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RESEARCH ARTICLE

TECHNICAL EVALUATION OF MANUAL WEEDERS FOR IRRIGATED RICE CULTIVATION IN BURKINA FASO: CASE OF ROTARY AND CONO WEEDERS

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ABSTRACT

Two rotaryweeders with, conical and hexagonal were developed and their performance was evaluated. Various parameters such as weeding efficiency, plant damage, field capacity and weeding time reduction were considered during the trial. The AfricRice rotary weeder and a hand hoe were used as controls. The Boulbi irrigated paddy field was used as the experimental setting.The trial was conducted in a completely randomized Fisher block design with 4 replications in an SRI. The performance of three weeders, two designed (hexagonal (T2) and conical (T3)) were evaluated with the AfricaRice model (T1) compared to weeding with the manual hoe (T0). Data were collected on performance and yield parameters. They were recorded with XLSTAT Version 2016.02.27444 and subjected to descriptive analyses. The results revealed that among the weeders, the highest actual field capacity was 0.024 ha/h with T3 and the lowest 0.014 ha/h with T1. The lowest percentages of plant damage at 15 DAT and 30 DAT were 0.26% and 0.16% with T0 and the highest 2.63% and 1.80% with T3. Weeding with the weeders reduced labor time for all three weedings by 55% with T1, 65% with T2 and 70% with T3 compared to T0.

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INTRODUCTION

In Burkina Faso, rice is of great importance in terms of consumption and cultivated area. Indeed, a staple food in most regions of the country, it represents, in order of importance, the fourth most important cereal crop in Burkina Faso, in terms of area, production and annual per capita consumption (MARHASA, 2015). However, rice growing in Burkina Faso, like most of the country's crop production, is subject to various biotic (diseases, insects and weeds) and abiotic (drought, soil poverty) constraints. The most important biotic constraints are weeds, nematodes, insect pests and diseases caused by bacteria, viruses and fungi, which limit production by 10 to 15% depending on the cropping season (Traore *et al.,* 2009; Sérémé *et al*., 2014; Wonni *et al.,* 2014; Thio *et al.,* 2017; Sanou *et al.,* 2019). Among crop pests, weeds are considered the most formidable. They cause enormous yield losses, and their management requires the mobilization of a large workforce. Indeed, in all regions, crop pests, particularly weeds, cause major yield losses. Crop weeding represents a high demand for manpower during the relatively short peak period when cultivation operations follow one another: ploughing, sowing and first weeding of the various crops.

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This labor requirement represents a bottleneck in the technical production itinerary, which is particularly acute in regions with low rainfall. In rice cultivation, weeding is the most tedious, laborious and time-consuming operation. It is estimated that one-third to one-half of the labor used in rice cultivation is devoted to weed control, with an average of 30-40% of labor-day/ha (Hobbs and Bellinder, 2004). The overall yield loss induced by weeds is of the order of 10% of actual yield (Remesan *et al.,* 2007). Yield losses range from 10 to 50% for transplanted rice and from 50 to 90% for upland rice, depending on the level of weed infestation (Remesan *et al.,* 2007). According to Johnson (1997) quoted by Nadié (2008), weed-related losses are estimated at 15% for irrigated rice and 30% in lowlands. The problem of weed management is therefore acute. To minimize losses caused by weeds, agricultural plots, both perennial and food crops, need to be weeded regularly, in accordance with the technical itineraries of the crops concerned. This should be done more or less frequently, depending on the age and/or type of crop, to avoid weed invasion leading to plot abandonment. In West Africa, and more particularly in Burkina Faso, agriculture is very poorly mechanized, so weeding is done by hand, with a hoe and/or by spraying herbicides. Manual weeding absorbs 20 to 50% of total work, from soil preparation to harvesting (Le Bourgeois, 1993). Mechanical and chemical controls are costly, and financial resources are not always available. With this in mind, it is more than ever necessary to introduce innovative technologies that are accessible and that take into account growers' purchasing power and respect for the environment, for healthy, sustainable production. The overall goal of this study is the technical evaluation of locally manufactured rotary weeder and conoweeder used for weed management to help increase the productivity of irrigated and lowland rice in Burkina Faso.

MATERIAL ET METHODS

Study Site

The study was conducted on the Boulbi irrigated paddy field. It is located in central Burkina Faso, in the rural commune of Komsilga, 25km south of Ouagadougou. The commune of Komsilga is one of six (06) communes in the Centre region. Located in the province of Kadiogo, it is bordered to the east by the commune of Koubri, to the west by the communes of Komki-Ipala and Tanghin-Dassouri, to the north by arrondissements 7 and 12 of the commune of Ouagadougou and to the south by the communes of Saponé and Kayao (province of Bazèga). The geographic coordinates are precisely 1° 35' 38" and 12° 16' 45" West longitude, 12° 03' 43" and 12° 16' 45" North latitude (PCD, 2013).

