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On-farm evaluation of weed control technologies in direct-seeded rice in The Gambia

by

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Abstract

Hand weeding is the major labour activity in direct- seeded upland and rainfed lowland rice in West Africa, and delayed weeding results in serious yield reduction. The objective of this study was to develop and test weed control options that would allow earlier, more rapid and repeated weeding in direct-seeded rice. These options included: row-seeding rice with animal-drawn and manual seeders; mechanical inter-row cultivation with animal-drawn equipment; and within-row weed control with herbicides or by hand pulling.

The animal-drawn SuperEco seeder proved superior to the hand-pulled Casamance seeder. Cultivating at 21 and 42 days after seeding with the animal-drawn Houe occidentale controlled inter-row weeds, yielding 1.3 t/ha in upland rice and 3.2 t/ha in rainfed lowland rice with no control of within-row weeds. Within-row weeds were effectively controlled by broadcasting oxadiazon (Ronstar) at 0.75 kg active ingredient/ha (a.i./ha) one day after seeding or by banding thiobencarb and propanil (Tamarice) at 0.72 and 1.30 kg a.i./ha over the row 21 days after seeding.

Herbicide use was not profitable in upland rice and only slightly profitable in rainfed lowland rice. Complete hand-pulling of within-row weeds in upland rice required 89 days/ha and was not profitable. Selectively removing larger weeds reduced hand weeding time to 37 days/ha and increased yields by 11%.

The results of this two-year study indicate that effective weed control without external inputs can be attained by row seeding with the donkey-drawn SuperEco seeder, cultivating twice with the Houe occidentale and selectively removing within-row weeds by hand pulling.

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Introduction

Weed control is the major labour activity on direct-seeded rice in West Africa. Insufficient labour limits the area that can be cultivated successfully and results in delays in completing hand weeding, leading to serious yield reductions. The use of animal traction for seeding and weeding upland cereals and groundnuts is widespread in Senegal and The Gambia, but is rarely used in rice production. The objectives of the studies described in this article were to:

- identify a suitable row seeder rice
- evaluate the use of animal traction for the control of inter-row weeds
- measure the effect of within-row weed competition on rice yield
- compare hand pulling and pre- and post-emergence herbicides for the control of within-row weeds.

It is anticipated that these technologies can be adopted incrementally by West African rice farmers, including women, in farming systems that have already undergone the transition from a hand hoe to an animal traction-based upland cultivation system.

Literature review

Direct-seeded rice in West Africa is generally broadcast as this method requires little time and no equipment. When correctly done it is an effective way to increase rice competitiveness with weeds (Renaut, 1972). However rice that is broadcast must be weeded by hand pulling which takes an enormous amount of time. Furthermore, weeding must be delayed until the grasses can be differentiated from rice seedlings and the weeds are large enough to be grasped by the hand. Insufficient time and a desire to avoid a second weeding results in further delays. In their survey of rice farming in Lower Casamance, Senegal, Posner, Kamuanga and Lo

(1991) found that rice yield declined by 25 kg/ha for each day that farmers delayed weed removal beyond 14 days after seeding.

Row seeding rice can reduce weeding time by allowing inter-row cultivation with a hand hoe or animal traction equipment. In Senegal (Posner, Kamuanga and Lo, 1991) and Nigeria (Curfs, 1976), weeding row-seeded rice with a combination of hand hoeing and hand pulling required only half the time of hand pulling in broadcast-seeded rice. Several authors have shown that row-seeded rice can be rapidly weeded with an animal-drawn cultivator (Patel and Rhodes, 1969; Haddad and Seguy, 1972; Travers, 1975). Unfortunately, neither the hand hoe nor animal traction equipment can control within-row weeds. These weeds can be controlled by hand pulling or with herbicide.

Renaut (1972) reported that in the Côte d'Ivoire a single hand pulling of within-row weeds provided adequate control, but Curfs (1976) found that in Nigeria within-row weeds had to be removed twice to avoid serious yield reduction. At the International Rice Research Institute (IRRI), Singh, Moody and Cho (1985) found that pulling within-row weeds resulted in a significant yield increase but was extremely tedious. They suggest that weeding time can be reduced by selectively removing the larger weeds only. This would still reduce weed competition because the effect of weeds on rice yield is influenced by total weed weight rather than by weed density (Noda, 1973).

