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Rice Growth Responses to Tillage and Weeding Frequency

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Abstract

The upland field study was conducted under rainfed conditions at Nyankpala, located in the Guinea Savannah agro-ecological zone of Ghana, to determine the effects of tillage and weeding frequency on the growth of the rice (*Oryza sativa* L.) variety NERICA 4. The experiment was set up as a split plot design with three tillage practices as main plots and four weeding frequencies as sub-plots. Each treatment was replicated three times. Apart from plant height and number of leaves per plant, the results indicated that tillage practices significantly affected the growth of NERICA 4. Disc ploughing followed by disc harrowing produced the highest percentage seedling emergence, tallest plants, the highest number of leaves per plant and the highest number of tillers per plant.

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The least crop performance was found in the no tillage plots. Crop growth was best with three weedings and poorest under the no weeding treatment. Based on these results and under the soil and weather conditions of the experiment, the best tillage practice and weeding frequency for NERICA 4 production is disc ploughing followed by disc harrowing, and weeding three times.

Keywords: Tillage; weed control; rice; growth.

1. Introduction

Rice (*Oryza sativa* L.) is the second most important cereal crop in the world after wheat [1], the most important cereal crop in sub-Saharan Africa [2], and the second most important cereal crop after maize (*Zea mays*, L.) in Ghana [3]. In Ghana, rice, which is an important food and cash crop, is mostly produced by smallholder farmers and its production 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 and weed control, and inappropriate tillage practices.

Tillage and weed control are two important inputs that affect crop performance. The purpose of tillage is to prepare soils for productive use or to place the soil in the best physical condition for the crop to grow. To be sure of normal plant growth, the soil must be in such a condition that roots can have enough air, water and nutrients [4]. Successful weed control in rice is essential for the optimum production of the crop. Weeds compete with the crop for moisture, nutrients, space, and light. However, the magnitude of weed-related losses depends on the type and density of a particular weed species, its time of emergence, and the duration of interference [5]. Rice growth losses are most severe when resources are limited and weeds and crops emerge simultaneously thus reducing the competitive advantage of the crop [6]. Crop growth decreases with increasing weed competition. The objective of this study was to assess the growth responses of the upland rice NERICA 4 to tillage and weeding frequency in the Northern Region of Ghana.

2. Materials and methods

2.1 Description of the study location

The field experiment was conducted under rainfed conditions at the upland rice experimental field of the Savannah Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) at Nyankpala, Northern Ghana, between July, 2014 and November, 2014. The site lies at latitude 09° 25'N and longitude 1° 00'W of the equator at an altitude of 183 m above sea level. The study area is located in the Guinea Savannah agro-ecological zone of Ghana. The soil at the site is sandy loam in texture in both the 0–15 cm and 15–30 cm layers. Details of selected physical and chemical characteristics of the soil at the experimental site are provided in Table 1. Weather data during the experimental period are summarized in Table 2.

2.2 Experimental design and treatments

The experiment was laid out in a split plot design with three tillage treatments as main plots and, four weeding

frequencies as sub-plots. The tillage treatments included disc ploughing only (DP), disc ploughing followed by disc harrowing (DP&H), and no tillage (NT). The weeding frequencies consisted of weeding with a hand hoe thrice (3W), twice (2W), once (1W) and no weeding (0W). Each treatment was replicated three times.

2.3 Data collection

Ten plants were tagged per plot for the determination of growth parameters. NERICA 4 rice plant population counts were taken daily until emergence was deemed complete. Percentage seedling emergence was calculated by dividing the number of emerged plants counted by the number of seeds planted and expressed as a percentage.

Plant height and number of leaves per plant were measured at weekly intervals for 10 weeks beginning at four weeks after planting (WAP).

The number of tillers per plant was counted at 9 and 12 WAP. Plant height was determined from the soil surface up to the apex of the plant using a meter rule, and the average of the 10 plant heights was calculated and recorded. Number of leaves per plant was determined by counting all the leaves on each plant and the mean of the 10 plants was recorded.

2.4 Data analysis

Data were analysed using the Analysis of Variance (ANOVA) procedure with the MINITAB Statistical Software Release 15 [7]. Significant differences between treatments were determined using the Least Significant Difference (LSD) test at the 0.05 level.

