The species found in the most western areas typically occurred in small groups, were mainly sedentary and did not congregate at the crop. An exception was the red-winged parrot which did form feeding flocks, usually of 10 to 20 but occasionally up to 60. It was also quite mobile; one group observed flew about 10 km to feed on sunflower.

As well as showing differences in tendency to flock and in mobility the species differed in their feeding behaviour at the crop. The species which fed in groups, such as the galah, cockatoo and cockatiel, fed in sessions immediately after dawn and before roosting at dusk. The duration of feeding varied considerably but was usually from 1 to 2 hours with the morning session being slightly longer. For other parrots, notably all non-flocking species, feeding was not restricted to these times though it was minimal in the midday period.

Many of the smaller parrots were able to perch on the sunflower head or on the stalk and deftly extract individual kernels. However the galah and cockatoo commonly caused considerable head damage by removing bracts and large pieces of capitulum. These large species often bent or broke the stalks while perched and the cockatoo would occasionally remove an entire head. These types of excessive damage increase the average loss of seed per individual of the species. Broome (1979) estimated sunflower seed lost per bird to be about 55 g per day for cockatoos and 40 g per day.

DISCUSSION

The pest status of the parrots attacking sunflower crops is essentially a product of three non-independent factors: the tendency of the species to form flocks, the mobility and the feeding behaviour of individuals and of flocks. The most serious pests of sunflowers (and many other crops) tend to form large, well co-ordinated feeding aggregations, to be highly mobile locally and regionally, and to cause much damage per individual. These characteristics are shown by the galah in mid-north western N.S.W. as well as most of the important bird pests throughout the world (Ward and Zahavi, 1973).

The tendency to flock is of critical importance as it allows a large number of birds to efficiently locate and exploit sparcely distributed food resources. Prior to agricultural development this strategy allowed many parrot species to survive in regions of low variable rainfall where patches of grasses were the main food. With the advent of cropping in these areas, large areas of native grasses disappeared and were replaced by monocultures of highly attractive seeds. It is not surprising that the parrots began to use these crops for food and that those species pre-adapted to exploit the new food resource with the greatest efficiency became the major pests.

To date many attempts at management and mitigation of the bird pest problem have been predictably ineffective and expensive. The parrot species differ from each other sufficiently in their feeding and flocking behaviour for there to be no single simple method for preventing their feeding on sunflower crops. However the efficiency of management decisions should be improved if each locality is investigated individually with attention to the ecological characteristics of the main pest species.

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AN INNOVATION IN THE CONTROL OF GALAHS, *CACATUA ROSEICAPILLA*, AND SULPHUR-CRESTED COCKATOOS, *CACATUA GALERITA*, IN SUNFLOWER.

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ABSTRACT

In eastern Australia, damage to sunflower by granivorous birds constitutes a major production problem. Methods of improving uniformity of head-height and evenness in plant density are encouraged. These practices, together with shooting and the use of recorded distress calls are currently the most useful in the mitigation of bird damage. A new method of bird control was explored based on the observation that galahs and cockatoos prefer crops, and locations in crops, that provide feeding birds with a maximum degree of horizontal vision. A three metre border of tall-growing forage sorghum was grown around each of two 40 hectare irrigated sunflower crops in the Boggabri area of New South Wales. This visual screen unsettled the birds' feeding behaviour and resulted in an 85% reduction in predicted seed loss to birds. Similar reduction in the time and cost of patrolling the crop was also achieved. Severe damage was restricted to those areas of sunflower immediately opposite "holes" in the screen where the sorghum had not germinated. In both screened trial sites, estimated bird damage was less than 5% of yield. With more intensive use of vegetative screens it is predicted that traditional bird controls will be more effective and loss of sunflower due to birds will be negligible.

INTRODUCTION

In the sunflower growing areas of New South Wales and Queensland, the sulphur-crested cockatoo, *Cacatua galerita,* and the galah, *C. roseicapilla,* regularly destroy many hectares of sunflower annually. While there are some 15 parrot species that attack sunflower in these two states, only the two *Cacatua* species (and occasionally the quarrion, *Nymphicus hollandicus*), assume economic importance.

