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Participatory evaluation of mechanical weeders in lowland rice production systems in Benin

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ABSTRACT

Weeds are a major constraint to rice (*Oryza sativa*) production in sub-Saharan Africa. Use of mechanical hand weeders could reduce the labor required for weeding. This paper uses a participatory approach to examine the suitability of six mechanical weeders in Benin. A total of 157 farmers (93 male, 64 female) in 14 villages tested the mechanical weeders, ranked them in order of preference, and compared them with their own weed management practices. The ring hoe had the highest rank, followed by the straight-spike weeder; 97% of the farmers preferred the ring hoe to their own weed management practices, by hand or using traditional hoe, because of its easy operation and high efficiency. The ring hoe tended to be preferred especially in the fields with non-ponded water and relatively higher weed pressure. The straight-spike weeder tended to be preferred to ring hoe in the fields where weed pressure is less, whereas in ponded conditions, farmers liked these two weeders in equal proportion. The preference of weeders was not related to gender, rice field size, or years of experience of rice cultivation. Among 23 farmers who used herbicides, 17 farmers preferred herbicides to the ring hoe and have rice field of >0.5 ha. Mechanical weeders can offer an effective approach for weed management, especially for small-scale rice farmers, and different types of mechanical weeders should be introduced to farmers based on water regimes and weed pressure level.

1. Introduction

Lowland rice production in West Africa occurs in a wide range of hydrological environments—from permanently flooded to permanently non-flooded conditions (Defoer et al., 2004). Rice grown on the upper slopes of valleys frequently experiences drought. Rice grown on the lower slopes benefits from a shallow water table and occasional flooding during the rainy season, whereas rice in the valley bottoms is usually grown under flooded conditions (Defoer et al., 2004). In this production system, weeds are one of the most important biological constraints to rice production with yield reduction ranging from 28 to 54% in transplanted and from 28 to 89% in direct-seeded lowland rice (Akobundu, 1980; Becker et al., 2003; Johnson et al., 2004; Rodenburg and Johnson, 2009). Large reductions in yield are due mainly to the limited number of effective and affordable weed management practices available to farmers (Rodenburg and Johnson, 2009). Farmers rely mainly on manual weeding or traditional hoe-weeding and, to a lesser extent, on herbicides (Adesina et al., 1994). Hand- or hoe-weeding, which are labor-intensive and time consuming, often result in delays in completing weeding, and consequently rice yields are reduced (Saito et al., 2010), while use of herbicides requires local availability of suitable products, functional application and protection equipment, and knowledge of safe application procedures. It is often difficult to meet these requirements in the region (Rodenburg and Johnson, 2009). Thus, improved weed management practices are needed to help reduce yield losses from weed infestation.

The introduction or development of mechanical hand weeders may be a cost-effective and safe approach for weed-management, particularly for resource-poor farmers in sub-Saharan Africa. The ideal weeders are adapted to a wide range of hydrological conditions and outperform current weed control by farmers. More importantly, such mechanical weeders should be locally and easily manufactured and the price should be affordable for the resource-poor farmers. Although mechanical weeders for irrigated lowland rice, such as the Cono Weeder, are currently available in some sub-

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Saharan countries (e.g. Burkina Faso, Madagascar), there are no mechanical weeders in most others, apart from simple and traditional hoes. This is the case for Benin, where we conducted this study. There is also limited knowledge of the efficacy of mechanical weeders in the lowland rice fields with different water availability in West Africa. Therefore testing a wide range of mechanical weeders for their performance across environments differing in water availability may provide new and useful information.

The objectives of this study were to investigate farmers' preferences among six mechanical hand weeders and their own weed management practices, and test whether the preference is related to field conditions, experience of rice cultivation, or gender. As we include different types of mechanical weeders, we hypothesize that farmers' perceptions would be affected by water status and soil texture. Weed cover could also affect farmers' preference, as weeders have different mechanisms for removing weeds. Also, farmers' perception of weeders might be related to socio-demographic parameters such gender and field size. This study used a participatory approach to evaluate the suitability of the weeders in field conditions (Bellon, 2001). Information obtained from farmers can provide insights for further improvement or modification of the technologies.

2. Material and methods

2.1. Description of the study area

The study area is in Benin; it covers Guinea Savanna in the south and Sudan Savanna in the north (latitude, 6°45′N to 11°48′N, longitude, 1°01′E to 3°24′E) and includes important rice cultivation areas (Table 1; Saito et al., 2013; Adegbola and Sodjinou, 2003).

2.2. Description of mechanical weeders

Technical details of the six mechanical weeders tested are shown in Table 2. Pictures and technical drawings can be obtained from the authors or the website (http://www.ricehub.org/).