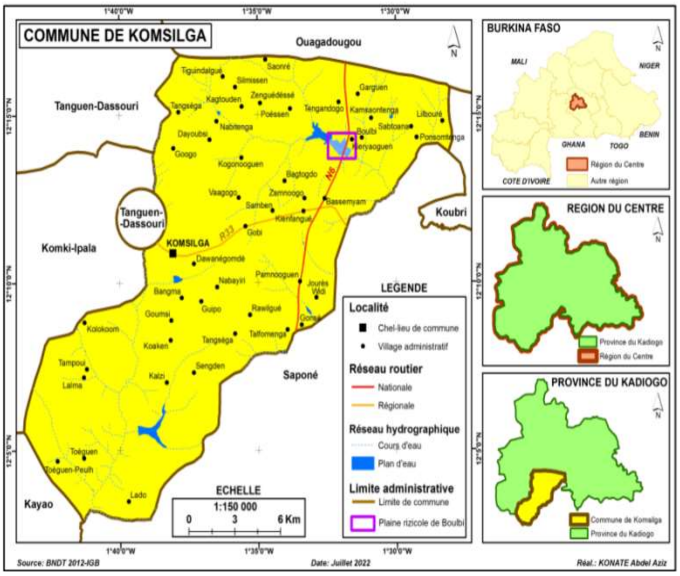


Figure 1. Geographic location of study site (BNDT/IGB, 2012)

Experimental Design

The trial was carried out on the farm using a completely randomized Fisher block design in an SRI system consisting of 4 treatments. The design was randomly repeated in 4 blocks of farms out of the 7 blocks on the Boulbi irrigated plain, to obtain 4 replicates per treatment. One farmer was randomly selected from each of the four blocks among those practicing SRI to conduct the trials. The spacing between bunches and between rows was 25 x 25 cm respectively. The surface area of each elementary plot was 30 m^2 (10 m x 3 m), spaced 1 m apart with a lane bund. The surface area of the block was 176 m^2 (22 m x 8 m).

Four tools were used during the weeding operations that made up the treatments:

- Weeding with the hand hoe (T0);
- Weeding with the Africa Rice model weeder (T1);
- Weeding with the rotary weeder (T2);
- Weeding with the cono weeder (T3).

Weeding frequency took place on the 15th day after transplanting (15 DAT), at 30 DAT and 45 DAT. Figure 2 below illustrates the experimental set-up of the study.

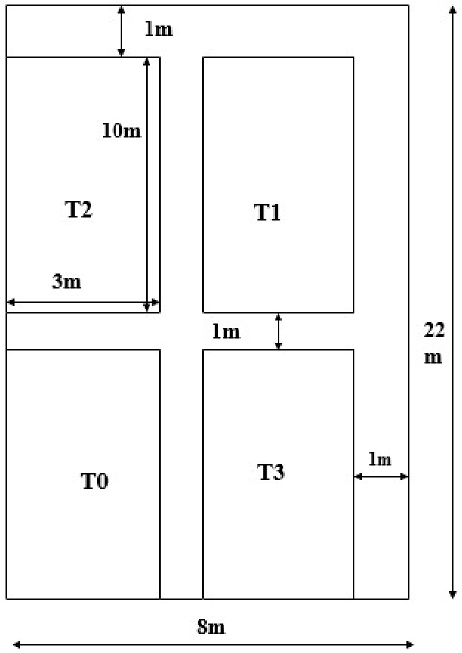
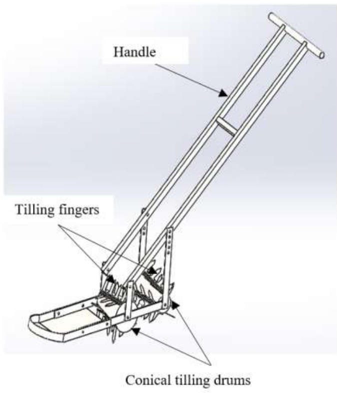


Figure 2. Experimental design

Figures 3 and 4 below illustrate the two types of weeders manufactured locally.



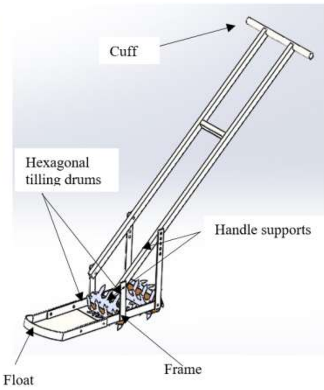


Figure 3. Cono weeder **Figure 4. Rotary weeder**

Data Collection: The variables measured concerned the capacity, efficiency and plant damage factor of the weeders used during weeding operations. They concerned:

Theorical field capacity (ha/h): The theoretical field capacity of the weeders was calculated using the relationship of Shakyaetal. (2016).

$$\textit{Theorical field capacity (ha/h)} = \frac{Weededarea}{Speedx\ 10000} \text{(Equation 1)}$$

With area in m^2andv = speedin km/h.