The most widely used rice herbicides in West Africa are oxadiazon (Ronstar) and a combination of propanil (Tamarice) and thiobencarb. Research in the Côte d'Ivoire (Merlier, 1983), Nigeria (Akobundu, 1981) and Senegal (Diallo, 1984) demonstrated that the pre-emergence application of oxadiazon at a rate of 1.0–1.5 kg a.i./ha suppressed weeds for up to one month. The combination of the pre-emergence thiobencarb and the post-emergence propanil effectively controlled weeds in Ghana (Carson, 1975), Nigeria (Akobundu, 1981), Côte d'Ivoire (Merlier, 1983) and Senegal (Diallo, 1984) when applied at rates of 0.76–2.0 and 1.73–2.2 kg a.i./ha, respectively, at 7–21 days after seeding. A post-emergence application enables the farmer to select fields where the herbicide is most needed (Posner and Crawford, 1991). Moody and Mian (1979) suggested that banding over the row can cut herbicide cost in half while still effectively controlling within-row weeds.

Figure 1: SuperEco seeder

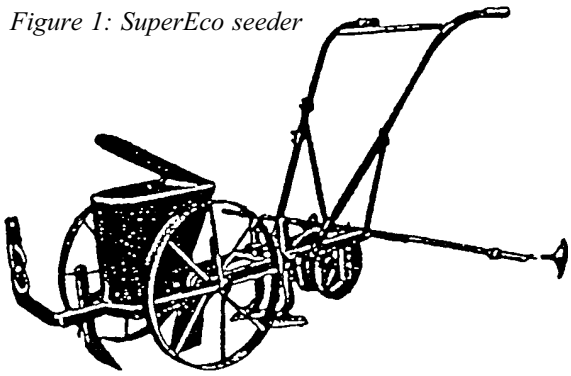
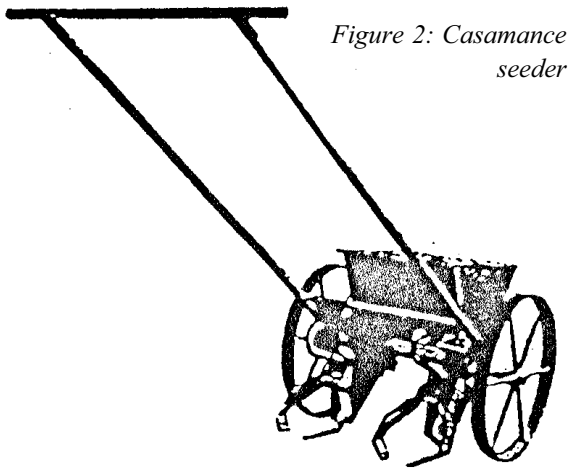


Figure 2: Casamance seeder



Evaluation of animal-drawn and hand-pulled seeders for rice

Two commercially available row seeders for rice were evaluated on-farm in cooperation with women rice farmers. The *SuperEco* is an animal-drawn single-row seeder that can be fitted with different plates to seed millet, sorghum, groundnut and maize as well as rice (Figure 1). There are an estimated 300 000 *SuperEco* seeders in Senegal (Havard, 1985) and 33 000 in The Gambia (Sumberg and Gilbert, 1988). The *Casamance* is a manual two-row seeder (Figure 2) designed to seed in 20-cm rows. Only a few hundred *Casamance* seeders have been introduced in southern Senegal between 1976 and 1980 (Havard, 1985).

Prior to field testing, the seeders were calibrated for a seed rate of 80 kg/ha using the short-grained upland rice cultivar Peking (24.6 g/1000 seeds). Seed was collected from the distributors over a 50 m length of concrete drying floor.

The seeders were subsequently tested on six farmers' fields where soil textures ranged from loamy sand to clay and soil and soil moistures from dry to saturated. The *Casamance* seeder was pulled by cooperating women, and traction

Table 1: *SuperEco* seeder calibration for seeding upland rice at 80 kg/ha seed rate[1]

Seed plate	*Seed rate* [2]	
30-tooth groundnut	378	25
24-hole groundnut		23
32-hole rice		

[1] *At a 30-cm row spacing, 240g/100m corresponds to an 80 kg/ha seed rate. At a 40-cm row spacing, 320g/100m corresponds to an 80 kg/ha seed rate*
[2] *Mean of five 50-m runs*

for the *SuperEco* was provided by a donkey in five of the tests and by a horse in the sixth.

