International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Effects of Tillage and Weeding Frequency on Rice Yield and Yield Components

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Abstract

The upland field study was conducted during the 2014 major crop growing season under rainfed condition on a sandy loam soil (Ferric Acrisol) to compare the effect of different tillage practices and weeding frequency on yield parameters and yield of NERICA 4 rice variety at the Savannah Agricultural Research Institute of the Council for Scientific and Industrial Research, Nyankpala, Northern Region of Ghana. The experiment was arranged in a split plot design with three replications. The tillage treatments consisted of disc ploughing only, disc ploughing followed by disc harrowing, and no tillage as main plots and four weeding frequencies (weeding thrice, twice, once and no weeding) as sub-plots.

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The results indicated significant effects of tillage practices on the yield components and yield of NERICA 4. Disc ploughing followed by disc harrowing produced the highest number of panicles, panicle weight, number of spikelet's per panicle, dry matter yield, number of grains per panicle, 1000-grain weight, grain yield and the longest panicles. The no tillage treatment gave the lowest yield performance. Similarly, weeding frequency significantly affected the yield components and yield of NERICA 4. Weeding thrice resulted in the best yield components and yield and the no weeding treatment recorded the poorest performance. Therefore, under the soil and weather conditions of the experiment, the best tillage practice and weeding frequency for NERICA 4 rice production is disc ploughing followed by disc harrowing, and weeding three times.

Keywords: Tillage; weed control; rice; yield.

1. Introduction

Rice is the seed of the grass species *Oryza sativa* (L.) (Asian rice) or *Oryza glaberrima* Steudel (African rice) [1]. As a cereal grain, rice is the food most consumed by much of the human population of the world, especially in Asia [2]. After maize (corn), rice has the second-highest global production and as such it is considered as the most significant grain with regard to human nutrition and caloric intake, providing more than a fifth of the calories consumed globally by the human species [3].

In Ghana, rice is regarded as the second most important cereal after maize and is rapidly becoming a cash crop for many farmers [4]. Rice is grown in all the 10 regions of Ghana mostly by smallholder farmers. In 1961, the area under rice production in Ghana was 27,518 ha and increased about eight times to 215,905 ha in 2013. Similarly, the production of rice in Ghana was 30,400 tonnes in 1961 compared to 569,524 tonnes in 2013, an increase of nearly 19 times [5]. Ghana has been importing rice using its scarce foreign exchange. [6] reported that annual rice imported into Ghana amounts to about US$500 million. Rice production in Ghana is constrained by several factors, including land tenure problems, removal of subsidy on inputs, absence of water control systems, erratic rainfall distribution, declining soil fertility, little or inadequate use of chemical fertilisers, poor insect pest control, poor weed control, and inappropriate tillage practices.

Tillage is the physical improvement of soil properties for the purpose of supporting crop growth. It is a process which involves the use of human, animal or machine energy for physical manipulation of soil to provide conditions favorable for plant growth [7]. The choice of the most suitable type of tillage depends on physical factors, such as soil properties, rainfall regime, climate, drainage conditions, rooting depth, soil compaction, erosion hazards, cropping systems, and socio-economic factors, including farm size and availability of inputs [8]. Furthermore, the use of correct tillage methods may help to promote higher profits, crop yields, soil improvement and protection, weed control and optimum use of water resources since tillage has a direct impact on soil and water quality [9].

Weeds are a constant pest of rice and can cause huge crop failures over vast areas [10]. Weeds remain the major crop production constraint in rainfed uplands and in the unbunded lowlands where they cannot be controlled by flooding the soil surface [11]. Weeds reduce crop yield through competition with crop plants for nutrients, space and light, deteriorate the quality of the produce and thereby reduce the market value of the produce [12]. Successful weed control in rice is essential for the optimum production of the crop. Delayed weed control may cause severe yield loss - yield losses could exceed 90 percent [13]. Yield losses are most severe when resources are limited and weeds and crops emerge simultaneously thereby reducing the competitive advantage of the crop [13]. The objective of this study was to assess the effects of tillage and weeding frequency on the yield components and yield of the upland rice variety NERICA 4.

