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Effect of Weeding Time on Rice (Oryza sativa Linn) Yield and Yield Components at Kaffa, Southwest Ethiopia

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Abstract
Weeds are major constraints to rice production in labor-limited, upland rice-based systems in Kaffa zone, Southwestern Ethiopia. The effects of weeding time on yield and yield components of two upland rice cultivars; Nerica 4 and Superica 1 was investigated at Gojeb testing site of Kaffa zone in 2009/2010 cropping season. The experimental treatments were weeding at 15-20+30-35+45-50 days after emergence (DAE), 20-25 +35-40 +50-55 DAE, 30-35+45-50+60-65 DAE and farmers practice (weeding at 20-25 DAE once) as control check. Moreover types of weed species are recorded. Based on the result dominant weed species observed on rice filed were *Digitaria abyssinica, Phalaris paradoxa, Setaria pumila, Hygrophila auriculata, Amharanthus caudatus, Commelina latifolia, Xanthium spinosum, Cynodon nlemfuensis* and *Cyperus assimilis.* ANOVA result shows that different weeding times affected significantly ($p < 0.001$) grain yield and yield components of both rice varieties. The maximum grain yield (44.18 and 63.82 Q/ha) was obtained when weeding made at 15-20+30-35+45-50 DAE while the minimum value (21.36 and 31.63 Q/ha) observed from weeding at 30-35+45-50+60-65 DAE for Superica-1 and Nerica-4 rice verities respectively. Moreover, maximum 1000 grain weight, straw yield and tillers number of rice were recorded upon weeding at 15-20+30-35+45-50 DAE. There for early weeding have significant roll on rice yield and yield components.
Keywords: rice, weeds, weeding time, yield and yield components

1. Introduction

Rice *(Oryza sativa* Linn) is the fifth most important cereal in Africa in terms of area harvested and the fourth in terms of production (FAO, 2008). Rice production in Africa is increasing at the fastest rate of any cereal, and over the past three decades, harvested area has risen by 105 % and production by 170% (Rodenburg and Johnson, 2009). Upland rice ecosystems roughly represent 39% of the total area under rice in sub-Saharan Africa leaving 33% to rain-fed lowlands, 19% to irrigated lowlands and around 9% to deep water and mangroves (Balasubramanian *et al.,* 2007; FAO, 2008). With respect to production and area statistics, important rice producing countries in Africa are Nigeria, Madagascar, Guinea, Sierra Leone, Egypt, Congo DR, Mali, Coˆ te d'Ivoire, Tanzania, and Mozambique (Rodenburg and Johnson, 2009). On hydromorphic areas, where the perched water table is within 50 cm of the soil surface for the majority of the growing season, rice and cash crops such as cotton, groundnut, soybean and sesame are grown. In upland cropping systems of subsistence farmers, input levels are generally low, and low yield is common due to poor soil fertility and weed competition (Windmeijer and Andriesse, 1993; Balasubramanian *et al.,* 2007; Rodenburg *et al.,* 2009).

Weeds are major constraints to rice production in labor-limited, upland rice-based systems in Southwestern Ethiopia. More over; Weeds are cited among the main production constraints in any of the rice ecosystems (Adesina *et al.,* 1994; Becker and Johnson, 1999; Diallo and Johnson, 1997; Rodenburg and Johnson, 2009). Common agronomic factors that contribute to weed problems are inadequate land preparation (soil tillage, soil leveling in lowland areas), rice seed contamination with weed seeds, use of poor quality rice seeds, broadcast seeding in lowlands, use of old rice seedlings for transplanting, inadequate water management, inadequate fertilizer management, mono-cropping, labor shortages for hand weeding and delayed herbicide applications and other interventions (Becker and Johnson, 2001; Diallo and Johnson, 1997). In the upland systems, crop intensification and inadequate fallow management are also contributory factors (Becker and Johnson, 2001).