Effective field capacity (ha/h): The effective capacity of the weeders was calculated according to the relationship of Shakyaet al. (2016).

$$\textit{Effective field capacity (ha/h)} = \frac{Areacoveredbyweeder}{Totaltimex10\ 000} \text{(Equation 2)}$$

With area in $m^2$and time in hour (h).

Field efficiency (%): It was calculated using the relationship of Shakyaet al. (2016).

$$\textit{Field efficiency (\%)} = \frac{Effectivefieldcapacity}{Theoricalfieldcapacity} x\ 100 \qquad \text{(Equation 3)}$$

Work capacity (h/ha): The working capacity of the weeders was calculated from the relationship of Bhagwan et al. (2016).

$$Work\ efficiency\ (h/ha) = \frac{1}{Effective field capacity} \quad \text{(Equation 4)}$$

Weeding efficiency: For weeding efficiency, weeds in a 1 m^2 area were counted before and after weeding. The mean value for weeding efficiency was calculated using Padole's (2007) relationship.

$$Weeding\ efficiency\ (\%) = \frac{W1-W2}{W1} X\ 100 \quad \text{(Equation 5)}$$

With W_1 = number of weed before weeding and W_2 = number of weed after weeding.

Plant damage factor (DPF): Plants on a 10 m line were counted before and after weeding and the plant damage factor was calculated using the following relationship (Yadav and Pund, 2007).

$$DPF\ (\%) = \left(1 - \left[\frac{q}{p}\right] X\ 100\right) \quad \text{(Equation 6)}$$

With : q = total numberof plants on 10 m line after weeding;
p = total number of plants on 10 m line before weeding.

Figures 5 and 6 below illustrate weeding operations at 30 DAT and 45 DAT.

Figure 5. Weeding at 30 DAT

Figure 6. Weeding at 45 DAT

RESULTS AND DISCUSSION

Weeder Technical Specifications: At the end of the tests, it was found that the conoweeder was the fastest, with an average weeding speed of 1.24 km/h, and the hand hoe the slowest, with an average weeding speed of 0.602 km/h. As for the actual field capacity of the weeders, the conoweeder with recorded the highest capacity of 0.024 ha/h and the hand hoe the lowest at 0.007 ha/h. As for useful weeding widths, the two weeders manufactured have a working width of 20 cm, compared with 15 cm for the Africa Riceweeder and 8 cm for the hand hoe. Table 1 below gives the technical specifications of the weeders used during weeding operations.

Table 1. Technical specifications for weeders used in weeding operations

Specifications	SMRA	SMRH	SMRC
Total length (mm)	1500	1560	1560
Total height (mm)	Mini = 720 Maxi = 1000	Mini = 840 Maxi = 1260	Mini = 740 Maxi = 1130
Total width (mm)	300	420	420
Weight (kg)	4,80	6,15	6,25
Number of elements / weeding fingers	6 blades, 3 with 2 fingers and 3 with 3 fingers	6 blades, 3 with 3 fingers and 3 with 4 fingers	6 blades, 3 with 3 fingers and 3 with 4 fingers
Workingwidth(cm)	15	20	20
Float dimensions (L x l x H) (mm)	135 x 150 x 30	250 x 200 x 30	250 x 200 x 30
Rotor spacing(mm)	210	190	230
Number of lines per run	1	1	1
Energy source	Man	Man	Man

Legend : SMRA : Africa Riceweeder ; SMRH : Rotary weeder; SMRC : Conoweeder.

Weeder Performance: Analysis of the data recorded in Table 2 shows that weeding efficiency increases regardless of the tool used. This is explained by the low density of weeds following past weeding operations. The plant damage factor decreases from 15 DAT to 30 DAT and cancels out at 45 DAT. This is due to the fact that at 45 days, the rice plants are very well rooted and have a certain height, so the weeders slide between the rows without causing any damage to the rice plants. As regards the time taken for weeding, it has to be said that weeding with the hand hoe took much longer at 15 DAT than with the manual weeders. It took 154.76 h/ha, i.e. around 20 Men/day/ha for 8 hours of work, compared with 45.05 h/ha for the conoweeder, which performed better with 6 Men/day/ha for 8 hours of work. Weeding with the conoweeder saved 14 Men/day compared with weeding with the hand hoe. The time required for weeding decreases with increasing weeding frequency, whatever weeder is used.