2. Materials and Methods

The field experiment was conducted to evaluate the effect of different tillage practices and weeding frequencies on the yield and yield attributes of NERICA 4 during the major cropping season in 2014 at the upland rice experimental field of the Savannah Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) in Nyankpala located in the Guinea Savannah agro-ecological zone of Ghana. The experiment was laid out as a split-plot under a Randomized Complete Block Design (RCBD) with three replications. The size of each sub plot was 5 m x 6 m. There were three tillage treatments (DP = disc ploughing only, DP&H = disc ploughing followed by disc harrowing and NT = no tillage) as main plots and four weeding frequencies (1W = one weeding, 2W = two weeding, 3W = three weeding and 0W = no weeding) were considered as sub plots. The NERICA 4 rice variety was sown on 24 July, 2014. All recommended agronomic operations were adopted to raise a good crop. The characteristics of the experimental soil are given in the Table 1. Average temperature and rainfall data during the experimental period are presented in Table 2.

2.1 Data collection

Data on yield and yield components were collected from 10 hills per plot and the average calculated. The number of panicles, panicle length, panicle weight, number of spikelets per panicle, number of grains per panicle, dry matter yield, 1000–grains weight and grain yield were determined at harvest. Panicle length was recorded from the basal node to the apex of each panicle. The number of filled grains per panicles on each hill was counted. Total number of grains from 10 randomly selected hills were counted and then averaged. One thousand clean dried grains were counted from the seed lot obtained from each plot and weighed on an electronic balance. Grains obtained from 10 randomly selected hills were sun-dried and weighed carefully to determine the average grain weight hill^{-1}. Straw obtained from the 10 sample hills in each plot was dried in sun and the average weight and dry matter weight determined. Grains harvested from each plot were sun-dried and weighed carefully. The dry weights of grains from the panicle sampled from the 10 hills per plot were added to the respective plot yield to record the grain yield per plot.

2.2 Data Analysis

The data were subjected to analysis of variance with the help of computer package MINITAB Statistical Software Release 15 [14]. The mean differences among the treatments were tested with the Least Significant Difference Test (LSD) at 5% level of probability.

Table 1: Soil properties at the experimental site

	Soil layer (cm)	
Soil Property	0–15	15–30
Sand (%)	51.64	47.64
Silt (%)	42.00	46.00
Clay (%)	6.36	6.36
Organic Carbon (%)	0.312	0.273
pH	4.70	4.51
Total N (%)	0.0269	0.0198
Ca (mg/kg)	184.67	187.63
Mg (mg/kg)	63.98	68.27
K (mg/kg)	49.85	55.76
Available P (mg/kg)	3.3125	6.0325
Exchangeable Acidity	1.43	1.27

Table 2: Temperature and rainfall at the experimental Site

Month	Tmax (^oC)	Tmin (^oC)	Rainfall (mm)
July	30.9	24.9	122.9
August	30.4	23.3	240.0
September	30.5	23.1	195.6
October	32.7	23.5	153.1
November	35.6	24.3	0.0

Tmax (^oC) Maximum Air Temperature; Tmin (^oC) Minimum Air Temperature

3. Constraints of the study

Notwithstanding the significant roles tillage and weed control plays in this study, its progress was faced by a number of constraints, amongst which were high cost of hiring tractor for ploughing and harrowing, less access to funds, limited and high cost of farm labour for planting and weeding.

