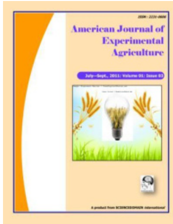

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Efficacy and Profitability of Some Weed Control Practices in Upland Rice (*Oryza sativa* L.) at Badeggi, Nigeria

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Research Article

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ABSTRACT

Field trial was conducted at the upland rice experimental field of the National Cereals Research Institute (NCRI), Badeggi, Nigeria (lat $09^0 45'$ N Long $6^0 07'$ E) in 2008 and 2009 to determine the efficacy of different methods of weed control and their profitability in inter-specific and intra-specific upland rice varieties (*Oryza sativa*). The trial was laid out in split plot design with two varieties of rice (NERICA 1 as inter-specific and FARO 46 as the intra-specific) assigned to the main plot while the seven weed control treatments [hoe weeding @ 25 days after sowing (DAS), @ 45 DAS, @ 25 and 45 DAS, @ 25, 45 and 65 DAS, application of 3',3' - dichloropropionanilide/2, 4 – Dichlorophenoxy acetic acid (orizo plus^R) by Candel company ltd at 3.5 kg a.i. ha^{-1} @ 25 DAS, hoe weeding @ 25 DAS followed by orizo plus @ 3.5 kg a.i., @ 45 DAS and weedy check] constituted the sub – plots. Results showed that three hoe weeding at 25, 45 and 65 DAS, twice at 25 and 45 and at 25 followed by orizo plus at 45 DAS gave better weed control than other treatments. However, hoe weeding at 25, 45 and 65 DAS gave significantly greater grain yield of 3.1 t ha^{-1} than other treatments. Hoe weeding at 25 DAS followed by orizo plus^R at 45 DAS gave the higher net profit of US$544.1 and US$514.7 for NERICA 1 in 2008 and 2009, respectively and US$404.9 and US$308.0 for FARO 46 in 2008 and 2009 respectively than other treatments. NERICA 1 gave the highest economic return when weed was controlled using hoe at 25 DAS followed by orizo plus at 45 DAS.

Keywords: Efficacy; profitability; weed control; rice.

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1. INTRODUCTION

Rice has fed more people than any other crop for thousands of years and is second largest in acreage after wheat. If the number of people who depend on a crop for a major portion of their daily food is the most appropriate measure of importance, then rice is the world's most important crop. It feeds one third of the world's population to whom it supplies almost two thirds of the food requirements (Labrada, 1996). It was claimed by FAO (2008) that one third of the world's population depends on rice for 50% of their daily caloric intake. The world grows 153.8 million hectares of rice annually with average worldwide yield of 3,885 Kg ha^{-1} which gives a production of 598.8 million metric tons, which is greater than that of either corn or wheat. Rice is the only major grain crop that is grown almost exclusively for human food.

In Nigeria, among the staple food crops, rice has risen to a position of pre- eminence. At independence in Nigeria, rice was merely a festival food consumed mostly in affluent homes at Christmas and during other religious festivals. Rice is no longer a luxury food to millions of Nigerians but has become the cereal that constitutes a major source of calories for the rural and urban poor with demand growing at an annual rate of 5% (Oikeh et al., 2006). However, the report by Akpoke et al. (2001) indicated that since the mid 1970s rice consumption in Nigeria has risen tremulously, (+ 10.3% per annum), a result of the accelerating population growth rate (+ 2.8% per annum) and increasing per capital consumption (+7.3% per annum). Nigeria is West Africa`s largest producer of rice, accounting for 45% of all rice produced in the region and 40% of total rice – cropping area and is also a major consumer with annual consumption estimated at 5 million tons in 2006, of which 1.6 million was produced domestically and the remaining 2.4 million was imported (WARDA, 2008).