DISCUSSION

According to (Shakya *et al.*, 2016), the performance index of weeding tools is directly linked to the effective field capacity, to weeding efficiency and inversely to the power exerted. This is a decisive factor in the choice of weeding tools for crops, and more specifically for rice, especially as poor weed management can lead to irreversible losses. Average values for effective field capacity of the weeders are around 0.007 ha/h for the hand hoe and 0.014 ha/h for the Africa Riceweeder. As for the manufactured models, we obtained average values of 0.022 ha/h for the rotary weeder and 0.024 ha/h for the conoweeder. These performance results are similar to those of a comparative study of rotary and conoweeders carried out in South India by Remesan *et al.* (2007), where they obtained an effective field capacity of 0.021 ha/h for the rotary weeder and 0.024 ha/h for the conoweeder. As for weeding with the hand hoe, Burkina Faso farmers performed better, as the same authors obtained a working output of 0.003 ha/h with the hand hoe. The low capacity of the Africa Riceweeder compared with the manufactured rotary weeder is due to the narrow working width of 15 cm versus 20 cm.

Table 2. Weeder performance

Treatments	Weedingefficiency (%)			Plants domage factor (%)			Weeding time (h/ha)		
	15DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T0	97.66	97.89	97.30	0.26	0.16	0.00	154.76	128.60	121.34
T1	93.37	97.10	94.10	2.13	1.30	0.00	72.28	67.27	39.35
T2	95.35	96.96	96.01	2.55	1.73	0.00	50.63	43.56	39.00
T3	94.79	96.12	94.89	2.63	1.80	0.00	45.05	38.30	36.81

These results corroborate those of Shakya *et al.* (2016), who showed that the difference between effective field efficiencies is linked to the large difference between useful working widths. Weeding efficiency at 15 DAT, 30 DAT and 45 DAT increased irrespective of the weeder used. This is due to the fact that the number of weeding frequencies considerably reduces weed density in the rice field.The values recorded are 97.67%; 97.90% and 98.30% respectively for weeding with the hand hoe; 93.37%; 97.10% and 97.50% for weeding with the Africa Rice weeder; 95.35%; 96.96% and 97.30% for weeding with the rotary weeder and 95.79%; 97.50% and 97.75% for weeding with the conoweeder. These trends are contrary to those of Bhagwan *and al.* (2016), who conducted a study in India on the performance evaluation of manual rice weeding tools at 20 DAT and 35 DAT, with decreasing efficiency. Their results were 99.01% and 97.09% for hand hoe weeding, 75% and 73.41% for rotary weeder and 73.20% and 70.42% for conoweeder. In their study, different levels of weediness were considered. That is, first weeding at 20 DAT and second weeding at 35 DAT. Their results show that the higher the level of weediness is, the lower the weeding efficiency is.

In terms of plant damage factors for the same weeding frequencies, the higher the plants, the less damage they suffer during weeding operations, whatever weeder is used. The percentage of damage decreases from 15 to 30 DAT, and is cancelled out by 45 DAT. After 45 days, when rice plants have reached maximum growth, weeder movements between rows can no longer cause damage to the plants.
Weeding with manual weeders saved time compared with weeding with a hand hoe. At the first weeding on 15 DAT, the working capacities (output) of the weeders were of the order of 154. 67 h/ha or about 20 Men/day/ha during 8hours of work for weeding with the hand hoe, 72, 28 h/ha (approx. 9 Men/day/ha) for the Africa Riceweeder, 50.63 h/ha (approx. 7 Men/day/ha) for the rotaryweeder and 45.05 h/ha (approx. 6 Men/day/ha) for the conoweeder. Weeding with manual weeders reduced labour time for the three weeding operations combined by 55% with the Africa Riceweeder with wheels, 65% with the rotary weeder and 70% with the conoweeder, compared with weeding with the hand hoe. These results corroborate those of Uprety (2010), who showed that labor requirements were reduced by 60% and the time needed for all the main rice-growing activities by 70% with the use of mechanization.

CONCLUSION

Manual rotary and conoweeders can be easily manufactured by craftsmen after training. The weeders manufactured in Burkina Faso have nominal performances of around 0.024 ha/h for the conoweeder and 0.022 ha/h for the rotaryweeder as effective field capacity. Weeding with the manufactured weeders reduced working time for the three weeding operations combined by 65% with the rotaryweeder and 70% with the conoweeder, compared with weeding with the hand hoe. Weeders can be easily used by farmers. They are easy to maintain and suited to the needs of farmers with limited financial resources.

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Compliance with Ethical Standards

Conflict of interest disclosure.
The authors declare that there are no conflicts of interest.

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