4. Results and discussion

4.1 Yield and yield components

The results showed a significant effect of tillage and weeding frequency on the yield and yield components of NERICA 4 rice variety. Tillage significantly affected the number of panicles, panicle length, panicle weight, number of spikelets per panicle, dry matter yield, grain yield and 1000 grain weight at 109 days after planting (DAP) (Table 3). Disc ploughing followed by disc harrowing gave the highest grain yield (4.073 t/ha) which was significantly higher than the yield associated with the disc plough only and no tillage treatments. The no tillage had the lowest grain yield (2.051 t/ha). On the other hand, differences between disc ploughing only (3.060 t/ha) and no tillage (2.051t/ha) were also significant (Table 3). A similar result was reported by [15] who recorded higher rice yield with disc ploughing followed by disc harrowing compared with disc ploughing only and no tillage in an Acrisol in Yandev, North Central Nigeria. Reference [16] reported higher maize yields under conventional tillage than under no tillage plots in the chernozem soil type in Zemun Polje, Serbia. Similarly, yield-related parameters, including number of panicles, panicle length, panicle weight, number of spikelets per panicle, straw yield and 1000 grain weight were significantly affected by the tillage treatments. The highest number of panicles (4.4) was obtained with disc ploughing followed by disc harrowing and no tillage resulted in the lowest number of panicles (3.0). Disc ploughing followed by disc harrowing gave the longest panicles (25.92 cm) while the shortest panicle (22.76 cm) was associated with no tillage. Disc ploughing followed by disc harrowing produced the heaviest panicles (4.0 g) while no tillage produced the lightest panicles (2.7 g). Similarly, the number of spikelets per panicle was significantly higher with disc ploughing followed by disc harrowing (13.4) than with the other tillage treatments and lowest with the no tillage treatment (10.6). These results are similar to that of [17] who reported higher rice panicle length, panicle weight and number of spikelets per panicle in conventional tillage plots than in conservation tillage plots on a sandy clay loam soil in Alexandria University, Egypt.

The result further indicated that the number of filled grains per panicle and 1000-grain weight was significantly influenced by tillage treatments. Both the number of filled grains per panicle (134.0) and 1000-grain weight (25.8) were significantly higher with the disc ploughing followed by disc harrowing treatment than with the no tillage treatment. There was, however, no significant difference in these yield components between the disc ploughing followed by disc harrowing treatment and that of the disc ploughing only treatment. The disc ploughing only treatment also resulted in significantly higher number of filled grains per panicle and 1000-grain weight than those of the no tillage treatment. These results are similar to those of [18] who observed that maize (*Zea mays* L.) had higher 1000-grain weight in the disc ploughing followed by disc harrowing plots than that of the disc plough only and no tillage plots on a sandy loam soil in Kumasi which is located in the semi-deciduous agro-ecological zone of Ghana. The disc ploughing followed by disc harrowing treatment had the highest dry matter yield (7.187 t/ha) while the no tillage treatment had the smallest dry matter yield (5.007 t/ha) which was below the average dry matter yield of 6.195 t/ha. According to [19], rice is not very competitive with weeds during the seedling stages, though this can be an important factor during the vegetative and reproductive stages. Crop competitiveness with weeds is particularly important to limit weed infestation after the initial weed control treatments. In this study, weeding frequency significantly ($p<0.05$) affected yield and yield components (number of panicles, panicle length, panicle weight, number of spikelets per panicle, straw yield, grain yield and 1000 grain weight) in NERICA 4 (Table 3). The highest number of grains per panicle was produced with weeding thrice (145.7) and least with the no weeding treatment (99.3). Similarly, weeding thrice resulted in the highest 1000-grain weight (26.6 g) and the no weeding treatment had the lowest (22.0 g). Weeding three times produced the highest grain yield (5.199 t/ha) compared to 1.357 t/ha for the no weeding treatment. Similar results were reported by [20] who recorded higher rice grain yield and 1000-grain weight with weeding thrice than weeding twice or once. The higher number of grains per panicle, 1000-grain weight and grain yield of

NERICA 4 under three weedings over the other weeding treatments might be due to less nutrients, moisture, light and space competition between crop and weeds in this treatment. Weeding three times gave the highest number of panicles per plant (5.2), significantly higher than those of the other weeding treatments, while the no weeding treatment gave the lowest (2.4). Panicles were longest with weeding thrice (26.3 cm) and shortest (22.8 cm) with no weeding. Weeding thrice gave the highest panicle weight (4.3 g) significantly greater than those of the other weeding frequency treatments and the no weeding treatment gave the smallest (2.6 g). This trend is similar to the findings by [20]. The highest number of spikelets per panicle (14.1) was recorded in plots weeded thrice than those that were not weeded (9.9). Weeding frequency significantly influenced the dry matter yield of NERICA 4 – 10.117 t/ha with weeding thrice, 8.400 t/ha with weeding twice, and 1.872 t/ha with no weeding. [20] reported similar results for rice in Bangladesh.

