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Efficacy of nets and fibres for protecting crops from grain-eating birds in Africa

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ABSTRACT. Birds cause extensive losses to cereal crops in Africa and damage to research or seed production fields is often acute. Physical barriers such as nets or acrylic fibres can block the access of birds to these fields and provide almost complete protection. Although the use of properly mounted and maintained nets is expensive, costing from US $1000 to over US $3000 per ha, nets have effectively protected fields at eight trial sites in five African countries between 1975 and 1980 and compare favourably with the cost of employing people as bird scarers. The use of nets to protect crops is, therefore, becoming increasingly popular for high-value crops at research centres and in production schemes in many countries in Africa.

Introduction

Bird damage to cereal crops in Africa represents losses of many millions of US dollars. In Senegal alone, several ploceid species of birds are responsible for crop losses of at least US $4–5 million annually (Bruggers and Ruelle, 1981). Consequently, many people and organizations have an interest in the development of new crop protection techniques and the improvement of those already available.

The individuals or organizations most concerned with bird pest problems include: (a) private farmers, who are the traditional mainstay of African agriculture; (b) government production schemes, which are becoming more important in country development programmes; and (c) agronomic research centres that are developing and providing seed of improved, locally acceptable varieties. The difference in the size, scope and objectives of these organizations and in the variety of different birds (their abundance, biology and behaviour) which damage cereals, illustrates the complexity of situations encountered in crop protection. Flexible and varying strategies are needed to combat these diverse problems. The use of barriers which block the access of pest birds to crops and provide complete protection is one strategy that is becoming increasingly popular in production schemes and at research

centres where high-value crops are grown. Our objective was to evaluate the efficacy and cost-effectiveness of several kinds of nets, and of an acrylic fibre, on a variety of cereal crops and to develop recommendations for their use. Nets were not being used regularly by many organizations in Africa at the onset of this work in 1975.

Methods

Three types of protective netting (cotton or nylon fish-net, plastic Xironet*, and plastic Conwed* nets) and one type of acrylic fibre web (Crylde®) were evaluated on eight occasions at agriculture research stations in five African countries between 1975 and 1981. The fish-nets were locally available. The Xironet, a yellow flexible lightweight diamond-shaped mesh (2·5 × 2·5 cm) netting, the Conwed net, a black, semirigid, heavy, square-shaped mesh (about 2·0 cm^2), and Crylde, a fine acrylic fibre which is spread out as a 'web' over a crop, were imported from Switzerland, the United States and France, respectively. The tests or demonstrations were conducted on individual isolated plots of sorghum, rice, wheat and millet, ranging in area from 0·02 to 0·20 ha at several research centres. The nets were also subjectively evaluated when used on larger fields.

Evaluating the effectiveness of nets progressed from simply laying them directly on ripening crops to detailing their use and costs for protecting large-scale plantings. Temporary and permanent support structures were constructed from locally available materials. Protection was judged on differences between the percentage of damage (based on visual estimates or linear measurement), weights of individual panicles or heads, or the yields (m^2 sample units or complete harvest) on plots with and without protective barriers at maturation. Test-plot replication was used whenever possible. Specific test designs employed and detailed descriptions of bird damage estimation techniques commonly used in Africa are discussed by Ingram (1977), Martin and Jackson (1977), Manikowski and DaCamara-Smeets (1979) and Bruggers and Jackson (1981).

Results and discussion

Net barriers

The experiments have shown that, when properly installed and maintained, nets can effectively block the access of pest birds to cereal crops. At all trial sites, damage was less in covered than in uncovered control (or reference) plots (Table 1). Nets often provide effective protection, for little more than their purchase price, by laying them directly on, or supporting them with tree branches slightly above, a ripening crop (Figure 1). However, such protection is sometimes incomplete because birds can perch on and feed through the mesh of the net, as occurred at Richard-Toll, Senegal, in October 1979. Nevertheless, fish-nets recently were laid over rice fields in government schemes in Benin and Guinea with apparently acceptable protection from grain-eating birds.

More consistent and effective protection can be achieved by supporting nets over crops on portable or permanent frameworks. The costs and logistics involved in constructing and erecting these support structures virtually restrict their use to

* Reference to trade names does not imply US Government endorsement.

