0	0.0	350.0
	92/93	22.0	97.3	221.1	173.0	9.9	0.0	0.0	523.3
Mean (1)		108.5	142.9	269.2	303.2	253.6	46.6	7.5	1131.5
Mean (2)		83.3	191.6	228.6	210.2	162.7	32.8	5.1	914.3
Mean (3)		63	115	205	186	149	32	12	762
Mean maximum daily temperature (°C)									
DDRF	90/91	38.7	34.6	32.5	31.5	35.1	33.6	32.0	
	91/92	37.3	41.1	38.2	36.7	35.0	33.6	34.4	
	92/93	N/A	37.5	35.2	33.7	36.6	37.2	36.0	
KRS	90/91	39.2	35.5	32.9	31.2	35.2	34.0	32.0	
	91/92	37.6	37.7	37.5	33.3	35.9	34.9	34.0	
	92/93	36.6	36.6	33.8	32.1	35.2	34.9	33.1	
WC	90/91	40.1	37.6	34.5	N/A	35.6	33.8	31.6	
	91/92	37.5	38.5	37.8	35.3	36.8	34.6	32.9	
	92/93	38.9	38.2	36.1	32.3	36.2	N/A	N/A	
Mean (1)		36.6	35.3	33.6	32.9	33.2	33.4	32.0	
Mean (2)		37.8	36.2	34.6	34.1	34.3	33.9	32.0	
Mean (3)		38.0	37.1	35.6	34.6	34.0	33.9	31.7	
Mean minimum daily temperature (°C)									
DDRF	90/91	23.7	23.9	23.9	23.9	22.4	20.7	15.0	
	91/92	23.9	22.6	22.6	22.6	23.1	21.7	19.7	
	92/93	N/A	23.3	23.6	24.0	23.2	21.0	20.4	
KRS	90/91	25.8	24.3	23.8	23.4	22.5	20.4	14.3	
	91/92	24.8	24.1	23.9	23.8	23.0	21.0	18.8	
	92/93	24.5	24.6	23.5	23.4	22.7	20.2	18.1	
WC	90/91	26.7	25.4	24.5	23.7	22.7	20.7	16.0	
	91/92	24.5	23.9	23.4	24.0	23.4	21.0	20.0	
	92/93	26.1	25.3	24.9	N/A	23.0	N/A	N/A	
Mean (1)		24.2	24.0	23.7	23.7	23.0	20.6	17.1	
Mean (2)		24.3	23.9	23.7	23.4	22.3	19.5	16.2	
Mean (3)		24.4	24.5	24.1	23.7	22.7	19.8	16.6	

Note: (a) does not include 48 mm of irrigation
(b) does not include 65 mm of irrigation

N/A not available

Table 5 Sesame genotypes and years evaluated

Sesame genotypes	Year evaluated 91	92	93	Comment
Yori 77[1]	*	*	*	Current cultivar, suitable for KRS and DDRF
Pachequino[1]	*	*	*	Alternative cultivar, suitable for KRS
Hnan Dun[1]	*	*	*	Alternative cultivar, suitable for WC and south
Y1:44	*	*	*	
PA:45	*	*	*	
P3:63	*			Discarded - medicore performance
DD:6	*			Discarded - susceptible to diseases
YA:69		*		Discarded due to lodging
Y5:83		*	*	
PB:64		*	*	
PA:40		*		Discarded - medicore performance
H:1			*	Discarded - susceptible to diseases
H:11			*	Discarded - too tall

Notes: [1] Standards

Table 6 Fertiliser applications

Site	Year	Basal fertiliser (kg/ha) N[1]	P[2]	K[3]	Zn	Cu	Top-dressing (kg/ha) N[4]
DDRF	91	20	18	50	2.2	2.2	60
	92	60	18	-	2.2	2.2	20
	93	-	11	25	-	-	60
KRS	91	67	18	-	3.3	4.0	-
	92	36	18	-	2.2	2.2	40
	93	41	14	-	-	-	28
WC	91	80	8	-	0.9	0.9	20
	92	experiment not sown					
	93	20	10	-	-	-	40

Notes:
[1] Urea (incorporated)
[2] Single superphosphate and trace elements
[3] Muriate of potash
[4] Urea (not incorporated)