Table 3: Effects of tillage and weeding frequency on yield and yield components of NERICA 4 rice variety

Treatment	**Panicle no.**	**Panicle Length (cm)**	**Panicle weight (g)**	**No. of spikelets/panicle**	**No. of grains/panicle**	**Dry matter weight(t/ha)**	**Yield (t/ha)**	**1000-grain weight. (g)**
DP	3.6	24.88	3.6	12.5	130.0	6.391	3.060	24.9
DP&H	4.4	25.92	4.0	13.4	134.0	7.187	4.073	25.8
NT	3.0	22.76	2.7	10.6	110.7	5.007	2.051	22.6
Mean	3.7	24.52	3.5	12.2	124.8	6.195	3.061	24.4
LSD (5%)	0.32	0.507	0.19	0.46	4.37	0.708	0.255	1.10
Weeding frequency								
1W	3.0	23.67	3.2	11.4	117.0	4.392	2.144	23.8
2W	4.0	25.30	3.8	13.2	137.6	8.400	3.545	25.2
3W	5.2	26.34	4.3	14.1	145.7	10.117	5.199	26.6
0W	2.4	22.77	2.6	9.9	99.3	1.872	1.357	22.0
Mean	3.7	24.52	3.5	12.2	124.9	6.195	3.061	24.4
LSD (5%)	**0.32**	**0.4998**	**0.13**	**0.51**	**3.87**	**0.423**	**0.217**	**0.76**
CV	**8.8**	**2.1**	**3.7**	**4.3**	**3.1**	**6.9**	**7.1**	**3.2**

NB: DP = disc ploughing only; DP&H = disc ploughing followed by disc harrowing; NT = no tillage; 1W = one weeding; 2W = two weeding; 3W, three weeding; 0W = no weeding; Dm = Dry matter; LSD=least significant difference, CV = coefficient of variation.

4.2 Interaction between tillage and weeding frequency on yield and yield components

There was significant interaction effect of tillage and weeding frequency on the yield and yield components of

NERICA 4 except for the number of spikelets per panicle, number of grains per panicle and 1000-grain weight (Table 4). The highest number of panicles (6.8), longest panicles (27.5 cm), and highest panicle weight (4.7 g) were recorded in the disc ploughing followed by disc harrowing and weeding thrice interaction. The interaction effect of no tillage and no weeding produced the lowest number of panicles (2.1), shortest panicles (21.5 cm), and lowest panicle weight (1.9 g). Tillage and weeding frequency did not have significant interaction effect on the number of spikelets per panicle, number of filled grains per panicle and 1000-grain weight (Table 4). The combination of disc ploughing followed by disc harrowing and weeding three times gave the highest number of spikelets per panicle (15.7), highest number of filled grains per panicle (153.3) and highest 1000-grain weight (28.0). On the other hand, the no tillage and no weeding interaction produced the smallest number of spikelets per panicle (8.3), lowest number of filled grains per panicle (87.7) and smallest 1000-grain weight (20.3). The combination of disc ploughing followed by disc harrowing and weeding thrice gave a grain yield of 7.252 t/ha compared with 0.923 t/ha for no tillage and no weeding. Similarly, the combination of disc ploughing followed by disc harrowing and weeding thrice produced the highest dry matter yield (11.722 t/ha) compared with 1.345 t/ha for no tillage and no weeding.