Table 1: Selected Soil Physical and Chemical 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 during the experimental period

Month	Tmax (^{o}C)	Tmin (^{o}C)	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 (^{0}C) Maximum Air Temperature, Tmin(^{0}C) Minimum Air Temperature

3. Results and discussion

3.1 Percentage Seedlings emergence

Seedling emergence differed significantly among the different tillage practices over a period of 20 days after planting (Figure 1). Differences were, however, not significant before the first three days of emergence. Overall, the highest seedling emergence of 94.95% occurred with disc ploughing followed by disc harrowing while the lowest seedling emergence of 73.74 % was found in the no-tillage plots. The elevated seedling emergence associated with disc ploughing followed by disc harrowing compared to the other tillage practices might be due to the breaking up of the hard pan which enables plant roots to penetrate into the lower soil regions to obtain available moisture and nutrients. Deep tillage breaks up high-density soil layers, improves water infiltration and movement in the soil, enhances root growth and development, and increases crop production potentials. The disc ploughing only treatment also resulted in significantly higher percent seedling emergence than those of the no tillage treatment.

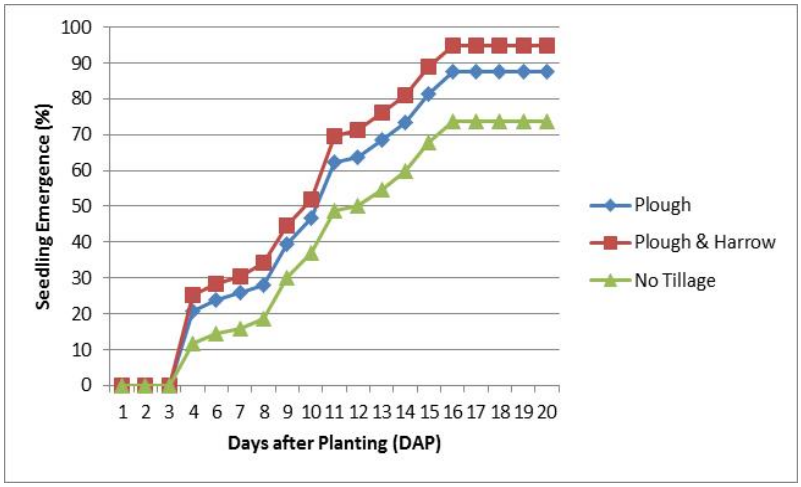

Figure 1: Effects of tillage on rice (NERICA 4) seedling emergence

3.2 Plant height

Plant height is an important parameter that determines the growth of the rice plant. The effects of different tillage and weeding frequency treatments on plant height are presented in Figures 2 and 3. At 13 weeks after planting (WAP), the different tillage treatments had no significant effect on the height of NERICA 4 plants. Plants were tallest (108.8 cm) in the disc ploughing followed by disc harrowing plots and shortest (94.4 cm) in the no tillage plots. This result is similar to that of [8] who recorded taller rice plants under conventional tillage than under minimum tillage on a sandy clay loam soil in Alexandria University, Egypt. [9] also reported that cowpea (*Vigna unguiculata* Walp.) plants were taller in tilled than in non-tilled plots. By contrast, [10] reported that rice plants were taller with no tillage than with disc ploughing followed by disc harrowing and disc ploughing only treatments on Acrisols in Yandev, North Central Nigeria. Unlike tillage, weeding frequency significantly affected plant height at 13 WAP (Figure 3). Weeding twice produced the tallest plants (108.8 cm) followed by weeding thrice (107.9 cm) and no weeding (88.8 cm). There was no significant difference in plant height between weeding twice and thrice but both produced significantly taller plants than the no weeding treatment. The effects of interactions between tillage and weeding frequency treatments on plant height were not statistically significant (Table 4). However, plants were tallest (118.49 cm) in plots with disc ploughing followed by disc harrowing plus weeding three times and shortest (80.64 cm) with no tillage and no weeding.