Weeds constitute a big constraint to the production of rice in the upland ecology and rank only second to drought stress in reducing its grain yield and quality. It also, host insect pests and diseases, require expensive labour and energy to control, reduce harvesting and processing efficiency, and sometimes are poisonous (Gupta and Toole, 1986). The occurrence of weeds as constant component of the ecosystem in comparison to the epidemic nature of other pests makes farmers unaware of the significant losses they incur from weed infestation. Ukungwu and Abo (2004) reported that weed is the greatest bottleneck to increased yields and quality of rice in Nigeria. Weeds were the most widely reported biological constraint to yield in a survey of upland rice producing countries covering 80% of the total production area, and upland rice in particular competes poorly with weeds and uncontrolled weed growth often results to 28% to 100% yield loss (Johnson, 1996).

Zhang (2001) reported that in China, 10 million tons of rice are lost annually due to weed competition, such a quantity of rice is sufficient to feed at least 56 million people for one year. The author also equally reported that in SriLanka, a country considered self - sufficient in rice, weeds are the major biotic stress in rice production and account for 30 - 40% of yield losses. It was found that weed growth in unweeded plots reduced grain yield up to 34% in transplanted rice and 67% in upland rice (De Datta, 1981). Heavy weed infestation in direct seeded rice, upland or lowland, has been reported to cause as high as 44 - 100% yield loss (Akobundu, 1987).

Weed control in upland rice involve a lot of human resource to carry out. Idem and Showemimo (2004) reported that hand weeding which is the common weed control practice among peasant farmers can consume as many as between 250 and 780 man-days ha^{-1}, depending on frequency of weeding, ecosystem, and environmental conditions during cropping.

For weed control technology to be acceptable by upland rice farmers, it must be effective and economically feasible. Economic feasibility depend upon the relative cost of weed control in relation to yield obtained. The study was therefore conducted in order to determine the efficacy and profitability of different weed control methods for upland rice farmers.

2. MATERIALS AND METHODS

The experiment was conducted at the upland rice research field of National Cereals Research Institute Badeggi, Bida Niger State (lat $09^0 45'$ N Long $6^0 07'$ E and 75 meters above sea level) in the Southern Guinea Savanna ecological zone of Nigeria in 2008 and 2009 cropping seasons to determine the efficacy and profitability of weed control methods in upland rice varieties.

The trial was laid out in a split plot design with two varieties of rice NERICA 1 (inter-specific variety) and FARO 46 (intra-specific variety) assigned to the main plot while seven weeding regimes (hoe weeding (HW) once at 25 or 45 days after sowing (DAS) , twice at 25 and 45 DAS, thrice at 25, 45 and 65 DAS, application of 3',3' - dichloropropionanilide /2, 4 – Dichlorophenoxy acetic acid (orizo plus^R) at 3.5 kg a.i ha^{-1} at 25 DAS, HW at 25 DAS followed by orizo plus^R at 3.5 kg a.i ha^{-1} at 45 DAS and the control weedy - check) constituted the sub-plots. The treatments were randomly assigned and replicated three times. The main plot size was 31 m x 6 m (186 m^2) with 0.5 m spacing between plots and 1 m between replications. The sub-plot was 4 m x 6 m (24 m^2) while the net plot was 3 m x 5 m (15 m^2).

The land was mechanically ploughed, harrowed and leveled and the seeds which were obtained from National Cereals Research Institute, Badeggi were sown on 27th July, 2008 and 11th July, 2009 on flat land. Five seeds were sown per hole at a spacing of 20 x 20 cm and later thinned to 4 seedlings per stand.

The fertilizer used was 80 kg/ha N, 40 kg/ha P_2O_5 and 40 kg/ha K_2O in the form of urea (46% N); single superphosphate (18% P_2O_5) and Muriate of potash (60% K_2O). The N was in split dose, applied basal, while the second dose was at panicle initiation stage. P and K were applied at planting. Broadcasting method of fertilizer application was adopted.