Worldwide, weeds are estimated to account for 32% potential and 9% actual yield losses in rice (Oerke and Dehne, 2004). The nature and severity of weed problems, however, vary according to the rice ecosystem. Likewise, weed management practices and the available options are often a function of biophysical and socioeconomic factors which, in turn, are determined by the agroecosystem. Weeds are the major constraints in rain fed uplands and in the unbunded lowlands, for instance, where they cannot be controlled by flooding the soil surface (Akobundu, 1987; Ampong-Nyarko and De Datta, 1991; Rodenburg and Johnson, 2009). In a survey of upland rice producing countries covering 80% of the total production area, weeds were the most widely reported biological constraint to yields. Upland rice, in particular, competes poorly with weeds and uncontrolled weed growth often results in negligible or zero yield. In West Africa, yields of upland rice with farmers' weed control, were 44% lower than on researcher weeded plots. Losses due to uncontrolled weed growth in upland rice in India were up to 90%, and in both lowland and upland systems in Africa losses were within the range 28-100% (David Johnson, 2013).

In areas of rain-fed lowland rice, without bunds, yields could be increased by 23% through improved weed control, while in the most widespread upland rice systems, yields could be raised by 16% (Becker and Johnson, 2001). These estimates indicate that in sub-Saharan Africa weeds account for rice yield losses of at least 2.2 million tons per year at a value of $1.45 billion (Rodenburg *et al.,* 2009), in addition to the costs of weed control. These estimated losses equate approximately to half the current imports of rice to Africa (Rodenburg and Johnson, 2009). Weed control is the major labor activity on direct-seeded rice in Africa. Insufficient labour limits the area that can be cultivated successfully and results in delays in completing hand weeding, leading to serious yield reductions (Rezene Fessehaie, 1996; Afun *et al.,* 1999). Weed control is important to prevent losses in yield and production costs, and to preserve good grain quality. Specifically, weeds decrease yields by direct competition for sunlight, nutrients, and water, increase production costs e.g., higher labor or input costs and reduce grain quality and price. In southwest part of Ethiopia, manual weeding by hand is an efficient and common method applied for rice weed control. However, when to start this weeding practice for efficient and economical weed control is not studied. Therefore, the objective of this study was to determine optimum weeding time on rice cultivation for effective weed control and better yield at Kaffa zone of southwestern, Ethiopia.

2. Materials and Methods

2.1. Area description

The trial was conducted on experimental station of Gojeb sub-station at Bonga agricultural research center during 2012/13 cropping season. The sub-station is located at Gimbo district of Kaffa zone, Southern Nations Nationalities and People's Region (SNNPR). It is found within the southwestern plateau of Ethiopia and 49 km, 450 km and 725 km far from zonal town Bonga, Federal city Addis Ababa and regional city Hawassa respectively. The area lies at $07^0 26'71''$N Latitude and $036^0 20'54''$ E Longitude at the altitude of 1223 masl. The area experiences one long rainy season, lasting from March /April to October. The mean annual rainfall ranges from 1710 mm to 1892 mm. Over 85 % of the total annual rainfall, with mean monthly values in the range of 125-250 mm occurs in the 8 months long rainy season. The mean temperature ranges from 18.1^0C to 19.4^0C. Environmentally the site is belongs to the sub-agro ecology tepid to lowland. The soil of the study area is sandy clay loam at the top and sandy clay at sub soil with ph of 5.4. The topography is characterized by slopping and rugged areas with very little plain land (BARC, 2013).

2.2. Experimental materials and design

Rice varieties 'Superica 1' and 'Nerica 4' with recommended agronomic practices were used for this experimental study. The research design used was randomized complete block design (RCBD) with three replications for each rice variety. DAP (46% P2O5 and 18% N) fertilizers were used in the trial. The split application of fertilizer was used at planting and tillering stage. The seed rate of rice was done as recommended rate of 60 kg/ha. Inorganic pesticides like herbicides, Insecticides and fungicides were not used during the growth of the crop. Plot size used for this experiment was 4m X 4m; consisting of 13 rows in row spacing of 30 cm between rows. The treatments were four weeding time as follows:

T1 weeding 15-20 DAE, weeding 30-35 DAE, weeding 45-50 DAE
T2 weeding 20-25 DAE, weeding 35-40 DAE, weeding 50-55 DAE
T3 weeding 30-35 DAE, weeding 45-50 DAE, weeding 60-65 DAE
T4 farmers practice (control) 20-25 DAE

2.3 Data collection and analysis

All relevant data were collected like plant height (cm), number of tiller/plant, panicle length(cm), Culm length(cm), grain yield(kg), 1000 seed weight (gm) and crop biomass weight (kg). Accordingly; additional data of number of days from emergence to flowering and number of days from emergence to maturity were recorded. At maturity, ten plants were randomly selected from each plot and tagged as the above data sources. Flowering date was recorded when 75% of plants in the plot reached flowering stage; whereas, maturity date was recorded when 95% of the plant in the plot turned to brown. At maturity the crop was harvested, threshed, air dried and weighed. Moreover, weed density as well as individual weed species population count were recorded. All measured variables were subjected to analysis of variance using general linear model procedure of SAS software (SAS Institute, 2000).