Seeder performance

Seeder calibration

Calibration of the *Casamance* seeder was problematic because the seed apertures frequently became blocked, confirming the observations of Fall (1985) and Havard (1985). This was caused by breakage of an average of 16% of the seed by the seed distributor when the seeder was calibrated at 160 g/100 m of row (80 kg/ha at a 20-cm row spacing). Increasing the aperture reduced seed breakage but increased the seed rate to over 150 kg/ha. The *SuperEco* seeder was calibrated with the rice plate and groundnut plates (Table 1). Although the rice plate is a more precise seed plate, the 24-hole groundnut plate is widely available and can be used to maintain an 80 kg/ha seed rate when seeding in 40-cm rows.

Woman farmer participating in on-farm evaluation of SuperEco seeder, The Gambia

Field evaluation

The *Casamance* performed satisfactorily only in a well-prepared dry seedbed that was free of surface trash. When left on the soil surface following dry tillage, surface trash collected under the opening shoes preventing uniform seed drop. When seeding was delayed, rain compacted the soil, increasing the manual traction effort to a level that was unacceptable to women. The *SuperEco* performed satisfactorily under a wide range of conditions. The problem of surface trash collecting under the seeder was eliminated by removing one of the two covering blades. Under saturated soil conditions both covering tines were removed and the furrow was closed by the weight of the press wheel alone.

Conclusions on seeder options

The animal-drawn *SuperEco* is a superior seeder to the hand-pulled *Casamance* implement. Its advantages include:

- **greater versatility**: whereas the *Casamance* is designed to seed rice only, the *SuperEco* is used for sowing groundnuts and upland cereals as well
- **greater adaptability**: unlike the *Casamance* seeder, which functions satisfactorily only under ideal seedbed conditions, the *SuperEco* can be modified to sow under a wide range of conditions
- **greater flexibility**: the *Casamance* seeder is designed to seed 20-cm rows; the *SuperEco* can seed either 30- or 40-cm rows, maintaining the recommended seed rate of 80 kg/ha by using either rice or groundnut plates
- **greater availability**: there are currently 33 000 *SuperEco* seeders in use in The Gambia and more than 300 000 in Senegal, but no *Casamance* seeders in The Gambia and only a few hundred in Senegal. The majority of women in western Gambia should be able to borrow or rent a *SuperEco* seeder and avoid the expense of purchasing a rice seeder.

Evaluation of manual, mechanical and chemical weed control methods

The animal-drawn *Houe occidentale* cultivator was selected for the study because of its wide availability and light weight (Figure 3). When equipped with three sweeps it weighs only 18 kg, approximately half that of the *Houe sine* cultivator commonly used with oxen. Donkeys

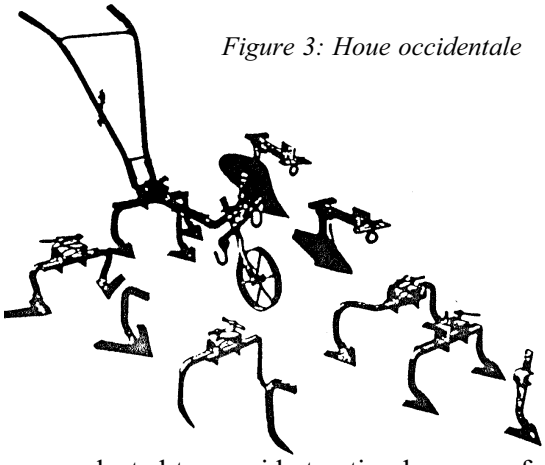


Figure 3: Houe occidentale

were selected to provide traction because of their greater availability compared with horses and oxen. An estimated 26 000 oxen, 16 000 horses and 37 000 donkeys were used for draft in The Gambia in 1988 (Sumberg and Gilbert, 1988).