2.1 Data Collection

2.1.1 Weed dry matter

This was done at four intervals (25, 45, 65 and 85 DAS) by throwing 1m^2 quadrant in each plot, and the weeds inside it were uprooted and dried for weed dry matter. Percentage weed reductions (PWR) was determined by subtracting the total weed density from each plot from that obtained from the check (W7), then multiply by 100 and divide by check.

$$PWR = \frac{WD - W7}{W7} \quad X\ 100$$

WD =Weed density obtained from each plot
W7 = weed density obtained from check

2.1.2 Yield components and yield

Rice tiller count was taken from 1m^2 quadrant at four intervals (25, 45, and 85 DAS). Number of panicle per m^2 was taken from 1m^2 quadrant (averaged over 3 - quadrants thrown at random at 100 DAS). Rice grain yield was obtained from the net plot, threshed and winnowed and the grain was weighed using weighing balance and converted into tonnes per hectare.

Economic analysis was done on different weed control practices in order to ascertain the weeding method that gave the highest net economic return. The profit margin was determined by subtracting the cost of production (which includes cost of seed, land preparation, herbicide application and labour for planting, hoe weeding, bird scaring, harvesting and processing) from the revenue derived from the sale of paddy rice. The price of seed was \$1.01kg^{-1}in both years, herbicide was \$7.43 per liter in 2008 and \$8.45 per liter in 2009 and labour cost was \$1.69 per man day in 2008 and \$2.03 per man day in 2009 while price of paddy was put at \$0.41 kg^{-1} and \$0.44 kg^{-1} in 2008 and 2009 respectively which was the prevailing prices during the harvesting period in both years.

2.2 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using statistic package M-Stat-C version 1.3 (Snedecor and Cochran 1967) except for percentage weed reduction where Crop stat was used and significant means were separated using Duncan Multiple Range Test (Duncan, 1955) at 5% probability.

3. RESULTS AND DISCUSSION

3.1 Weed Control

The prominent weeds found in the experimental plots in the two years of study included all categories of weeds (broad leaf weeds 30%, grasses 63% and sedges 7% in 2008 and 35%, 60% and 5% respectively in 2009) (Table 1). The presence of these weeds in the experimental plots agreed with the work of Mirza et al. (2007). The prevalence of grass weeds such as *Cynodon dactylon*, *Digitaria horizontalis* and *Digitaria milanjiana* in the experimental site in both years of study could have resulted to more yield reduction than broad leaf weeds and sedges. This agreed with the finding of Shari et al. (1985), who reported grass weeds as the most troublesome weed of upland rice because they both belong to Poaceae family and also have similar canopy architecture, hence severe interference.

Weed dry matter was significantly affected by different weed control methods in both years of study and at all sampling periods, except at 25 DAS. Application of orizo plus^R at 3.5 kg ai ha^{-1} @ 25 DAS gave the lowest dry matter at 45 DAS which was statistically similar to other treatments, except hoe weeding @ 45 DAS, and weedy check in both years of study (Table 2). The similar weed dry matter recorded at 45 DAS in the entire weeding control methods, except hoe weeding @ 45 DAS and weedy check might be due to simultaneous first weed control at 25 DAS in those treatments and the second weeding was not performed at this stage. This agrees with the work of Mirza et al. (2007), who observed no significant difference in weed density at 30 days after transplanting (DAT) between one hand weeding and two hand weeding. The no-significant differences recorded at 25 DAS among all the weeding regimes might be due to the fact that rice plant had not formed enough tillers and canopy to interfere with growth of weeds at this stage of growth. Suzuki et al. (2002) reported similar result that competition of rice cultivar with weeds increases with time. Similarly, weed growth were still small at this stage. In a trial conducted by Fischer et al (2001) to determine competiveness of semi dwarf rice cultivars against B brizantha and B decumbens, he observed that rice varieties did not have effect on the weed growth till 45 DAS. Adeosun (2008) reported that the critical period of weed interference between rice and weed is between 42 and 56 DAS.