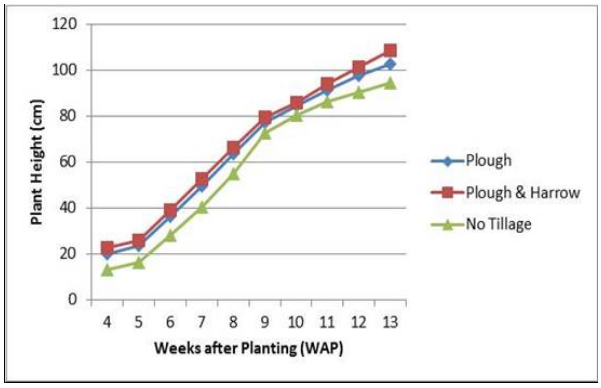

Figure 2: Effect of tillage on NERICA 4 plant height

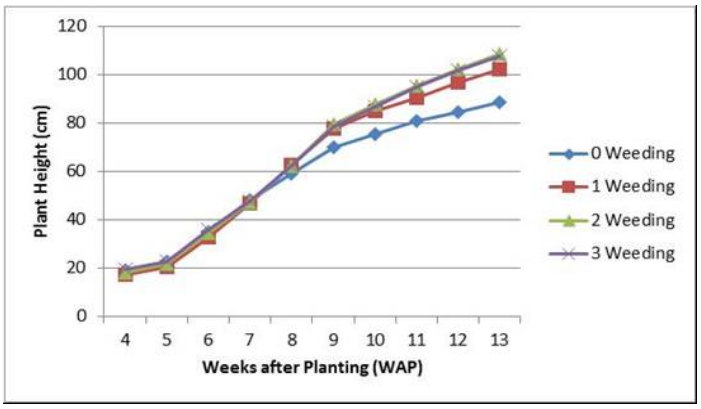

Figure 3: Effect of weeding frequency on NERICA 4 plant height

3.3 Number of leaves per plant

Tillage increased the number of leaves per plant although there was no significant difference in the number of leaves per plant between the tillage treatments at 13 WAP (Figure 4). Disc ploughing followed by disc harrowing was associated with the highest number of leaves per plant (64), followed by disc ploughing only (56.2) and no tillage (49.4). A similar result was reported by [11]. Differences between the four weeding frequencies were significant (Figure 5) - weeding thrice produced the highest number of leaves per plant (80.0), followed by weeding twice (78.6), weeding once (47.3) and no weeding treatment (20.2). Number of leaves per plant was significantly lower with no weeding than with all the other weeding treatments but differences between weeding twice and thrice were not statistically significant. The highest number of leaves per plant (94.3) was associated with the combination of disc ploughing followed by disc harrowing, plus weeding three times while the lowest (19.8) was given by the combination of no tillage and no weeding (Table 4).

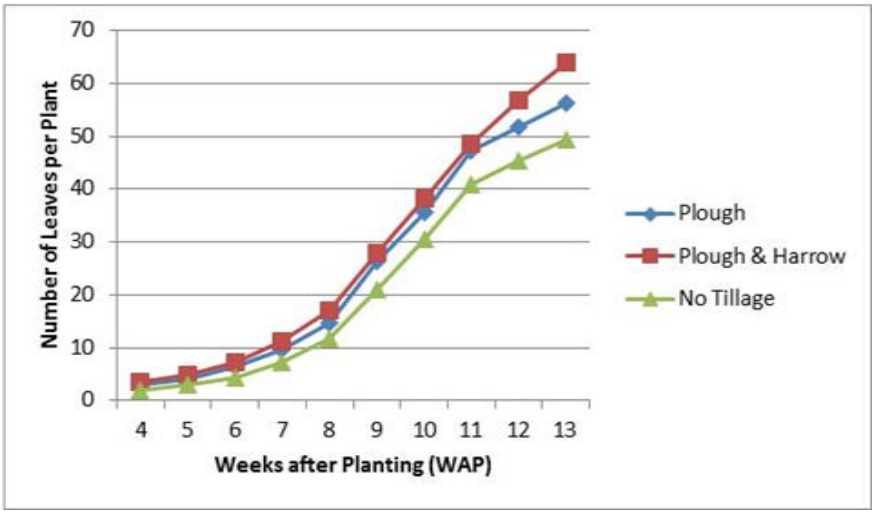

Figure 4: Effects of tillage on number of leaves per NERICA 4 plant

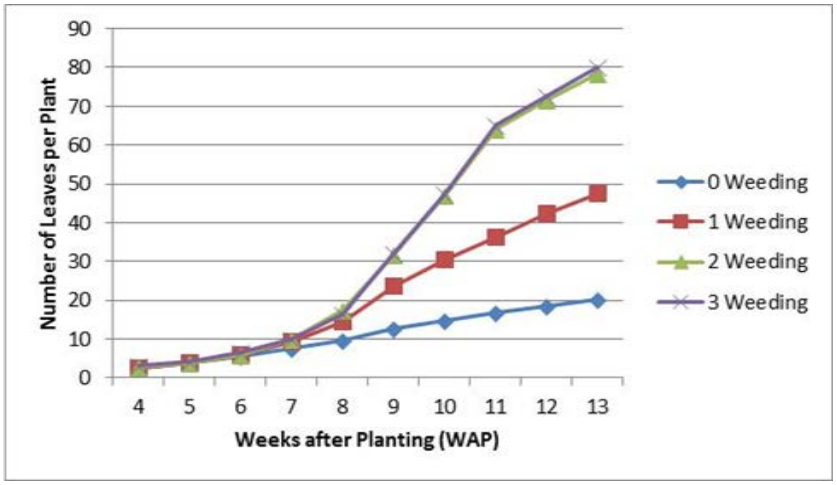

Figure 5: Effect of weeding frequency on number of leaves per NERICA 4 plant

3.4 Number of tillers per plant

Tillage treatments significantly influenced the number of tillers per plant (Table 3). At 9 WAP, disc ploughing and harrowing gave the highest number of tillers per plant (9.5) and this was not significantly different from the 7.8 tillers per plant under the disc ploughing treatment. Differences between the no tillage (6.3) and the other treatments were significant. Similarly, at 12 WAP, disc ploughing gave the highest number of tillers per plant (13.1) and this was not significantly different from the 12 tillers per plant under the disc ploughing treatment. Differences between the no tillage (9.1) and the other treatments were significant. Similar results were reported by [10] for rice in Yandev, North Central Nigeria.