Materials and methods

In 1987, three farmer-managed and one researcher-managed exploratory tests were carried out to ascertain the acceptability of the *Houe occidentale* for the control of inter-row weeds. A second objective of the researcher-managed test was to compare alternative methods of within-row weed control. The farmer-managed tests were seeded with the *SuperEco* seeder and cultivated twice with the *Houe occidentale*. Row spacing and within-row weeding were at the discretion of the cooperating farmers. The researcher-managed test was seeded in 30-cm rows (the recommended row spacing for upland rice) and cultivated at 25 and 47 days after seeding with the *Houe occidentale*. Within-row weed control treatments included: no within-row weeding; broadcast Ronstar at one day after seeding; and complete hand pulling at 52 days after seeding. Individual plot size was 15 x 43 m, or 645 m^2 (Table 2).

In 1988 three methods of within-row weed control were compared in a researcher-managed trial: no within-row weeding; banded application of Tamarice at 21 days after seeding; and selective hand pulling at 45 days after seeding. Rice was seeded in 40-cm rows with the *SuperEco* seeder and cultivated at 21 and 42 days after seeding with the *Houe occidentale.* This was a randomised complete block design with three replicates. Individual plot size was 3 x 35 m, or 105 m^2 (Table 2).

Results and discussion

Inter-row weed control with the donkey-drawn *Houe occidentale* was highly effective in both the farmer- and researcher-managed tests carried out in 1987. The three participating farmers seeded rice in 40-cm rows rather than the recommended 30 cm, and selectively hand pulled the larger within-row weeds only. In spite of the wider row spacing and the incomplete within-row weeding yields were excellent, ranging from 3.2 to 4.0 t/ha. In Nigeria, Akobundu and Ahissou (1985) found no significant yield difference when rice was seeded in 15-, 30- or 45-cm rows when weeds were adequately controlled, and Haddad and Seguy (1972) recommend the wider row spacing in order to facilitate animal traction weeding and reduce weeding time.

Table 2: Trial protocols for the researcher-managed evaluation of the animal-drawn *SuperEco* seeder and *Houe occidentale*, herbicides and manual weeding in direct-seeded rice production

Site	*Upland 1987*	*Rainfed lowland 1988*
Soil texture	Sandy clay loam	Sandy loam
Plowing	Tractor and disk harrow	Oxen and mouldboard plow
Seedbed preparation	–	Oxen and spike-tooth harrow
Row spacing	30 cm	40 cm
Seed plate	32-hole rice	24-hole groundnut
Variety	Barafita (90 days)	DJ 12-519 (100 days)
First cultivation	25 DAS	21 DAS
Second cultivation	47 DAS	42 DAS
Herbicide (T2)	Ronstar	Tamarice
Rate (kg ai/ha)	0.75	0.72/1.30
Application method	Broadcast	Banded
Application time	1 DAS	21 DAS
Hand pulling (T3)	52 DAS complete	45 DAS selective
Fertiliser (N-P-K)	48-6.6-12.5	48-6.6-12.5
Harvest	97 DAS	101 DAS

DAS = *days after seeding*

Table 3: Effect of broadcast Ronstar or complete within-row hand pulling in combination with two mechanical inter-row cultivations on upland rice yield in 1987

Treatment [1]	*Yield (kg/ha)*	*Yield increase (%)*
No within-row weed control	1291	–
Ronstar (1 day after seeding)	1655	28
Complete hand pulling (52 days after seeding)	1814	41

[1] *All three treatments were cultivated with the Houe Occidentale at 25 and 47 days after seeding*

In the researcher-managed test, weeding time was 12.2 hours/ha at a 30-cm row spacing. Increasing the row width to 40 cm, the spacing preferred by the farmers, would theoretically have reduced weeding time by 25%. In the researcher-managed test, yields increased by 28% following Ronstar treatment, and by 41% after complete removal of within-row weeds, compared with no within-row weed control (Table 3). The complete hand pulling of weeds required 89 days/ha. In contrast, the selective hand pulling of within-row weeds by the participating farmers required substantially less labour.

In the 1988 trial, banded Tamarice increased yields by 16% and selective hand pulling of within-row weeds by 11%, compared with inter-row cultivation alone (Table 4). When banded over the row, Tamarice significantly reduced weed weight at 45 days after seeding (Table 4). Selectively hand pulling the larger weeds only required 52 fewer days than in 1987, but resulted in only a 11% yield increase compared with no within-row control.