Table 4: Interaction effect of tillage and weeding frequency on yield and yield components of NERICA 4 rice variety

Tillage x weeding frequency	**Panicle no.**	**Panicle length(cm)**	**Panicle Weight (g)**	**No. of spikelets/ Panicle**	**No. of grains/panicle**	**Dry matter weight (t/ha)**	**Yield (t/ha)**	**1000-grain weight (g)**
DP x 0W	2.6	23.20	2.8	10.3	102.7	1.995	1.475	22.4
DP x 1W	2.9	23.67	3.4	12.3	121.7	4.712	2.137	24.3
DP x 2W	4.0	25.83	3.9	13.3	144.0	8.425	3.735	25.7
DP x 3W	4.7	26.83	4.5	14.0	151.7	10.432	4.893	27.4
DP+H x 0W	2.6	23.60	3.1	11.0	107.7	2.276	1.672	23.3
DP+H x 1W	3.5	25.20	3.7	12.3	127.7	4.908	2.762	25.0
DP+H x 2W	4.7	27.33	4.5	14.7	147.3	9.844	4.608	26.6
DP + H x 3W	6.8	27.53	4.7	15.7	153.3	11.722	7.252	28.0
NT x 0W	2.1	21.50	1.9	8.3	87.7	1.345	0.923	20.3
NT x 1W	2.7	22.13	2.4	9.7	101.7	3.557	1.533	22.2
NT x 2W	3.2	22.73	2.9	11.7	121.3	6.930	2.293	23.4
NT x 3W	4.0	24.67	3.6	12.7	132.0	8.198	3.453	24.5
Average	**3.7**	**24.52**	**3.5**	**12.2**	**124.9**	**6.195**	**3.061**	**24.4**
LSD (5%)	**0.53**	**0.8314**	**0.24**	**NS**	**NS**	**0.838**	**0.374**	**NS**

NB: DP = disc ploughing only; DP&H = disc ploughing followed by disc harrowing; NT = no tillage; Dm = Dry matter; LSD=least significant difference; 1W = one weeding; 2W = two weedings; 3W, three weedings; 0W = no weeding; NS = not significant

4.3 Weed species

Weed species identified in the study area include broad leaved weeds, grasses and sedges (Table 5), with Grassy and broad leaved weeds dominating. Ten species of weeds were identified - *Ageratum conyzoides* Linn, *Celosia laxa* Schum. and Thonn, *Phyllanthu amarus* Schum and Thonn, *Hyptis suaveolens* (L). Poit, *Spermacoce ruelliae* Linn, *Setaria pumila* Roemer and Schulles, *Digitaria sanguinalis* Scop, *Cynodon dactylon* (L.) Pers., *Rottboellia cochinchinensis* (Lour.) W. Clayton and *Cyperus rotundus* L.

Table 5: Weeds present in the experimental plots

Species	Family
Ageratum conyzoides Linn	Asteraceae
Celosia laxa Schum. and Thonn	Amarantheceae
Phyllanthu amarus Schum and Thonn	Euphorbiaceae
Hyptis suaveolens (L). Poit	Labiatae
Spermacoce ruelliae Linn	Rubiaceae
Setaria pumila Roemer and Schulles	Gramineae
Digitaria sanguinalis Scop	Gramineae
Cynodon dactylon (L.)	Gramineae
Rottboellia cochinchinensis (Lour.) W. Clayton	Gramineae
Cyperus rotundus L.	Cyperaceae

5. Conclusion

It was concluded that NERICA 4 rice variety had higher grain yield and yield components with disc ploughing followed by disc harrowing and weeding three times compared to other tillage practices and weeding methods. Hence the above treatment combination would be the best for increasing rice production in the Northern Region of Ghana.

6. Recommendations

Future research should be undertaken to investigate the long-term effects of tillage and weeding frequency on the yield and yield components of NERICA 4 in the Northern Region of Ghana.

Economic analysis should also be carried out to determine the effects of tillage and weeding frequency on yield and yield components of NERICA 4 in the Northern Region of Ghana.

Acknowledgements

The authors are grateful to the West African Agricultural Productivity Project – Sierra Leone (WAAPP–1C SL) for financing the study through the Sierra Leone Agricultural Research Institute (SLARI).

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