There are two critical factors which predestine the cockatoo species to be of economic importance: (i) cockatoos are large birds with destructive feeding habits and (ii) these species roost and feed communally. Communal roosting and flock feeding are characteristics of all major bird pest-species throughout the world (Ward and Zahavi, 1973; Dyer and Ward, 1977). Cockatoo feeding behaviour is significant because these birds waste or destroy several times the amount they consume by; decapitating sunflower heads and dropping them without consuming all of the seed; causing sunflower stems to bend or break under their weight (many of these plants do not get harvested); and by providing infection sites for pathogens by damaging the sunflower head with their beaks and claws (Kochman, 1977).

Detailed surveys of the in-crop distribution of bird damage to Australian sunflower, (Bennett, 1978; Broome *et al.*, 1979), show that these birds have distinct preferences for certain crop attributes. These preferences are: crops of uneven head-height; low or uneven plant densities; crops that are relatively small with irregular margins; and crops that are surrounded by trees, fences and powerlines (de la Motte, 1977; Bennett, 1978). All these crop attributes are similar in that each provides feeding birds with good horizontal visability. Past bird control recommendations have advocated all mechanical and chemical methods of producing dense crops of even head-height and the removal or avoidance of those features like trees, fences, powerlines etc., which predispose crops to bird damage. These recommended methods reduce the crops' susceptibility to bird attack through habitat manipulation by altering the crop environment. Habitat manipulation has long been recognised as an effective, efficient technique for controlling pests (Wright, 1968).

In the 1980/1981 season, a new method of habitat manipulation was investigated based on the observation that birds have a distinct preference for crops, and locations in crops that provide feeding birds with a maximum degree of horizontal vision. The objective was to produce a "screen" or visual barrier around the sunflower crop that would prevent horizontal vision out of the crop.

The results of these preliminary investigations in the 1980/1981 season are reported in this paper.

MATERIALS AND METHODS

A vegetation screen was selected because the cost of purchase, construction and maintenance of a man-made material screen would be too expensive. A three metre strip of forage sorghum (four rows, one metre apart) was found to provide an effective visual barrier under irrigation. As a consequence of the severe drought in the 1980/1981 season only two irrigated, screened crops were grown, both in the Boggabri area of New South Wales.

The first trial was sown in two adjacent 40 ha blocks (referred to as block 1A and 1B) in October 1980. The sunflower cultivar used was Hysun 31 which was planted first, along with a pre-emergent herbicide. The forage sorghum, Sudax ST6 was sown around the crop immediately afterwards (without the herbicide) at a rate of 4 kg/ha. Additional "screens" were sown either side of a fenceline and an elevated head-ditch within the crop. The sunflower crop was of a good uniform population of 50,000 plants per hectare. The screen varied, however, being effectively non-existent in block 1B and generally good along the sides of the block 1A. At the head-ditch end of block 1A the screen was patchy and it was non-existent at the tail-ditch end. Poor sorghum establishment in parts of block 1A was due to over-spraying with herbicide and water-logging in the tail-ditch area. Shortly after sowing, a deluge of rain at the critical stage of germination destroyed all but a few metres of the sorghum screen in block 1B.

The second trial was sown in January 1981 and Hysun 31 and Sudax ST6 were again used. However, the screen was planted before the sunflower so that overspraying with herbicide could be avoided. This sunflower trial was also in two adjacent blocks of 25.5 ha (block 2A) and 17 ha (block 2B). The sunflower plant population in block 2A was very uneven, down to 6000 pl/ha towards the tail-ditch end due to water-logging and up to 30,000 pl/ha in most other areas. Block 2B was less variable and had a plant population of approximately 37,000 pl/ha. As in the first trial, the sorghum screen was patchy to non-existent at the tail-ditch ends and had several holes of 10 — 50 m at these ends. Generally the achieved visual barrier in all three screened trial sites was no more than 80% of the crop margin. The trial sites were visited occasionally before sunflower maturation and it was found that it was not until the sunflower formed a bud and began to flower that forage sorghum began to outgrow the sunflower. However, by the time bird pests began to attack sunflower (in the milky stage of seed development) the forage sorghum was more than one metre taller than the crop. In block 2B, and fifteen days before harvest, four lengths of hessian 2 x 50 m, suspended on steel pickets were used to "plug" some of the worst holes in the sorghum screen.