As the season progressed to 65 DAS, hoe weeding @ 25 and 45 DAS gave significantly lower weed dry matter in both years of study and their mean which was at par with hoe weeding @ 25, 45 and 65 DAS and hoe weeding @ 25 DAS followed by orizo plus @ 3.5 kg ai @ 45 DAS. There was consistent higher weed dry matter in treatment weedy check at all the sampling period and in both years. Similar results were also observed by Mitra et al. (2005) and Mirza et al. (2007). Weed population and dry matter were significantly influenced by the rice varieties at 45 DAS and the plot of NERICA 1 gave the lowest weed population and dry matter.

Table 1. The dominant weeds found in the experimental sites

Weed species	Family	Life span	Degree of occurrence	
			2008	2009
Broad leaf				
Cassia mimosoides (Linn)	*Caesalpiniaceae*	A	+++	++
Cleome viscose (L)	*Cleomaceae*	A	++	+
Commelina beneghalensis (L)	*Commelinaceae*	A	+	++
Celosia trigyna (L)	*Amaranthaceae*	A	+	+
Euphorbia hirta (Linn)	*Euphorbiaceae*	A	+	+
Hibiscus asper (Hooh f)	*Malvaceae*	A	+	-
Hyptis suaveolens (Poit)	*Lamiaceae*	A	+	+
Hyptis lanceolata (Poir)	*Lamiaceae*	A	-	+
Ipomoea asarifolia (Desr)	*Convolvulaceae*	A	+ + +	+
Oldenlandia corymbosa (Linn)	*Rubiaceae*	A	+	-
Ipomoea triloba (Linn)	*Convolvulaceae*	A	+ +	+
Grass				
Brachiaria jubata (Stapf)	*Poaceae*	A	+ +	+
Cynodon dactylon (Linn)	*Poaceae*	A	+ + +	+++
Digitaria horizontalis (Willd)	*Poaceae*	A	+ + +	+++
Digitaria milanjiana	*Poaceae*	A	+ + +	+
Eragrostis tremula (Hochst)	*poaceae*	A	+	+
Eragrostis atrovirens (Desf)	*Poaceae*	A	+ +	-
Paspalum orbiculare (Forst)	*Poaceae*	A	+ +	+++
Setaria pumila (Schum)	*Poaceae*	A	+ ++	++
Sedge	*Cyperaceae*	A	+ +	++
Cyperus esculentus (Linn)	*Cyperaceae*	A	+	-
Kyllinga erecta (Scumach)				

A = annual, + =low, ++ = moderate +++ = high

Table 2: Effects of rice varieties and weed control treatments on weed dry matter (g m^{-2}) in 2008 and 2009 cropping seasons

Treatments	25DAS			45DAS			65DAS			85DAS		
	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean
Varieties (V)												
NERICA 1	59.0	72.0	65.5	162.2	133.4^{b}	136.1^{b}	156.1^{b}	158.9	157.5^{b}	293.2	252.8	257.0
FARO 46	54.9	66.8	60.9	238.8^{b}	154.6^{a}	158.4^{a}	183.0a	183.4	183.2^{a}	289.5	264.5	277.0
Significance	NS	NS	NS	*	*	*	*	NS	*	NS	NS	NS
SE ±	NS	NS	NS	2.9	3.91	3.1	7.4	8.40	4.8	14.5	12.2	NS
Weeding regimes(WR)												
HW at 25 DAS	66.9	68.0	67.4	41.5^{b}	42.5^{b}	42.0^{b}	296.8^{b}	296.5^{b}	296.6^{b}	365.3^{b}	360.1^{b}	362.7^{b}
HW at 45 DAS	67.3	68.2	67.7	418.0^{a}	394.9^{a}	406.4^{a}	172.5^{c}	159.2^{c}	165.8^{c}	352.6^{b}	349.4^{b}	351.0^{b}
HW at 25 and 45 DAS	48.7	91.2	69.9	38.7^{b}	40.2^{b}	39.4^{b}	33.2^{d}	33.1^{d}	33.2^{d}	98.7^{c}	100.4^{d}	99.5^{d}
HW at 25, 45 and 65 DAS	65.0	62.3	63.6	37.6^{b}	37.7^{b}	37.7^{b}	33.4^{d}	33.8^{d}	33.6^{d}	24.3^{c}	25.0^{e}	24.7^{e}
Orizo plus at 25 DAS	50.0	71.3	60.7	25.2^{b}	35.4^{b}	30.3^{b}	124.7^{c}	117.6^{c}	121.1^{c}	227.0^{bc}	240.8^{c}	233.9^{c}
HW at 25 DAS Fb Orizo plus at 45 DAS	36.7	62.7	49.7	46.8^{b}	40.6^{b}	43.7^{b}	34.7^{d}	32.1^{d}	31.9^{d}	197.1^{bc}	88.0^{d}	86.7^{d}
Weedy Check	64.4	62.0	63.3	445.8^{a}	416.6^{a}	431.2^{a}	494.4^{a}	526.0^{a}	530.4^{a}	774.4^{a}	648.8^{a}	710.6^{a}
Significance	NS	NS	NS	*	*	*	*	*	*	*	*	*
SE ±	NS	NS	NS	26.8	12.4	20.5	15.8	14.3	47.4	52.3	31.8	18.0
CV %	17.6	19.54	12.8	8.8	15.5	13.8	20.0	22.5	18.1	37.9	21.6	22.9