Weeding frequency significantly affected the number of tillers per plant both at 9 and 12 WAP (Table 3). At 9 WAP, differences between weeding thrice (10.9) and twice (10.4) were not significant but both were significantly better than no weeding (3.1). Similarly, at 12 WAP, differences between weeding thrice (17.4) and twice 14.9 were not significant but both were significantly better than no weeding (4.2). The lowest number of tillers per plant was found in the no weeding plots. This result is similar to that of [12] who associated the highest number of rice tillers with weeding thrice compared with weeding twice or once at the Patuakhali Science and Technology University, Bangladesh. Similar data were also reported by [13]. Although the combination of disc ploughing followed by disc harrowing and weeding thrice produced the highest number of tillers per plant (20.8) and that of no tillage and no weeding produced the lowest number of tillers per plant (4.3), the effects of these interactions were not statistically significant (Table 4)

Table 3: Effects of tillage and weeding frequency on NERICA 4 rice tiller count

Treatment	**Number of tillers**	
Tillage	9 WAP	12 WAP
Disc plough	7.8	12.0
Disc lough and harrow	9.5	13.1
No tillage	6.3	9.1
Average	7.9	11.4
LSD (5%)	1.65	2.49
Weeding Frequency		
0 Weeding	3.1	4.2
1 Weeding	7.0	9.1
2 Weeding	10.4	14.9
3 Weeding	10.9	17.4
Average	**7.9**	**11.4**
LSD (5%)	**1.33**	**1.78**
CV	**17.1**	**15.8**

NB: LSD = least significant different; WAP = weeks after planting, CV = coefficient of variation

Table 4: Interaction between tillage and weeding frequency on NERICA 4 rice growth

Tillage x Weeding frequency	Plant height (cm) at 13 WAP	Number of leaves/ plant at 13 WAP	Number of tillers 9WAP	12WAP
Disc plough x 0 Weeding	95.54	19.9	2.8	4.1
Disc plough x 1 Weeding	100.73	43.7	6.2	8.6
Disc plough x 2 Weeding	108.60	79.0	10.9	16.3
Disc plough x 3 Weeding	106.04	82.1	11.3	18.8
Disc plough + Harrow x 0 Weeding	90.19	21.0	3.8	5.0
Disc plough + Harrow x 1 Weeding	113.33	53.6	9.2	10.4
Disc plough + Harrow x 2 Weeding	113.30	87.1	11.9	17.1
Disc plough + Harrow x 3 Weeding	118.49	94.3	13.0	19.9
No tillage x 0 Weeding	80.64	19.8	2.6	3.4
No tillage x 1 Weeding	93.31	44.6	5.7	8.2
No tillage x 2 Weeding	104.50	69.6	8.3	11.3
No tillage x 3 Weeding	99.08	63.7	8.6	13.5
Average	101.98	56.5	7.9	11.4
LSD ($p > 0.05$)	NS	NS	NS	NS

NB: LSD = least significant different; WAP = weeks after planting, NS = not significant

4. Conclusions

In view of the important contribution to the realization of the rice Green Revolution in sub-Saharan Africa where many farmers plant rice in the upland ecology under different tillage practices, this trial was conducted at Nyankpala in the Northern Region of Ghana to assess the growth response of the upland rice variety NERICA 4 to three tillage practices and four levels of weed control. NERICA 4 performed best with disc ploughing followed by disc harrowing and weeding thrice when planted at a spacing of 20 cm x 20 cm and worst with the combination of no tillage and no weeding. Disc ploughing followed by disc harrowing and weeding thrice together with line sowing at a spacing of 20 cm x 20 cm are therefore recommended for the optimum productivity of NERICA 4 and similar upland rice varieties in the Northern Region of Ghana.

5. Recommendations

There is a need to conduct a similar study to investigate the long-term effects of tillage and weeding frequency on the growth of NERICA 4 in the Northern Region of Ghana. Economic analysis should also be carried out to determine the profitability of tillage regime and weeding frequency on the growth of NERICA 4 in the Northern Region of Ghana.

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