TABLE 1. Results of trials in East and West Africa evaluating the efficiency of nets in preventing damage to ripening cereals by bird pests

Location, date, crop	Trial plots: Treatment	Replicates	Area (ha)	% damage or yield	Bird pests	Comments
East Africa						
Machachos, Kenya Dec 3, 1979; sorghum	Xironet	I	0·06	0%	*Ploceus* weavers; glossy starling	Easily laid out, but easily torn; heavily flawed, and not reusable.
		II	0·03	0%		
		III	0·02	4%		
	Control	I	3·00	9·8%		
Afgoi, Somalia Aug 6. 1979; rice	Xironet	I	0·05	1111 kg/ha	Red-billed quelea; red bishop	Xironet easily torn. Conwed net durable, but heavy and cumbersome; reusable.
	Conwed net	I	0·16	1562 kg/ha		
	Control	I	0·11	1102 kg/ha		
	Control	II	0·16	1022 kg/ha		
Arusha, Tanzania Sep 14, 1979; wheat	Xironet	I	0·25	2508 kg/ha	Red-billed quelea; *Ploceus* weavers	Easily torn.
	Control	I	0·13	1925 kg/ha		
West Africa						
Richard-Toll, Senegal August 1975; rice	Fish-net	I	0·05	2·83 g/head	Red-billed quelea; red bishop; *Ploceus* weavers	Heavy, rapidly deteriorated. but locally available.
	Control	I	0·11	0·02 g/head		
	Control	II	0·09	0·00 g/head		
October 1979; rice	Fish-net	I	0·04	3·00 g/head	Yellow-crowned bishop; red-billed quelea	Locally available.
	Control	I	0·04	2·00 g/head		
	Control	II	0·04	1·73 g/head		
Bambey, Senegal May 1976; millet	Fish-net	I	0·10	15·5%*	Red-billed quelea; red bishop; golden sparrow	Only usable once.
	Control	I	0·04	93·0%		
	Control	II	0·04	99·0%		
	Control	III	0·04	100·0%		
Fanaye, Senegal August 1979; rice	Fish-net	I	0·03	25%; 1·46 g/head	Red-billed quelea; yellow-crowned bishop	Very effective initially, but tore with extensive use.
	Fish-net	II	0·03	5%; 1·50 g/head		
	Control	I	0·03	80%; 0·48 g/head		
	Control	II	0·03	0%; 0·54 g/head		
Ouémé, Benin June 1975; rice	Fish-net	I	0·20	2–4%	Village weaver; red-headed weaver	Only usable once.
	Control	I	0·11	75%		

* Net not maintained; holes not repaired and birds not regularly removed.

high-value crops, research trials, or small areas of seed multiplication crops. Portable support frameworks were erected in Somalia and Tanzania at extrapolated costs per ha (based on one season of use) with Xironet of US $2525 and US $3240, respectively. The cost of using Conwed net in Somalia was about US $500/ha greater than the Xironet, because of the increased cost of materials and preparation (primarily poles) for supporting the heavier nets (Table 2; Figure 2). In Senegal, a similar structure supporting fish-nets, but based on three cropping seasons a year, costs more than US $1100/ha. Materials (steel and bamboo support poles, guide wire and stakes) and labour (materials preparation and installation) represented almost 50% of the cost. During 1976 at the Institute of Senegalaise de Recherche Agronomique (ISRA) at Bambey, Senegal, a permanent support system of wires was attached to trees which previously had been planted at 5 m intervals along the border of a 2 ha research field. This system was set up for little more than the cost of labour and wire. The only maintenance costs were for repairing or replacing the nets, and removing birds trapped inside. The duty-free cost in Senegal of sufficient fish-net to enclose 1 ha has increased from about US $1770 in 1976 to about US $3500 in 1981.

FIGURE 1. Locally available cotton or nylon fish-nets, shown here supported on a framework of branches and string over rice at Richard-Toll, Senegal, can provide excellent protection against grain-eating birds.