*Means followed by the same letter (s) within a column are not significantly different at 5% level of probability (DMRT). NS –not significant, * - significant, at P ≤ 0.05, Fb – followed by, DAS – days after sowing and HW – hoe weeding.*

The lowest weed density and weed dry matter which was recorded in plots of NERICA 1 variety at 45 DAS as compared to FARO 46 might be due to the fact that it has characters such as rapid early growth, drooping leaves, good tillering ability and high leave area that confer weed suppression and competitive ability in rice plant. Similar result was reported by Ekeleme et al. (2008) who reported lower weed dry weight in NERICAs than other upland rice varieties tested.

3.2 Percentage Weed Reduction

The result of this study suggested that different weed control methods gave different level of weed reduction. The application of orizo plus @ 25 DAS gave highest weed reduction at 45 DAS in both years of study but as the season progress to 65 DAS hoe weeding at 25, 45 and 65 DAS gave better weed reduction which was at par with twice hoe weeding @25 and 45 DAS and hoe weeding @ 25 DAS followed by the use of orizo plus @ 45 DAS (Table 3). The higher percentage weed reduction in these treatments was due to effective weed management by these weed control methods.

Table 3. Percentages weed reduction as affected by different weed control methods

Treatments	**2008**			**2009**		
	45 DAS	**65 DAS**	**85 DAS**	**45 DAS**	**65 DAS**	**85 DAS**
HW at 25 DAS	73.6_c	57.9^c	49.3^e	82.9^b	67.9^b	48.8^d
HW at 45 DAS	17.4^d	59.2^c	53.2^d	21.7^d	68.6^b	51.2^c
HW at 25 and 45 DAS	79.0^b	80.1^a	80.2^c	82.5^b	84.1^a	76.7^b
HW at 25, 45 and 65 DAS	79.5^b	81.9^a	88.2^a	81.0^b	85.2^a	87.6^a
Orizo plus at 25 DAS	86.9^a	60.1^b	52.1^d	91.1^a	68.7^b	47.1d
HW at 25 DAS Fb Orizo plus at 45 DAS	74.3^c	81.8^a	83.2^b	79.9^c	84.7^a	85.9^a
Weedy Check	0^e	0^d	0^f	0^e	0^c	0^e
SE	2.7	2.5	2.0	1.9	2.3	1.8
LSD	7.9	7.4	6.1	5.6	6.7	5.3
CV	9.2	8.4	7.1	6.2	7.1	6.3

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT), Fb – followed by, DAS – days after sowing, HW – hoe weeding