Three weeders were manufactured in Japan: the ring hoe ("Kezuttaro Slim" DK-801; Doukan Co. Ltd., Hyogo), the straight-spike weeder ("Tagayasu power" TP-90; Mukai Kogyo Co. Ltd., Osaka), the two-row spike-and-blade weeder ("Kabumatohru", KJW-Z1; Sasagawanouki Co. Ltd., Niigata). The curved-spike floating weeder, twisted-spike floating weeder, and fixed-spike weeder were manufactured in Bobo-Dioulasso, Burkina Faso, Antsirabe, Magadascar, and Kumasi, Ghana, respectively. Apart from the ring hoe and fixed-spike weeder, the test weeders have a rotary action. The ring hoe and straight-spike weeder were originally developed for upland crops, whereas the others are intended mainly for flooded lowland conditions. While all the traditional hoes found in farmers' fields in this study require the user to stoop for weeding, all the mechanical weeders tested can be used in an upright position.

2.3. Participatory testing of mechanical weeders

On-farm testing of weeders using a participatory approach was undertaken from July 29 to September 20 2012. Fourteen rice fields in 14 villages (one field per village) were selected in collaboration with local extension officers, based on uniform crop establishment which is required for testing of the weeders (e.g. row sowing, sowing in grid formation), and weed infestation in the fields. Information was collected at each rice field (village-level) on land preparation methods and dates of crop establishment (by transplanting or direct sowing) by interviewing participants. Water status (completely or partially ponded; not ponded, but soil is wet.) and weed cover (weed cover ≤10%; weed cover >10% and ≤60%.) were visually scored by field observation (Savary and Castilla, 2009) (Table 1). Soil texture at 0–20 cm depth was determined by the hydrometer method (Gee and Bauder, 1979) and classified into two levels using clay content (clay content >20% and ≤20%) for statistical analysis.

For each test field, information was collected at farmer-level on 10–12 participating farmers randomly selected in the chosen village, excluding the farmers who were growing rice in the field. Prior to the participant selection process in each village, the gender ratio of the farmers who do weeding was determined to establish the number of male and female participants required (e.g. if weeding is always done by women, all the participating farmers should be women).

In each test field, the participating village farmers were assembled. We explained how to use the mechanical weeders one by one, and then asked all the participating farmers to test each weeder in one or two rows in the field and to evaluate effectiveness and ease of operation. Once all the weeders had been tested,

Table 1
Rice-growing environment and date of crop establishment in 14 fields, Benin.

Field code	Village where test field was located	Latitude	Longitude	Rice-growing environment	Sowing date for direct seeded rice	Transplanting date for transplanted rice	Weed infestation below rice canopy	Dominant weed group	Water regime at testing time	Soil texture	Clay content (%)
F1	Allahe	7°11′N	2°16′E	Rainfed lowland		July 18th	1[a]	1[b]	1[c]	Sandy loam	19
F2	Za-Hla	7°11′N	2°16′E	Rainfed lowland		July 9th	1	1	1	Sandy clay loam	27
F3	Deve	6°45′N	1°39′E	Rainfed lowland	July 15th		2	1	2	Sandy loam	15
F4	Kinwedji	6°43′N	1°40′E	Irrigated lowland		July 17th	2	1	1	Sandy loam	19
F5	Hlodo	6°44′N	1°40′E	Rainfed lowland		Aug 15th	1	2	2	Sandy loam	15
F6	Vovokanmey	6°47′N	1°45′E	Irrigated lowland		July 5th	2	1	1	Clay	53
F7	Ouedeme	8°00′N	2°11′E	Rainfed lowland	July 27th		2	1	2	Loam	13
F8	Kpakpa-zoume	7°55′N	2°15′E	Rainfed lowland	July 19th		2	2	2	Sandy loam	13
F9	Dogue	9°06′N	1°56′E	Rainfed lowland	July 28th		2	1	1	Sandy loam	15
F10	Kodowari	9°11′N	1°34′E	Rainfed lowland	Aug 5th		2	2	2	Sandy loam	15
F11	Cobly	10°28′N	1°01′E	Rainfed lowland	Aug 19th		1	3	2	Sandy loam	15
F12	Bagapodi	10°31′N	1°03′E	Rainfed lowland	Aug 23rd		2	1	2	Sandy loam	15
F13	Monkassa	11°47′N	3°24′E	Rainfed lowland		July 20th	1	2	1	Sandy clay loam	25
F14	Bodjekali	11°48′N	3°23′E	Rainfed lowland		Aug 10th	2	2	2	Loam	19

[a] 1 = weed cover ≤10%; 2 = weed cover >10% and ≤60%.
[b] Broad-leaved species = 1; sedges = 2; grasses = 3.
[c] 1 = completely or partially ponded; 2 = not ponded, but soil is wet.