When calculating the benefit of herbicide or follow-up hand weeding in mechanically-weeded rice, the increased yields are offset by the following costs: herbicide, sprayer, labour for spraying, labour for hand weeding and labour for harvesting the additional yield. In the 1987 researcher-managed test, the costs associated with using Ronstar exceeded the value of the additional yield, giving a net loss of US$ 3.95/ha. However, in the 1988 trial, banded Tamarice was slightly profitable, with a net gain of US$ 11.39/ha. The complete hand pulling of weeds in 1987 resulted in a net loss of US$ 10.89/ha. This was due to the excessive number of days needed to complete the weeding. Selectively removing the larger weeds only, as done by the participating farmers the previous year, was profitable in the 1988 trial, with a net gain of US$ 8.95.

Conclusions

Inter-row cultivation with the donkey-drawn Houe occidentale

Inter-row cultivation with the animal-drawn *Houe occidentale* effectively controlled inter-row weeds, resulting in a yield of 1.3 t/ha in upland rice in 1987 and 3.2 t/ha in rainfed lowland rice in 1988, with no control of within-row weeds. Participating farmers demonstrated that increasing the row width to 40 cm can reduce the time needed for seeding and inter-row weeding without depressing yields.

Table 4: Effect of banded Tamarice or selective within-row hand pulling on rice yield and on weed weights in rainfed lowland rice in 1988

Treatment [1]	*Yield (kg/ha)*	*Yield increase (%)*	*Weed dry weight* [2] *(kg /ha)*
No within-row weed control	3235	-	475
Banded Tamarice (21 days after seeding)	3759	16	130
Selective hand pulling (52 days after seeding)	3597	11	625
Least significant difference (LSD at 5%)	ns		265
Coefficient of Variation (CV)	8.2%		28.6%

[1] *All three treatments were cultivated with the Houe Occidentale at 25 and 47 days after seeding*
[2] *Two of the treatments (no within-row weed control and selective hand-pulling) had received identical treatment at the time of weed sampling*

Within-row weed control with pre- and post-emergence herbicides

Both Ronstar in 1987 and Tamarice in 1988 effectively controlled weeds and increased yields over no within-row weed control. However, when inter-row weeds were mechanically controlled, a broadcast application of Ronstar at 3 l/ha was not profitable on low yielding upland rice and a post-emergence banded application of Tamarice at 3 l/ha was only slightly profitable on high-yielding rainfed lowland rice. Herbicide profitability can be increased by directing its use to high yield potential situations and by reducing herbicide quantity by banding.

Control of within-row weeds by hand pulling

Hand pulling of inter-row weeds is an effective but time-consuming method of weed control. As demonstrated by participating farmers in 1987, and confirmed in the researcher-managed trial in 1988, the time required for within-row hand weeding is less when the larger weeds only are selectively removed.

Recommendations

A technical package for improved weed control in direct-seeded rice that does not require the purchase of external inputs has been identified. Components of this package include:

- row seeding with the animal-drawn *SuperEco* seeder in 40-cm rows using the 24-hole groundnut plate for a seed rate of 80 kg/ha
- controlling inter-row weeds at 21 and 42 days after seeding with the animal-drawn *Houe occidentale*
- controlling within-row weeds by selectively hand pulling the larger weeds only.

Farmer adoption of mechanised row seeding

A survey was conducted in three villages in 1989 to ascertain the rate of adoption of the *SuperEco* seeder for row seeding rice fields that are normally broadcast seeded. Adoption rates of 25, 44 and 63% were extremely encouraging (Jones, 1989). Factors that encouraged adoption included animal ownership and participation in training programmes. In 1989 the Department of Agricultural Research organised a workshop on low external input rice production technologies, including mechanised row seeding (Gritton, 1989). Workshop participants included field staff of five non-governmental organisations who work directly with subsistence rice farmers, as well as government extension personnel. Since 1989 the adoption of mechanised seeding has continued to increase. In several villages it has become commonplace to observe men assisting women seeding with donkeys and *SuperEco* seeders (Leisz, 1992).

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