3.3 Yield Components and Yield

Rice tiller was significantly affected by different weed control methods at all the sampling periods, except at 25 DAS. At 45 DAS, higher tiller numbers were obtained from, which was at par with hoe weeding @ 25, 45 and 65 DAS and hoe weeding @ 25 DAS in 2008 and 2009 and their mean (Table 4). At 85 DAS, hoe weeding @ 25, 45 and 65 DAS and gave significant higher number of tillers in both years of study and their mean (Table 4). The consistent significant higher tiller production obtained from hoe weeding @ 25 DAS hoe weeding @ 25 and hoe weeding @ 25, 45 and 65 DAS in both years of study might be attributed to the fact that the treatments controlled weeds most effectively. This led to reduced competition between rice plant and weeds thereby leading to high tillers in these treatments. This is in line with the work of Mitra et al. (2005), who observed higher number of tillers in weed - free treatment which was similar to two hand weeding treatment and lowest in unweeded treatment.

Table 4. Effects of rice varieties and weed control treatments on rice tiller (m^{-2}) in 2008 and 2009 cropping seasons

Treatments	25DAS			45DAS			85 DAS		
	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean
Varieties (V)									
NERICA 1	144.4[a]	152.8[a]	148.6[a]	215.0[a]	212.8	213.9[a]	235.9	245.4[a]	240.0[a]
FARO 46	119.8[b]	119.6[b]	119.7[b]	176.6[b]	179.7	178.2[b]	222.7	222.3[b]	223.0[b]
Significance	*	*	*	*	*	*	NS	*	*
SE ±	5.1	5.7	3.3	5.7	3.1	3.3	NS	7.0	4.32
Weeding regimes(WR)									
HW at 25 DAS	130.3	129.2	129.8	228.5[a]	260.3[a]	244.4[ab]	266.2[ab]	299.2[bc]	282.7[bc]
HW at 45 DAS	126.0	131.2	128.6	143.2[b]	131.3[c]	137.3[c]	186.0[cd]	167.8[d]	176.9[d]
HW at 25 and 45 DAS	149.0	153.0	151.0	258.8[a]	257.2[a]	258.0[a]	320.5[a]	320.3[ab]	320.4[ab]
HW at 25, 45 and 65 DAS	146.8	158.8	152.8	269.3[a]	262.8[a]	266.1[a]	333.3[a]	327.6[a]	331.5[a]
Orizo plus at 25 DAS	108.7	113.3	111.0	129.7[b]	119.0[c]	124.3[c]	155.8[de]	142.3[d]	149.1[d]
HW at 25 DAS Fb Orizo plus at 45 DAS	125.0	126.5	125.8	215.8[a]	222.8[b]	219.3[b]	237.5[bc]	274.3[c]	257.6[c]
Weedy Check	138.8	141.2	140.0	125.2[b]	120.7[c]	123.0[c]	103.7[c]	105.3[e]	105.3[e]
Significance	NS	NS	NS	*	*	*	*	*	*
SE ±	NS	NS	NS	13.0	9.7	10.0	17.2	11.9	13.3
CV %	17.7	19.3	15.7	13.4	7.2	10.8	10.2	13.6	12.1

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT).
*NS –not significant, * - significant, at P ≤ 0.05, Fb – followed by, DAS – days after sowing and HW – hoe weeding.*

Panicle production was highest in hoe weeding @ 25 DAS in plot of inter-specific varieties while lowest rice panicle was recorded in weedy check. Among the weed control treatments the highest grain yield of 3120.0 kgha^{-1} and 3157 kgha^{-1} of rice was obtained from hoe weeding @ 25 DAS in 2008 and 2009 respectively, while lowest grain yield of 417 and 407 kgha^{-1} was recorded in weedy check in 2008 and 2009 respectively. Generally better grain yield was recorded from the inter-specific variety (NERICA). The significant higher grain yield recorded in the interaction between NERICA 1 and hoe weeding @ 25 DAS might be due to less crop - weed competition that ensured sufficient supply of plant nutrients for rice plant growth. This result is also in accordance with the findings of Moynul et al. (2003), who recorded higher grain yield from weed-free regimes, which was identical to three weeding regimes.