3. Results and Discussion

The result of analysis of variance indicated that there was a significantly different at $p< 0.05$ among weeding time on Superica 1 rice variety yield and yield components. Weeding time treatments have shown effect on plant height, number of tiller per plant, panicle length, culm length, actual yield per hectare of rice (Table 1 and 2). In 'Superica-1" rice variety treatment one scored the highest grain yield (44.18 Q t/ha) and significant difference from treatment three (21.36 Qt/ha) which give the lowest grain yield. However other treatments such as treatment two (29.75 Qt/ha), three (21.36 Qt/ha) and four (29.93 Qt/ha) have no significant difference with respect to grain yield (Figure 1). More over other yield related parameters plant height, tiller number, panicle length, straw yield and 1000 seed weight result showed significantly difference at $p<0.05$ among weeding time. In all parameters treatment one bits other treatments. In tiller number highest number was recorded for treatment one (8.86) while lowest number recorded for treatment three (6.33) which is lower than control, treatment four. Lowest plant height was recorded for control treatment (92 cm) but highest plant height was recorded for treatment one (109.33 cm). Moreover 1000 seed weight showed significant difference among treatments. The highest seed weight was recorded for treatment one (37.73 gm) while the lowest grain weight was recorded for treatment four (36.07) (Table 1).

The grain yield of rice showed increasing trend with early time weeding. Late weeded rice field gave significantly the lowest grain yield irrespective of early weeded. This result is supported by Mohammadi and Amiri, (2011) states that there is not much competition from weeds once the crop is well established but it is always important getting rid of all weeds when the crop is in the very early stages of vegetative growth. According to David Johnson (2013), 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.

There were significantly difference at $p<0.05$ among weeding time on 'Nerica-4' rice variety yield and yield components. Weeding time treatments have shown effect on plant height, number of tiller per plant, panicle length, culm length, actual yield per hectare of rice. In 'Nerica-4' rice variety treatment one scored the highest grain yield (63.82 Qt/ha) and significant difference from treatment three (31.63 Qt/ha) which give the lowest grain yield (Figure 1). More over other yield related parameters plant height, tiller number, panicle length, straw yield and 1000 seed weight result showed significantly difference at $p<0.05$ among weeding times. In all parameters treatment one bits other treatments. In tiller number highest number was recorded for treatment one (10.20) while lowest number recorded for treatment two (6.20) which is lower than control. Lowest plant height was recorded for treatment two and three (89 cm) but highest plant height was recorded for treatment one (100.33 cm). Moreover 1000 seed weight showed significant difference among treatments. The highest 1000 seed weight was recorded for treatment two (38.73 gm) while the lowest grain weight was recorded for treatment four (36.53 gm) (Table 2). In contrary to other parameters clam length of treatment four (71.3 cm) is highest than other treatments. The grain yield of rice showed increasing trend with early time weeding in "Nerica-4' rice variety (Table 2). Late weeded rice field gave significantly the lowest grain yield irrespective of early weeded. This result is supported by Mohammadi and Amiri (2011) which states that there is no competition from weeds once the crop is well established but it is always important getting rid of all weeds when the rice is in early stages of vegetative growth. According to David Johnson (2013), 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. Similar results were reported on chickpea by Al-Thahabi *et al*. (1994), Rashid *et al*. (2009), Tepe *et al*. (2011) and Fathi *et al*. (2011) where weed interference decreased simultaneously tiller number and 1000 grain weight. Conversely, the beneficial effect of reduced weed competition show on tiller number, seed in plant, 1000 grain weight, and total dry matter, which is ultimately reflected in seed yield.

Generally the result shows that the advantages of early time of weeding on superica-1 and Nerica-4 rice varieties over farmers practice gives yield advantage of 14.25qt/ha and 15.65 qt/ha respectively. Weeding superica-1 and Nerica-4 prior to recommendation as 28 and 41 days after emergency (DAE) for the first and second weeding time respectively have tremendous yield advantages. This is because at early stage superica-1 and Nerica-4 are highly sensitive to any weed competition. Early weeding has additional advantage than reducing weed-crop competition by reducing diseases and pest prevalence. Rice is not 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, such as land preparation and early hand weeding, have been undertaken. Crop and weed interactions largely involve the competition for light, water and nutrients. Where water and nutrients are not limiting, light becomes the most important limiting factor. Reducing the distance between rows or hills, has been shown to reduce weed infestation in rice. Likewise, increased weed populations can decrease crop yield loss.