Table 7

Site	Year	Weed control	Sowing date
DDRF	91	Hand weeding	18 January
	92	Hand weeding	10 January
	93	Trifluralin 0.48 kg a.i/ha	21 January
KRS	91	Metolachlor 0.72 kg a.i/ha[1] Glyphosate 0.90 kg a.i/ha[2]	16 January
	92	Metolachlor 0.86 kg a.i/ha[1] Glyphosate 0.90 kg a.i/ha[2]	11 January
	93	Metolachlor 1.08 kg a.i/ha[1]	17 January
WC	91	Glyphosate 0.90 kg a.i/ha[2] Hand weeding	12 January
	92	Experiment not sown	-
	93	Metolachlor 1.08 kg a.i/ha[1]	4 January

Glyphosphate 0.90 kg a.i/ha[2]

Notes: [1] Herbicide applied pre-plant not incorporated

[2] Spot spraying

Table 8 Mean seed yields

Sites	**Years**	**Genotypes**	**Seed yield (kg/ha)**
DDRF, KRS	92, 93	Yori 77	1065 a[1]
		Pachequino	1373 b
		Hnan Dun	1418 bc
		Y1:44	1526 cd
		PA:45	1538 cd
		Y5:83	1567 d
		PB:64	1579 d
LSD (5%)			241.6

Note: [1] Mean seed yields differ (P<0.05) if not followed by a common letter

Table 9 Mean seed yields

Sites	**Years**	**Genotypes**	**Seed yield (kg/ha)**
DDRF, KRS	91, 92, 93	Yori 77	1120 a[1]
		Pachequino	1239 a
		Hnan Dun	1248 a
		Y1:44	1441 b
		PA:45	1525 b
LSD (5%)			183.8

Note: [1] Mean seed yields differ (P<0.05) if not followed by a common letter

Table 10 Mean of characteristics for sesame lines evaluated for 2 years at DDRF and KRS

Characteristic	Yori 77	Pach-equino	Hnan Dun	PA:45	Y1:44	Y5:83	PB:64
1. Seed yield (kg/ha)	1065	1373	1394	1538	1567	1526	1579
2. Seed quality							
2.1 1000 seed weight (g)	2.9	3.2	3.2	3.3	3.4	3.5	3.2
2.2 oil content (%)	54.7	54.2	54.7	54.1	54.5	54.3	53.8
2.3 seed colour[1]	6.9	6.1	1.8	6.5	5.5	4.6	6.8
2.4 seed palatability[2]	4.8	6.0	4.5	5.8	6.0	8.0	5.8
2.5 seedling vigour (mm)[3]	16	13	14	10	11	9	14
2.6 seed dormancy, approx. (%)[4]	<10	30-40	30-40	30	30-40	20	30-40
3. Plant morphology							
3.1 plant height (cm)	127	133	132	134	131	131	133
3.2 height of lowest capsule (cm)	77	76	72	71	76	74	71
3.3 branches/plant	1.6	0.1	1.6	0.1	0.2	0.1	0.1
3.4 capsule length (mm)	24.4	27.4	28.9	26.8	26.7	26.4	26.4
3.5 capsule width (mm)	5.5	5.9	5.6	6.1	6.1	6.2	6.1
3.6 apex gap of capsule (mm)	6.8	7.4	7.8	7.3	6.8	6.9	7.3
3.7 seed weight/ capsule weight ratio (%)	49.7	54.0	54.4	52.8	55.1	54.8	52.9
3.8 harvest index (%)	28.4	32.6	30.8	33.3	34.5	34.3	33.3
3.9 50% plants flowering (DAS)	43	45	36	42	41	42	42
4. Resistance to							
4.1 diseases (%)[5]	5.5	4.0	6.0	3.5	3.0	6.0	3.0
4.2 insects (%)[6]	22	29	8	13	20	N.A[8]	N.A
4.3 lodging (%)[7]	80	20	30	30	30	30	30

Years of evaluation - 1991/92 and 1992/93

Notes:

1 Seed colour - 1 = grey brown, 10 = bright white
2 Seed palatability - 1 = pleasant nutty, 10 = bitter
3 Seedling vigour - radicle length at 48 hours
4 Seed harvested at maturity
5 Diseases - 1 = minor infection, 10 = severe leaf defoliation
6 Insects - percentage of capsules damaged
7 Lodging - percentage of plants lodged
8 N.A - not available

Table 11 Mean of characteristics for sesame lines evaluated for 3 years at DDRF and KRS

Characteristic	Yori 77	Pach -equino	Hnan Dun	PA:45	Y1:44
1. Seed yield (kg/ha)	1077	1331	1237	1349	1485
2. Seed quality					
2.1 1000 seed weight (g)	3.0	3.2	3.1	3.5	3.2
2.2 oil content (%)	53.8	53.5	54.5	53.0	53.9
2.3 seed colour[1]	6.6	6.7	1.9	6.0	7.0
2.4 seed palatability[2]	5.0	6.9	4.4	5.3	5.7
2.5 seedling vigour (mm)[3]	14	11	12	9	10
2.6 seed dormancy, approx. (%)[4]	<10	30-40	30-40	30	30-40
3. Plant morphology					
3.1 plant height (cm)	116	121	116	121	119
3.2 height of lowest capsule (cm)	71	68	62	66	72
3.3 branches/plant	1.5	0.2	1.4	0.1	0.1
3.4 capsule length (mm)	24.5	26.6	28.0	26.0	25.2
3.5 capsule width (mm)	5.5	5.9	5.7	6.0	5.8
3.6 apex gap of capsule (mm)	6.8	7.1	6.9	6.9	6.6
3.7 seed weight/ capsule weight ratio (%)	50.9	53.4	53.4	52.6	52.2
3.8 harvest index (%)	30.4	33.4	31.4	33.7	32.6
3.9 50% plants flowering (DAS)	46	46	37	42	42
4. Resistance to					
4.1 diseases (%)[5]	5.5	4.0	6.0	3.5	3.0
4.2 insects (%)[6]	22	29	8	13	20
4.3 lodging (%)[7]	80	20	30	30	30

Notes:

1 Seed colour - 1 = grey brown, 10 = bright white

2 Seed palatability - 1 = pleasant nutty, 10 = bitter

3 Seedling vigour - radicle length at 48 hours

4 Seed harvested at maturity

5 Diseases - 1 = minor infection, 10 = severe leaf defoliation

6 Insects - percentage of capsules damaged

7 Lodging - percentage of plants lodged

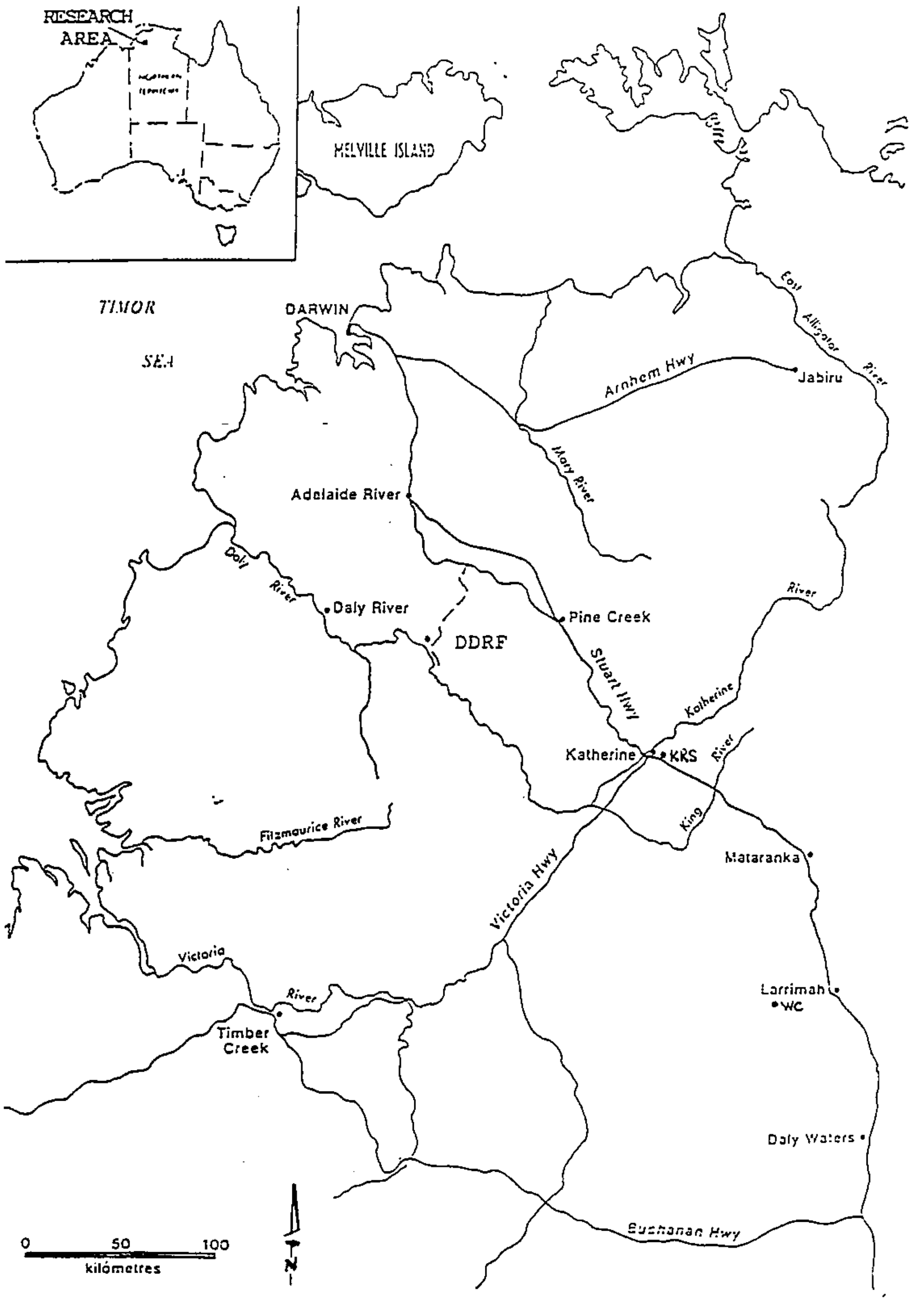

Figure 1 Location of Experiments

DDRF - Douglas Daly Research Farm
KRS - Katherine Research Farm
WC - Western Creek Station