Table 5. Interaction of rice varieties and weed control treatments on panicle m^{-2} and grain yield (kgha^{-1}) in 2008 and 2009 cropping seasons

Treatments	Panicle m^{-2}		Grain yield (kgha^{-1})	
	2008	2009	2008	2009
NERICA I				
HW at 25 DAS	74.3^{bc}	76.0^{bc}	1653.3^{g}	1713.3^{f}
HW at 45 DAS	49.7^{fg}	50.3^{ef}	941.3^{k}	843.3^{f}
HW at 25 and 45 DAS	94.0^{a}	50.7^{eg}	2966.7^{b}	2912.0^{b}
HW at 25, 45 and 65 DAS	95.7^{a}	95.7^{a}	3120.0^{a}	3157.0^{a}
Orizo plus at 25 DAS	49.7^{fg}	50.7^{eg}	1916.7^{f}	1863.3^{e}
HW at 25 DAS Fb Orizo plus at 45 DAS	62.3^{de}	73.0^{bcd}	2626.7^{c}	2566.7^{c}
Weedy Check	44.8^{hi}	18.0^{h}	263.3^{m}	239.0^{K}
FARO 46				
HW at 25 DAS	53.7^{efg}	55.0^{e}	1233.3^{i}	1266.7^{g}
HW at 45 DAS	66.0^{cd}	66.3^{d}	1030.7^{j}	1000.0^{h}
HW at 25 and 45 DAS	81.7^{b}	41.7f^{g}	2246.7^{d}	2150.0^{d}
HW at 25, 45 and 65 DAS	82.0^{b}	82.0^{b}	2316.7^{d}	2500.0^{c}
Orizo plus at 25 DAS	44.0^{g}	41.7^{fg}	1326.7^{h}	1240.0^{g}
HW at 25 DAS Fb Orizo plus at 45 DAS	56.7^{def}	67.0^{cd}	2036.6^{e}	2056.7^{e}
Weedy Check	26.0^{h}	33.0^{g}	471.7^{L}	407.0^{J}
SE ±	3.0	3.0	8.9	38.0
CV %	8.4	8.3	2.4	3.9

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT), Fb – followed by, DAS – days after sowing, HW – hoe weeding

3.4 Cost of Weed Control

Different weed control methods involved different amounts of cost which affected total production cost. Generally, hoe weeding was laborious and more expensive. In this study three hoe weeding hoe weeding @ 25 DAS gave maximum weed control cost of \$221.5 and \$238.5 ha-1 for NERICA 1 and FARO 46 in 2008 respectively and \$270.8 and \$283.1 ha^{-1} for NERICA 1 and FARO 46 in 2009 respectively (Table 5). The use of herbicide gave the lowest cost of weed control in both years of study. The use of oriza plus at 25 DAS gave lowest weed control cost of \$51.4 and \$57.4 ha^{-1} for 2008 and 2009 respectively (Table 5). The cost of weed control was generally higher in 2009 than in 2008 which was due to the cost of both Labour and herbicide being higher in 2009. The result of this trial is in line with the work of Mirza et al. (2007) who observed that hand weeding is laborious and gave higher weed control cost while the use of herbicide (clearR) gave the lowest cost of weed control.

Table 6. Cost of weed control in different weed control practices (US dollar) in relation to the weedy check

Treatments	2008		2009	
	NERICA 1	FARO 46	NERICA 1	FARO 46
HW at 25 DAS	221.5	238.5	270.8	286.4
HW at 45 DAS	54.1	58.5	63.4	70.3
HW at 25 and 45 DAS	115.2	101.5	136.1	121.8
HW at 25, 45 and 65 DAS	13.0	159.9	165.8	192.2
Orizo plus at 25 DAS	51.4	51.4	57.4	57.4
HW at 25 DAS Fb Orizo plus at 45 DAS	109.8	103.0	127.8	127.8