Blocks 1A and 1B were assessed the day before harvesting commenced on 9 February. Blocks 2A and 2B were assessed on 26 April, the day after harvesting had commenced.

Bird damage was assessed in regular transects through the crop. Ten adjacent sunflower heads were selected and measured at intervals of 5 m or 10 m through the crop depending on the presence or absence of damage. Originally the area of seed removed (cm^2) was measured with a perspex template, and the diameter of the head was recorded for each plant so that later the percent damage could be calculated. This method proved laborious and slow. The method finally used was to randomly walk transects through the crop, more intensively in the damaged areas. The percentage of seed removed by birds was estimated from ten adjacent heads and categorized as follows: (i) 1 — 5%, light bird damage, (ii) 6 — 15% moderate, (iii) 16 — 50% severe and (iv) 51 — 100% extreme. Using this method, bird damage was mapped for the entire crop. Neighbouring irrigated sunflower crops without screens were used as controls for the second trial (trial 3 and 4). Trial 3 of 20 hectares and trial 4 of 22 hectares were both harvested between 10 and 15 April.

On all trial sites, growers conducted their normal methods of bird control (shooting, scareguns, drying etc.).

RESULTS

On the screened sunflower crops, cockatoos and galahs reduced the total yield by 3.7% and 5.0% (blocks 1A and blocks 2A, 2B respectively), compared to 38.9%, 15.0% and 18.2% damage to the unscreened blocks (1B, 3 and 4 respectively). The most significant aspect of the damage to screened crops was that the few severely damaged areas were located immediately opposite holes in the sorghum screens (Figures 1 and 2).