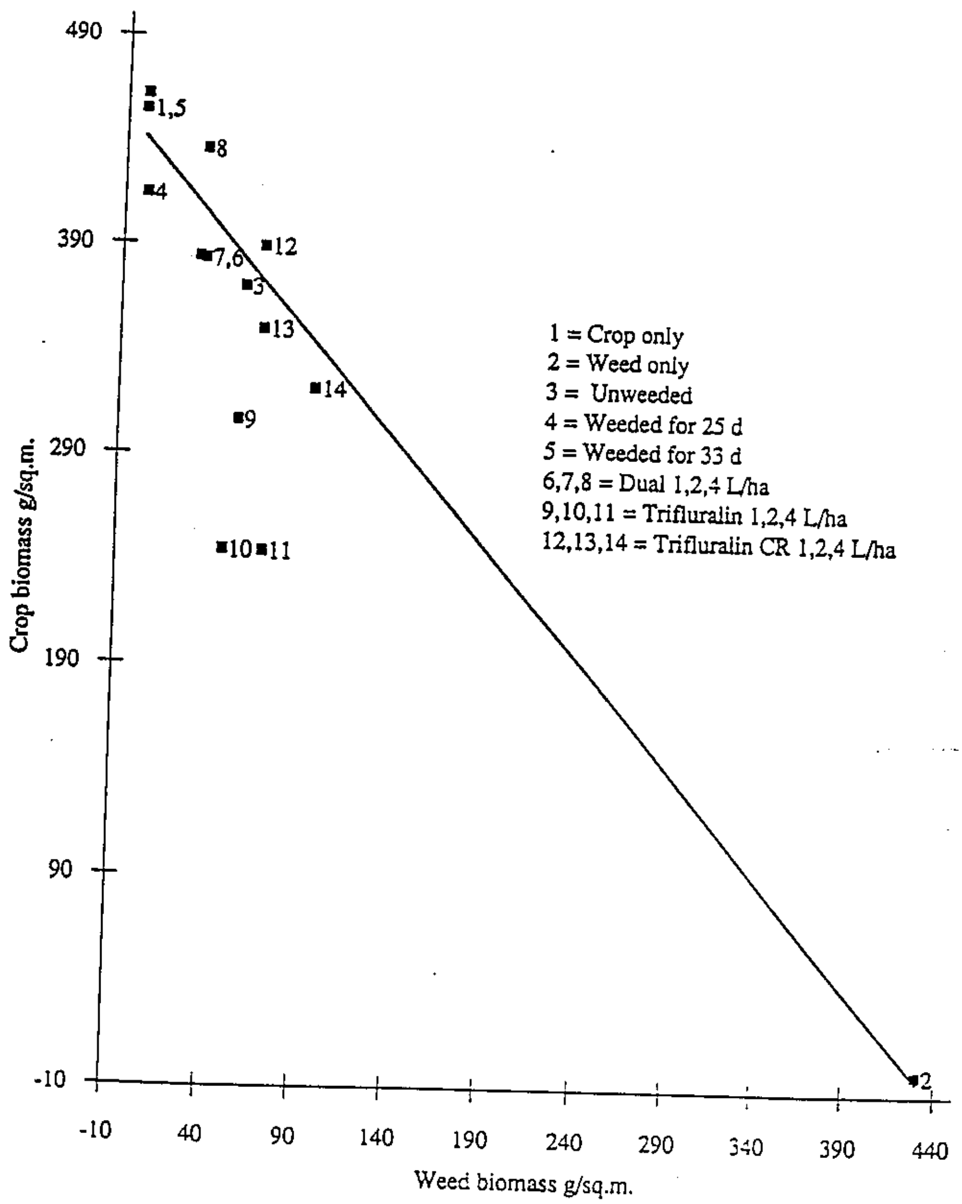

Figure 2. Relation between crop and weed biomass as affected by herbicides and hand weeding. The regression line is for treatments 1 to 5 and has an r^2 of 0.95.

Table 12. Effect of herbicides on weed and sesame yield at KRS 41 DAS in 1991/92.

Treatment	Population Density	Sesame biomass	Grass weeds	Legume weeds	Broad-leaf weeds	Total weed
L ha^{-1}	m^{-2}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	$\log_{10}$(kg ha^{-1})
Trifluralin 1	25.9	1663	54	95	99	2.39
Trifluralin 2	27.2	1524	26	49	53	1.99
Trifluralin 4	22.1	1482	11	42	126	2.06
Dual 1	27.4	1540	15	136	60	2.28
Dual 2	25.9	1534	0	109	19	1.51
Dual 4	21.0	1109	10	160	113	2.43
Yield 1.6	23.0	1307	15	109	9	1.57
Yield 3.2	21.7	1320	3	47	15	1.36
Yield 6.4	16.2	921	52	105	23	2.25
No herbicide	25.9	1466	58	187	111	2.51
Hand weeded	29.0	1657	0	0	0	0.00
LSD@P<0.05	5.1	350	35	ns	ns	0.82

Table 13. Effect of herbicides on weed and sesame yield at DDRF 42 DAS in 1991/92.

Treatment	Population Density	Sesame biomass	Grass weeds	Legume weeds	Broad-leaf weeds	Total weed
L ha^{-1}	M^{-2}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	$\log_{10}$(kg ha^{-1})	$\log_{10}$(kg ha^{-1})
Trifluralin 1	10.0	561	1	1	3.22	3.22
Trifluralin 2	8.6	602	0	4	3.18	3.18
Trifluralin 4	8.9	592	0	2	2.49	2.50
Dual 1	21.3	1503	0	3	2.46	2.46
Dual 2	17.4	1122	0	1	2.45	2.45
Dual 4	14.5	855	0	1	2.20	2.26
Yield 1.6	11.9	816	0	1	2.99	2.99
Yield 3.2	11.3	763	0	3	2.94	2.95
Yield 6.4	6.3	436	0	0	2.87	2.87
No herbicide	23.0	1152	2	0	3.19	3.19
Hand weeded	24.7	1621	0	2	0.00	0.00
LSD@P<0.05	53.5	405	ns	ns	0.81	0.82

Table 14. Effect of herbicides on weed and sesame yield at KRS and DDRF at final harvest in 1991/92.