At the Ethiopian Sorghum Improvement Project (ESIP) in Nazareth, Ethiopia, another permanent netting enclosure of about 1 ha was constructed in 1979 with wooden support poles, wire and 3 × 3 cm mesh screen at a cost of more than US $13 000. The netting was an effective barrier to red-billed quelea (*Quelea quelea*), which weigh about 20 g, but allowed passage of red bishops (*Euplectes franciscanus*) which weigh about 15 g; of more than 200 birds netted inside the enclosure, only four were quelea. In recently constructing a second similar enclosure, a mesh size of 2·0–2·5 cm was used. These costs were justified because the enclosures protect

TABLE 2. Comparative costs of net installation with portable support structures in Tanzania and Somalia during 1979

Materials and labour	Tanzania	Somalia	
	Xironet (0·13 ha) Approx. price (US $)	Xironet (0·05 ha) Approx. price (US $)	Conwed (0·17 ha) Approx. price (US $)
Materials			
Steel support poles (1·5 m × 4 cm)	30·00	54·60	234·00
Sisal support poles (2·0 m × 6–8 cm)	1·92	—	—
Iron basal plates (25 cm × 25 cm)	12·00	2·80	12·00
Wood net support plates (10 cm × 10 cm)	4·80	1·12	4·80
Iron guidewire stakes (25 cm)	6·00	9·75	17·55
Iron support pole stakes (40 cm)	12·00	4·55	19·50
Cord* (100 m/roll)	4·00	8·00	14·00
Support and guideline wires (per kg; 1·5 and 2·0 mm diameter)	22·50	10·00	17·50
Paint (per litre)	5·50	—	—
Nails (per kg)	0·38	0·67	0·67
Subtotal	99·10	91·49	320·02
Labour			
Cut, weld, drill, paint structure materials	250·00†	16·67†	58·33†
Netting: original covering and repair			
Xironet ($56 per 2000 m^2 roll)	56·00	5·60	
Conwed ($515 per 7890 m^2 roll)			108·00
Grand total			
(per area used)	405·10	113·76	486·35
(extrapolated per ha)	3240·00	2525·25	2947·57

* Nylon cord in Tanzania; waxed string in Somalia.

† Labour to prepare support structure was privately contracted in Tanzania and provided by Ministry of Agriculture in Somalia. Actual installation costs are not included in either country.

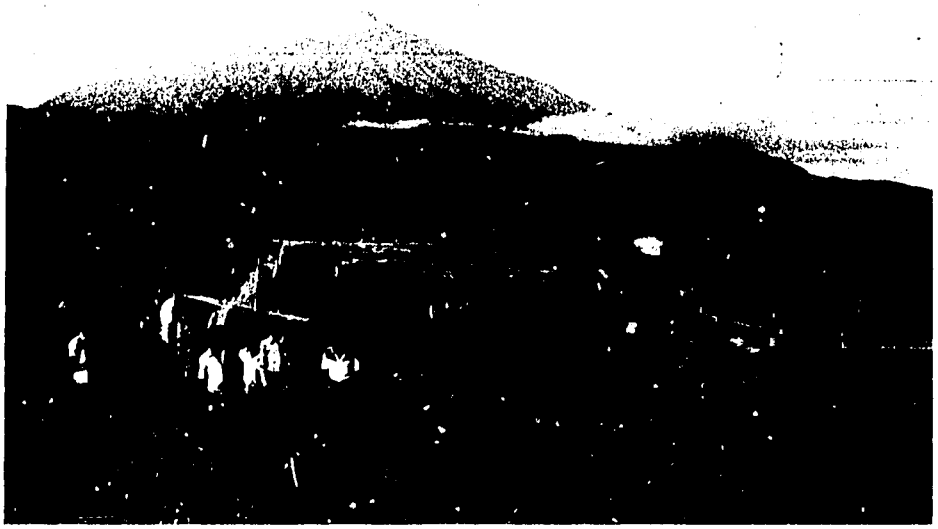

FIGURE 2. A durable, yet portable support structure, seen here supporting Xironet over ripening wheat at Arusha, Tanzania, is even more effective than fish-nets.

variety and breeding-line trials which are used to increase the production of sorghum, Ethiopia's staple diet (Brhane Gebre-Kidan, personal communication).