Fb – followed by, DAS – days after sowing, HW – hoe weeding

3.5 Profitability of Different Weed Control Methods

The result of this trial indicated that NERICA 1 gave the highest economic return when weed was controlled using hoe at 25 DAS followed by orizo plus at 45 DAS. The higher economic return from this combination of treatment might be due to higher grain yield and less cost of production compared to three hoe weeding where highest grain yield was obtained but higher cost of production. Although, the use of herbicide once at 25 DAS gave lowest weed control cost but was not profitable as the rice grain yield from this treatment was very low. Similar result was reported by Singh and Chauhan (1978) that applying butachlor + one hand weeding gave a good economic return. However, Upanhyay and Chaudhary (1979) found that hand weeding and hoe weeding at 3 and 6 WAS was more economical than applying herbicide. On the other hand, Chakraborty and Majumdar (1973) obtained best economic return with propanil + 2, 4-D followed by propanil +MCPA. Generally, net – return was higher in 2008 than 2009 because of higher cost of production in 2009.

In most studies applying herbicide or herbicide plus manual weeding was more economical than manual or hand weeding alone (Sabio and Pastories 1981). The result of this trial indicated that the use of herbicide reduced the cost of rice production, which might be due to higher number of man-days required to weed a hectare of rice field manually. Gupta and O'Toole (1986) observed that the use of butachlor took 186 hours while two hand weeding took 604 hours ha^{-1}.

4. CONCLUSION

The results obtained from this trial suggest that different weed control methods greatly affected both the efficacy and profitability of the weed control methods, crop character, yield and yield components of upland rice. Among the weed control treatments, the integration of hoe weeding followed by the use of herbicide (orizo plus) at 25 and 45 DAS respectively was the most profitable and effective weed control method. Although, highest grain yield was obtained from three hoe weeding (@ 25, 45 and 65 DAS), the cost of weed control in this treatment superseded the difference in yield. The two rice varieties also differ in their response to different weed control treatments and NERICA 1 (inter – specific) variety gave better grain yield than the intra – specific variety (FARO 46).

Table 7. Effect of varieties and weed control treatments on rice production net income (US dollar) during 2008 and 2009 cropping season

Treatments	Cost of production (US $)		Revenue (US $)		Profit (US $)		Benefit cost ratio (US $)	
	NERICA 1	FARO 46	NERICA 1	FARO 46	NERICA 1	FARO 46	NERICA 1	FARO 46
HW at 25 DAS	**545.0**	**545.0**	**670.3**	**500.0**	**-125.3**	**45.0**	**1.2**	**0.9**
	556.7	556.7	694.6	513.5	-137.9	43.2	1.3	0.9
HW at 45 DAS	**597.4**	**597.4**	**381.6**	**417.8**	**-215.8**	**-181.6**	**0.6**	**0.7**
	602.7	602.7	341.9	405.4	-260.8	-197.3	0.6	0.7
HW at 25 and 45 DAS	**686.4**	**683.3**	**1202.7**	**910.8**	**516.3**	**227.5**	**1.8**	**1.3**
	688.3	659.1	1180.5	871.6	492.2	212.5	1.7	1.3
HW at 25, 45 and 65 DAS	**752.2**	**773.9**	**1264.9**	**939.2**	**512.7**	**165.3**	**1.7**	**1.2**
	787.1	782.9	1279.9	1013.5	492.7	230.6	1.6	1.3
Orizo plus at 25 DAS	**473.3**	**473.3**	**777.0**	**537.8**	**303.7**	**64.5**	**1.6**	**1.1**
	478.7	478.7	755.4	502.7	282.1	24.0	1.6	1.1
HW at 25 DAS Fb Orizo plus at 45 DAS	**520.8**	**520.8**	**1064.9**	**825.7**	**544.1**	**304.9**	**2.0**	**1.6**
	525.8	530.9	1040.5	833.8	514.7	308.0	2.0	1,6
Weedy Check	**454.7**	**454.7**	**106.8**	**191.2**	**-348.0**	**-263.5**	**0.2**	**0.4**
	454.7	454.7	96.9	165	-357.8	-289.7	0.2	0.4

DAS = days after sowing, HW = hoe weeding, bold phase = 200 8cropping season, light phase =2009 cropping season, Fb = followed by, $ = US dollar

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