Treatment	Population Density		Seed Yield	
	DDRF	KRS	DDRF	KRS
L ha^{-1}	m^{-2}	m^{-2}	kg ha^{-1}	kg ha^{-1}
Trifluralin 1	12.1	24.0	1667	1383
Trifluralin 2	11.2	24.7	1279	1114
Trifluralin 4	10.4	22.7	1074	1364
Dual 1	20.1	26.0	2000	1408
Dual 2	19.8	23.8	1734	1229
Dual 4	14.1	17.6	1770	1349
Yield 1.6	-12.2	24.7	1620	1358
Yield 3.2	11.7	21.9	1332	1119
Yield 6.4	8.3	2.9	1279	961
No herbicide	27.0	21.2	1605	1098
Hand weeded	3224.5	24.2	1579	1334
LSD@P<0.05	6.4	49.0	ns	ns

Table 15. Effect of herbicides on weed and sesame yield at KRS at final harvest in 1992/93.

Treatment	Population Density	Total Crop Biomass	Seed Biomass	Weed Biomass		
				Broad-leaf	Grass	Total
L ha^{-1}	m^{-2}	g m^{-2}	g m^{-2}	g m^{-2}	g m^{-2}	g m^{-2}
Crop only	60	454	69	0	0	0
Weed only	0	0	0	358	73	430
Crop, unweeded	56	371	42	35	21	56
Weeded for 25 DAS	53	414	59	1	1	2
Weeded for 33 DAS	53	462	66	1	0	1
Dual 1	68	384	54	33	2	34
Dual 2	43	385	51	30	1	31
Dual 4	41	436	80	32	1	33
Trifluralin 1	31	307	50	49	6	54
Trifluralin 2	19	245	50	32	15	48
Trifluralin 4	15	245	51	60	9	69
Trifluralin CR 1	42	390	64	58	8	66
Trifluralin CR 2	28	350	77	60	7	67
Trifluralin CR 4	22	322	64	92	3	95
LSD@P<0.05	19	93	23	28	22	37

Table 16. Residual levels in soil and seed of trifluralin and metolachlor at DDRF and KRS in 1991/92.

Treatment	DDRF		KRS	
	Soil[1]	Seed[1]	Soil	Seed
L ha^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
No herbicide (trifluralin)	-	0.008	-	0.002
Hand weeded (trifluralin)	ND	0.009	ND	0.001
No herbicide (metolachlor)	-	ND	-	ND
Hand weeded (metolachlor)	ND	ND	ND	ND
Trifluralin 1	0.006	0.011	0.002	0.001
Trifluralin 2	0.010	0.013	0.003	0.001
Trifluralin 4	0.036	0.011	0.015	0.001
Dual 1	0.009	ND	0.015	ND
Dual 2	0.028	ND	0.041	ND
Dual 4	0.039	ND	0.051	ND

1. Limits of determination were :
Metolachlor, 0.01 and 0.005 mg kg^{-1} for seed and soil respectively;
Trifluralin, 0.001 and 0.002 mg kg^{-1} for seed and soil respectively.
ND = < determination limit.
- = not done.

Table 17. Residual levels in soil and seed of trifluralin and metolachlor in 1992/93.

Treatment L ha^{-1}	Soil[1] mg kg^{-1}	Seed[1] mg kg^{-1}
Crop only (metolachlor)	-	ND
Unweeded (metolachlor)	0.010	-
Crop only (trifluralin)	-	ND
Unweeded (trifluralin)	0.001	-
Dual 1	0.019	ND
Dual 2	0.027	ND
Dual 4	0.054	0.010
Trifluralin 1	0.007	ND
Trifluralin 2	0.047	ND
Trifluralin 4	0.160	ND
Trifluralin CR 1	0.009	ND
Trifluralin CR 2	0.013	ND
Trifluralin CR 4	0.076	ND

1. Limits of determination were :
Metolachlor, 0.01 and 0.005 mg kg^{-1} for seed and soil respectively;
Trifluralin, 0.001 and 0.002 mg kg^{-1} for seed and soil respectively.
ND = < determination limit.
- = not done.