An effective, portable support system can be established by placing hollow steel poles (2·5–4·0 cm in outside diameter and 1·0–1·5 m tall, depending on the crop) at 10–15 m maximum intervals along the periphery and in parallel rows in the interior of the crop field. A 25 cm^2 basal plate with an iron spike 40 cm long projecting downwards into the soil, welded to the base of the pole, provides additional stability in irrigated schemes (F. Pinto, personal communication). The poles should be painted to resist rust. Locally available poles (such as sisal or bamboo) can be used to provide inexpensive, additional interior support. Wire with a minimum diameter of 2·0–2·5 mm should be stretched between the poles, and secured in holes (3–4 mm in diameter) at their tops. Pole-to-ground guidewires are necessary. Small, wooden plates placed over the top of the poles reduce tearing of the net when it is in place; empty cans are used in Senegal for the same purpose. Nylon cord is preferable for sewing the overlying bands of netting together, but cotton string (or sisal) also can be used. The net can be tied to the base of the perimeter poles and the edges covered with dirt to form a complete enclosure.

Cotton or nylon fish-nets may be locally available, but ultraviolet-stabilized plastic netting is more durable and preferable, even if it must be imported. (Descriptions, costs, and manufacturers' addresses of several brands currently being used in Africa are given in Table 3.) Mesh dimensions of 2·0–2·5 cm^2 usually are the maximum that will afford protection against small birds like bishops (*Euplectes* spp.) and golden sparrows (*Passer luteus*) which weigh 13–16 g. With mesh sizes of 2·0–2·5 cm^2, non-target birds are not likely to be trapped. Only three birds were

caught by the Xironets (mesh size of 2·5 × 2·5 cm) that were used for more than 1 month in Somalia and Tanzania. In contrast, Twedt (1980) reported that 138 birds of seven species (average 3·8 birds/exposure day) became entangled in Xironet (mesh size of 4·0 × 6·0 cm) which had been draped over grape vines in Oregon, USA; 95 % of the birds were American robins (*Turdus migratorius*).

Nets should be installed before the onset of damage. Birds trapped inside the enclosure should be removed regularly because they attract other birds which can cause serious damage (Figure 3). Entrapped birds entering through unrepaired holes were responsible for the abnormally high levels of damage to the net-enclosed plots at Bambey, Senegal, in May 1976 and Fanaye, Senegal, in October 1979 (15·5 % and 25 %, respectively; Table 1).

Nets are non-toxic, noiseless, often reusable barriers that are potentially 100 % effective (Stuckey, 1973). In developing countries the high cost is the main constraint to more widespread use of nets for protecting crops from birds. However, the expense seems more reasonable when compared with the costs of hiring people as bird scarers. For example, in Senegal the West African Rice Development Association (WARDA) employs 12 bird scarers/ha each day (two teams of six on 8 h shifts) for 45 days to protect their research and seed production fields, at an average daily wage of US $4·20 per scarer or a total of US $2119/ha.

FIGURE 3. Pest birds can easily enter netting enclosures in which large mesh is used or holes are not repaired, with subsequent extensive damage to grain crops. Most of the grain on these millet heads at Bambey, Senegal, has been eaten by red-billed quelea and red bishops.

TABLE 3. Representative examples and approximate costs of netting used in Africa

Net type	Supplier address	Product available and cost	Cost* in 1981 (US $ per m²)
Olivene S nets	Suppliers of Nets and Fibres Agrinova Spa 20063 Cernusco Via Verdi N 104–106 Milano, Italy	Roll dimensions variable; widths from 2–6 m, lengths as required	0·27
'Birds off' nets	French Textiles Company, Inc. 835 Bloomfield Ave. Clifton, NJ 07012, USA	$138 per roll of 12 × 61 m	0·19
Fish-nets	IFAP BP 280 Dakar, Senegal	$56 per roll of 15 × 20 m, locally	0·31
Conwed	Conwed Corporation Plastics Division 770 29 Ave SE Minneapolis, MN 55414, USA	$515 per roll of 5 × 1·25 m (order > 11 rolls)	0·07
Xironet	Xiro AG CH. 1700-Fribourg 7 Switzerland	$90 per roll of 1 m × 350 m (expands to cover ≃ 2000 m²)	0·05
BIF CropNet	British Industrial Fastenings, Ltd. Gatehouse Road Aylesbury, Bucks HP19 3DS, England	$44 per role of 2 × 200 m or 4 × 100 m	0·11
Crylde acrylic fibre	Rhone-Poulenc Textiles Tour Credit Lyonnais 129 rue Servient BP 107-69398 Lyon Cedex 3, France	1 kg package theoretically covers 1000 m²	0·01
Le Filet Kinon	J. P. Desmazure Ave. Liberation 83106-La Valette, France	5 kg roll of 10 × 45 m	0·31

* Costs may vary depending on factors such as the size of the roll, the number of rolls ordered, and the mesh size.