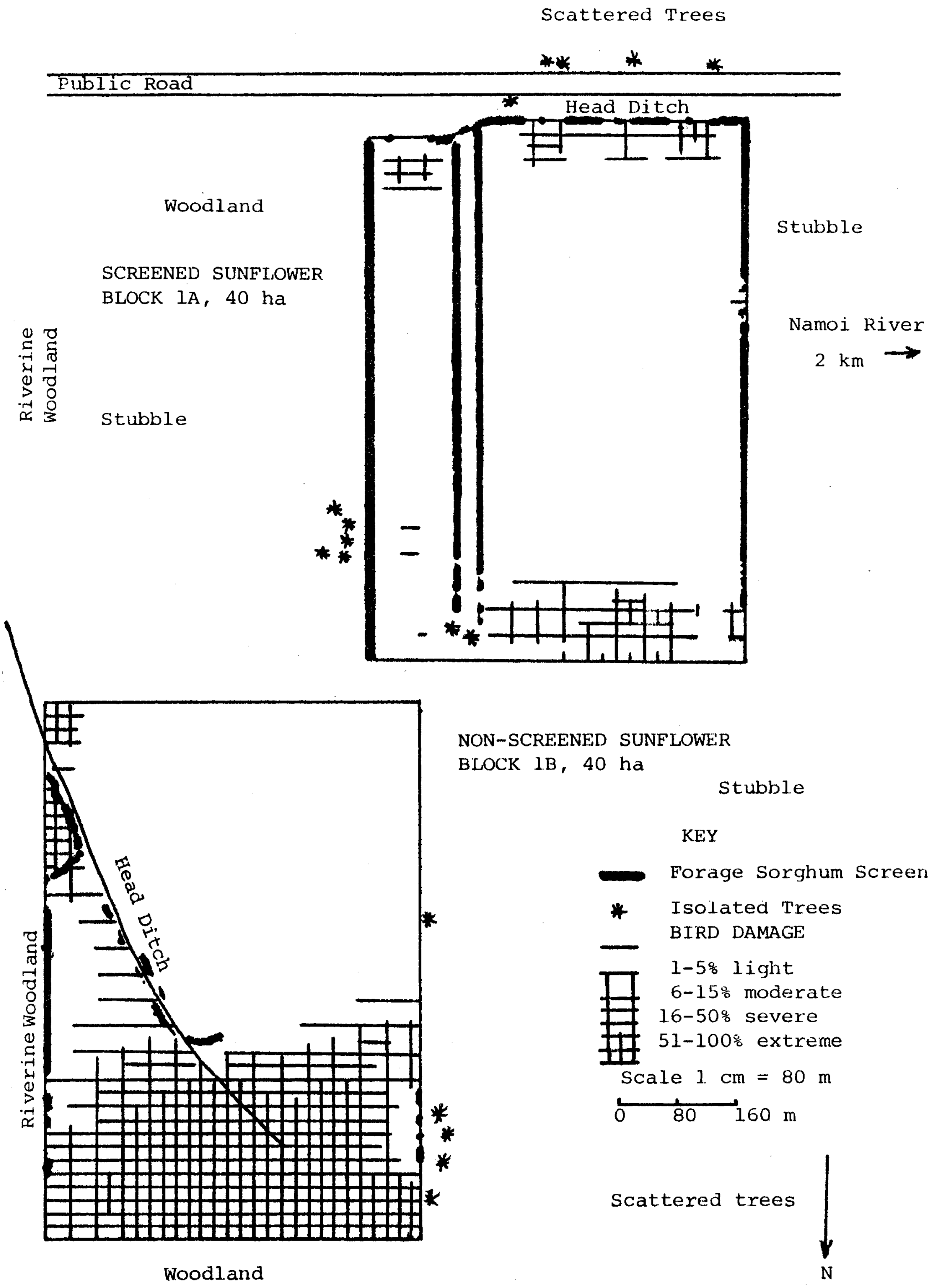

Figure 1. Distribution of bird damage in blocks 1A and 1B, assessed the day before harvest, 10 February 1981. Note areas of significant damage opposite holes in forage sorghum screen.

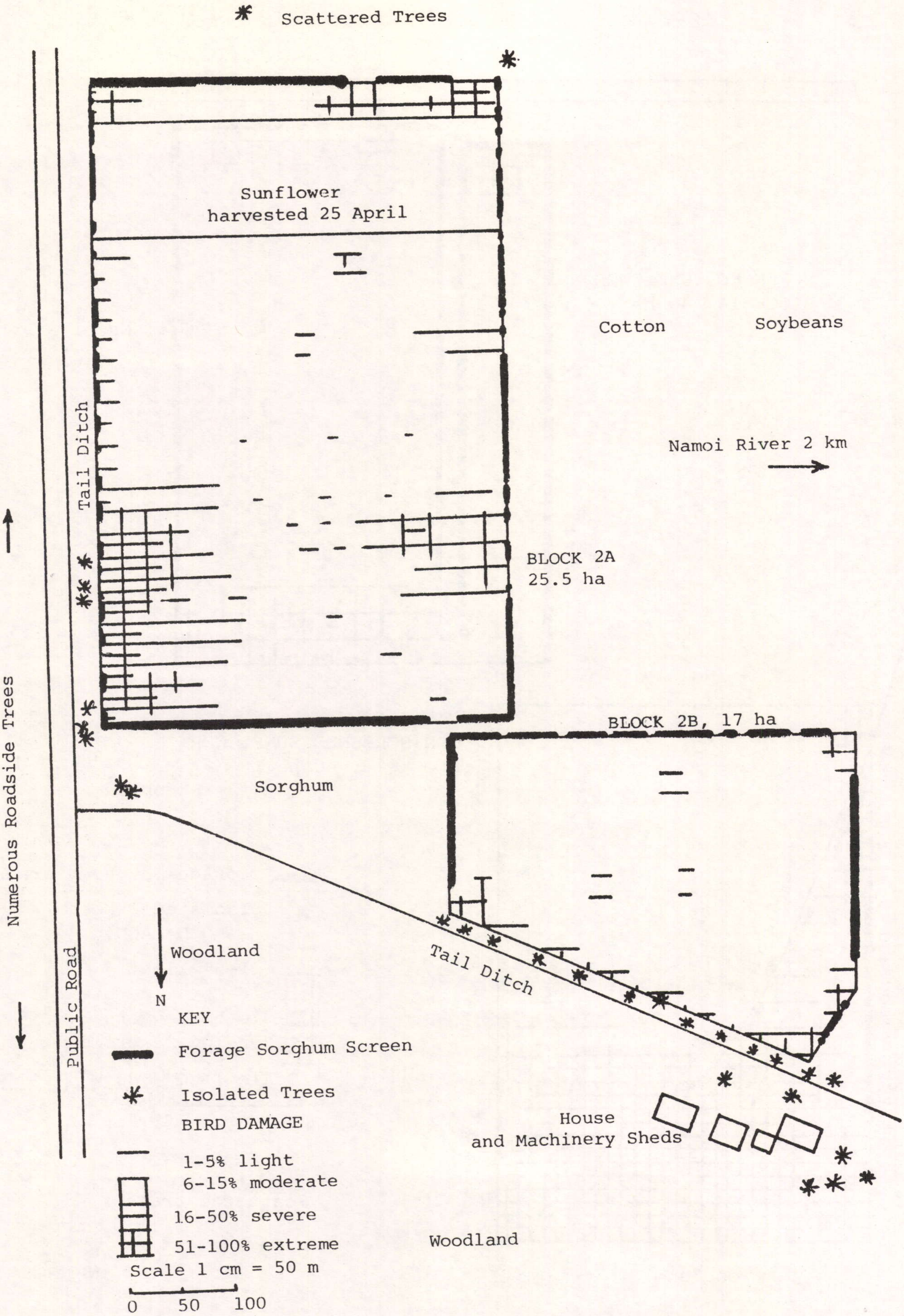

Figure 2. Distribution of bird damage on screened sunflower trial 2A, 2B, assessed at harvest 26 April 1981.

Damage was reduced in screened sunflowers because the visual barrier surrounding the crop produced an unusual unsettling effect on cockatoo behaviour. Mixed flocks of several hundred birds were observed to land in the crop. However, they would rarely remain on the crop for more than a few moments unless they were adjacent to holes in the sorghum screen. Flocks would often descend into the crop and slowly traverse the whole perimeter of the screen before leaving. It was also noticed that the traditional methods of shooting and scaring were many times more effective against birds when screens were present. Flocks of a thousand or more birds were easily flushed away by firing perhaps one or two .22 cal rounds, even from distances of several hundred metres.

In addition to the reduction in seed loss due to bird damage, there was a significant difference in the cost of bird control between screened and unscreened blocks. The most significant cost in bird control is labour. The labour component and to a smaller degree the cost of ammunition were greatly reduced in screened crops because flocks were more easily and quickly dispersed (see Table 1).

Table 1. An analysis of bird damage to screened and non-screened irrigated sunflower crops during the 1980/1981 season.

		Screened Sunflower		Non-Screened Sunflower		
		Block 1A	2A, 2B,	1B	3	4
1	Areas of sunflower (hectares)	40	42.5	40	20	22
2*	Non Bird damaged yield (t/ha)	1.43	1.78	1.11	2.47	1.23
3t	Actual yield (tonnes)	55	72	27	42	22.5
4s	Seed loss to birds (tonnes)	2.1	3.8	17.4	7.4	5.0
5#	Loss of sunflower production	$ 481	$ 638			
6±	Sunflower seed loss	$1111	$1777	$5220	$2220	$1500
7+	Cost of bird control	$ 256	$ 595	$1452	$1112	$ 923
8°	Cost of growing screen	$ 103	$ 71			
9	Adjusted cost of bird control	$ 359	$ 666	$1452	$1112	$ 923
10	Total cost of bird damage	$1470	$2443	$6672	$3332	$2423
	Cost per hectare	$36.75	$57.48	$166.80	$166.60	$110.14