Acrylic fibre barriers

Acrylic fibres, such as Crylde, are used in Europe to protect fruit trees and seed beds. Acrylic fibres are less expensive than nets to purchase and instal but are easily displaced by strong winds and rain (Figure 4). The material is spread out in a web-like fashion directly on the plants. When Crylde is employed over ripening cereals, it can be supported with a network of string attached to internal and peripheral poles. The string should be aligned at right angles to the prevailing wind to minimize displacement by wind. Unless the fibres are rearranged regularly, birds can feed through these wind-induced openings. The fibres must be carefully removed before the crop is harvested, to reduce losses due to shattering of entangled

FIGURE 4. Acrylic fibres, shown here laid out and supported over ripening rice at Richard-Toll, Senegal, can provide a fairly effective barrier to bird passage unless the fibres are extensively disarranged by wind and rain.

grain. For these reasons, acrylic fibres are more applicable for use in Africa on rice seed-beds than on ripening crops.

Net trapping

Nylon mist or fowling nets are beginning to be promoted and used as a crop-protection method. Mist nets are fine black nearly invisible nets, approximately 3 m in height and sometimes 20 m in length, which are hung vertically between two bamboo poles and partly hidden in the vegetation along the periphery of the crop. Trapping results generally have been poor or inconsistent. However, when the nets are carefully placed in bird flight corridors, regularly monitored to remove trapped birds, and frequently repositioned to limit habituation, many birds may be trapped, particularly during periods of poor light and low visibility. For example, a 12 × 2 m net positioned along a border of a rice plot at Fanaye, Senegal, on 2 August 1979 between 0900 h and 1430 h caught 194 birds. In contrast, in Gambia between 9 and 17 April 1980, nets placed around rice caught 24 birds the first day, 16 the second, and only an occasional bird the rest of the time. Most of the birds, of which quelea made up only 13 %, were captured during the morning. Quelea, perhaps because of their large dense highly synchronized flocks, are not as easily trapped as other ploceids and can easily manoeuvre around or over mist nets. In Gambia, the Crop Protection Services personnel reported an average capture of 41 village weavers (*Ploceus cucullatus*), in each net 1·5 m high × 5 m long, every day between April and December, when the nets were placed in flight corridors and moved regularly (Table 4).

Mist nets have also been used in Benin since 1976 to capture birds around rice

schemes at Ouémé and Dome. More than 324 000 birds (primarily village weavers) were reported to have been collected during the 5 years after the nets were installed (Table 4), at a daily cost of approximately US $0·25. This cost is calculated on the basis of mist nets and poles costing US $11·00 and US $0·17 each, their use for 45 days in each of 3 years and the employment of six men to supervise between 25 and 50 nets/day at a daily wage of US $0·75 (Adama Ouattara and Alioune Ndiaye,

TABLE 4. Number of birds captured in mist nets in Gambia between 1979 and 1981 and in Benin between 1976 and 1980. Data for Gambia provided by Gambia Crop Protection Service and for Benin by West African Bird Control Project

Date	Total number of birds caught	Number of net days	Average number birds/net/day
Gambia			
June 79	482	18	27
Aug 79	4719	99	48
Sep 79	2759	60	46
Oct 79	2310	69	34
Nov 79	3264	74	44
Dec 79	5669	134	42
Apr 80	717	21	34
May 80	4413	120	37
May 81	260	8	33
Total	24593	603	41
Benin			
1976	40266	NA*†	NA
1977	95014	NA	NA
1978	105500	NA	NA
1979	49807	NA	NA
1980	33454	NA	NA
Total	324041		

* Information about the number of net days and the average number of birds captured/net/day is not available.
† NA—not applicable.

personal communication). Unfortunately, no information is available on the actual protection afforded to the ripening rice by these mist-netting operations; bird destruction and crop protection are not necessarily synonymous.

Mist nets can also trap large numbers of birds in forest nesting colonies bordering agricultural land. J. Besser (personal communication) was able to trap 100 quelea fledgelings in less than 10 min using two mist nets 3 m long in Sudan. However, because of their variable success, fragility (easily damaged while removing birds), and potential impact on non-pest species, mist nets are not generally recommended as a crop-protection method.

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