* Information from grower, estimated by the tonnage removed by the header over a known area of undamaged crop.
t Cleaned dry weight.
s Seed loss to birds was calculated by two methods and averaged.
Method 1 (Non bird damaged yield per hectare x area of crop) — actual yield.
2 Area of bird damaged crop x % bird damage x non bird damaged yield per hectare.
The largest discrepancy between these two estimates was 2.0 tonne in block 1A and 0.4 tonne for the other trials.
\# Represents the loss in seed production for growing sorghum instead of sunflower over the three metre strip.
± Cost of seed lost through bird damage at $300/tonne plus the loss resulting from the growing of sorghum instead of sunflower.
\+ Contains the cost of ammunition, labour at $5.00/hr, fuel at 28¢/1 and the cost of any method of preventing or reducing bird damage including gas for scareguns, drying of seed etc.
° Cost of sorghum seed plus fuel and time to sow.

DISCUSSION

The reason why cockatoos select more elevated feeding sites is not firmly established. However, the most likely reason for this behaviour is predator-avoidance (de la Motte, 1977). According to Brown and Amadou (1968) and Frith (1976), there are some eight species of raptor that have been reported as predators of galahs and cockatoos. All of these raptors are either falcons (Falconidae) or goshawks (Accipitridae), and they attack unwary birds using a similar technique. These predatory species catch their prey by striking suddenly at high speed using ambush, low-level flying and extreme manoeuvrability. If this is the reason for the observed cockatoo feeding behaviour, it is unlikely that birds would become habituated to crops surrounded by sorghum screens which automatically predispose feeding birds to surprise attacks from these raptors. Bird control techniques such as recorded distress calls and shooting provide an additional source of alarm for feeding birds and would complement the use of screens. To achieve the full potential of screens as a method of bird control, it is essential to create a visual barrier around the entire crop. The difficulty of sowing sorghum into head and tail-ditch areas and sowing sorghum next to crops treated with herbicide plus subsequent cultivation and irrigation introduce additional problems for a grower. There appears to be an advantage in sowing the sorghum screen before the sunflower, and there should also be advantages gained by sowing additional screens at various intervals throughout irrigated crops.

For dryland sunflower there are fewer problems in sowing a sorghum screen. In marginal areas and where moisture stress is common, the sowing rate of the sorghum screen should be reduced to 1 kg/ha and to maintain a visual barrier, six rows instead of four would be required. As it is essential to avoid holes in the screen a grower would need to deep rip around the trees that occur adjacent to the sown sorghum screen. An alternative technique (or in addition to this), would be to plant the sorghum screen approximately 50 metres in from the crop edge.

There are a variety of fodder sorghums that could be used for screening sunflower. Sudax ST6, a sterile cultivar, was used in these trials because there is no problem with volunteer regrowth over subsequent years and because this cultivar may be planted earlier at soil temperatures of 16°C. Alternatively "Honeydrip" and "Magic" are both excellent cultivars and are recommended for screening as they grow to heights of three metres or more and would not produce seed until after the sunflower is harvested.

The results of these preliminary trials indicate that the use of screens would provide significant reductions in bird damage and bird control costs. More importantly, growers would be released from many hours of unproductive time spent patrolling crops.

ACKNOWLEDGEMENTS

Appreciation is extended to A.B. Dale (Special Agronomist for the Department of Agriculture), for providing technical information and to D. Donovan and J. Watson, co-operating sunflower growers in the Boggabri area.

This research has been supervised by Dr P. Jarman and funded by a grant from the Oilseeds Marketing Board.

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THE ECONOMICS OF CHEMICAL DESICCATION AND MECHANICAL DRYING AS METHODS OF REDUCING BIRD DAMAGE IN SUNFLOWER.

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ABSTRACT

In response to the high levels of bird damage experienced by sunflower growers, many methods of controlling birds or reducing bird damage have been developed. This paper attempts to weigh the benefits of two methods, chemical desiccation and mechanical drying, in relation to the cost of applying these methods. Results indicate that for either of these methods to be economically justified as a means of reducing bird damage very large bird numbers are required. For summer harvests, it is unlikely that bird numbers could reach a level that would economically justify the application of these techniques for the purpose of reducing damage.

INTRODUCTION

Detailed surveys undertaken by students from the Department of Ecosystem Management, (University of New England) have estimated bird damage in northern New South Wales at 5 — 30% of yield on a shire (county) basis (de la Motte, 1977; Bennett 1978). These surveys identified the sulphur-crested cockatoo, *Cacatua galerita,* and the galah, *C. roseicapilla,* as the major pest species damaging sunflower.

Chemical desiccation and mechanical drying have been recommended as viable methods of reducing the period of crop susceptibility and hence reducing bird damage (Whitehead, 1977; Besser, 1978; Easdown and Beeton, 1980). For either of these two methods to be economically justified as a technique for reducing bird damage, the cost incurred by desiccating or drying must be less than the cost of additional bird damage incurred between alternative harvest dates.

In this paper a simple equation is generated that allows these and other bird damage control methods to be evaluated.

Method of calculating cockatoo and galah damage to sunflower.

To evaluate the cost of bird damage we can use a simple formula:

$$B.D.(\$) = \frac{(C^n \times 54.8 + G^n \times 36.8)D^n \times S}{10^6}$$

Where C^n and G^n are an estimate of the number of sulphur-crested cockatoos and galahs respectively, that are feeding on the sunflower crop per day. D^n is the number of bird-feeding days, or in this case in the number of days difference between harvest dates. S is the current or expected price per tonne of sunflower seed when sold.

Small (1975) made a rough estimate of cockatoo damage per day, per bird, based on stomach contents from a sample of cockatoos shot after feeding on sunflower. However, a more accurate estimate of the weight of sunflower seed eaten (and wasted) by galahs and cockatoos was made by Broome *et al.,* (1979 unpublished). In this study the mean numbers of cockatoos and galahs per day, the mean number of feeding minutes per bird and the seed eaten or destroyed was recorded for a 55-day period on a sunflower crop of 3.5 hectares.

From these detailed records it was calculated that cockatoos eat or destroy 54.8 grams of sunflower per day per bird and galahs eat or destroy 36.8 grams. The advantage of these estimates is that the figures generated from this approach incorporate the seed actually eaten by birds (unaffected by bird controls), plus the seed wasted or destroyed through decapitation of sunflower heads.

Cockatoo numbers (C^n) and galah numbers (G^n) are not calculated in this analysis. For calculating bird numbers in a field situation, the best technique is a photographic count. Without this technique and especially when large flocks of several thousand birds form, it is extremely difficult to obtain a population estimate by direct observation.

The number of days by which desiccation or drying may shorten the period between physiological maturity and harvest maturity (D^n) in a sunflower crop depends on two important factors; (i) moisture content of seed when desiccated, or moisture content of the seed when harvested to be dried, and (ii) general weather conditions during the drying-down period.

To achieve the earliest possible harvest using desiccation, the chemical must be applied soon after the sunflower reaches physiological maturity, at moisture levels of 30 — 40% (Barrett, 1978; Dale, 1980). If chemical desiccants are applied when the moisture level has fallen below this level, their effectiveness in allowing an earlier harvest diminishes rapidly. There is no reported yield difference produced when sunflower is desiccated at 30 — 40% seed moisture (Degtyarenko, 1976; Palmer and Sanderson, 1976; Barrett, 1978), or any change in oil quality (Degtyarenko, 1976). Harvesting sunflower with high moisture often results in higher yields with less lodging, head-dropping and seed-shattering (Dale, 1980). For the earliest possible harvest using mechanical drying, sunflower should be harvested at 17% moisture (Dale, *pers. comm.* 1981).

Rain and especially cool autumn temperatures prolong the drying-down of sunflower. Depending primarily upon the time of year, mechanical drying and chemical desiccation may allow an earlier harvest by several weeks (see Table 1).