In irrigated lowland systems in West Africa, crop seed rates up to 200 kg/ha have been reported to be used by farmers to improve weed suppression by the crop. It has been noted that some "modern" higher yielding rice varieties are less able to compete with weeds than many of the traditional rice varieties they were intended to replace (David Johnson, 2013). Traditional varieties tend to be tall, of longer duration, droopy leaves and high vegetative vigor, while the modern varieties often combine short stature, short growth duration and erect leaves. This suggests that increases in yield potential of modern rice varieties compared to tall, leafy traditional varieties has been achieved by sacrificing their competitive ability with weeds. The lack of weed competitiveness in modern varieties may be one reason that many upland rice farmers have retained traditional varieties. The competitive ability of different rice varieties has become a focus of research, with the intention of combining competitive ability with other desirable characteristics in order to develop varieties suitable to low-input conditions. Studies on different plant types show that tillering ability, height, leaf canopy and root development may be important factors in determining the competitive ability of rice plants (David Johnson, 2013).

Weed species identified in the study area include broad leaved, grassy and sedges as shown in Table 3. Number of weed types and species compete with rice in research field. In the experimental plots grassy weeds and sedges dominated than broad leaved weeds in terms of infestation but interims kind broad leaves are higher. Here the recorded broad leaved weeds are 11 in number while grass weeds are six and recorded sedge was one. The major weed species competing vigorously with rice at early stages of growing periods were *Cyperus assimilis, Setaria pumila, Phalaris paradoxa* and *Xanthium spinosum* much of them are grass species which are the same family with rice (Table 3).

4. Conclusion

From the above results it could be concluded that different weeding times affected significantly grain yield and yield components of Nerica 4 and Superica-1 rice varieties. The maximum grain yield was obtained when weeding made at 15-20+30-35+45-50 DAE while the minimum value observed from weeding at 30-35+45-50+60-65 DAE for both verities. Moreover, maximum 1000 grain weight, straw yield and tillers number of rice were recorded upon weeding at 15-20+30-35+45-50 DAE. Therefor early weeding have significant roll to increase rice yield and yield components moreover it is important to prevent losses in yield and production costs and to preserve good grain quality. In general weeding rice field at 15-20+30-35+45-50 DAE gave the highest grain yield, maximum 1000 grain weight, high straw yield and better tiller number. Hand weeding Nerica-4 and Superica-1 at 15-20 DAE as first weeding, 30-35 DAE as second weeding and 45-50 DAE as third weeding time are ideal and potential weeding period in kaffa zone, southwest Ethiopia and similar rice producing agro-ecologies.

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Table 1. Effect of weeding time on yield and yield components of 'Superica-1' Rice variety at Kaffa, SW Ethiopia

Treatments	Tiller no.	Plant h. (cm)	Panicle L. (cm)	Culm L. (cm)	Straw Yield (Kg/m^2)	Yield (Qt/ha)	1000sw (gm)
T1	8.86	109.33	18.47	90.80	1.73	44.18	37.73
T2	7.67	97.20	18.17	78.90	1.27	29.75	37.07
T3	6.33	94.73	17.87	76.87	0.63	21.36	37.53
T4, control	6.40	92.00	16.97	75.03	0.87	29.93	36.07
Mean	7.32	98.32	17.87	80.40	1.13	31.30	37.10
LSD (5%)	3.21	14.68	2.72	12.50	1.35	20.56	1.66
CV	21.95	7.47	7.61	7.78	19.86	32.86	2.25

NB: T1 =weeding 15-20 DAE, 30-35 DAE, 45-50 DAE; T2 = weeding 20-25 DAE, 35-40 DAE, 50-55 DAE; T3 = weeding 30-35 DAE, 45-50 DAE, 60-65 DAE; T4 = farmers practice(control) 20-25 DAE; LSD=least significant difference; CV=coefficient of variation

Table 2. Effect of weeding time on yield and yield components of 'Nerica-4' Rice variety at Kaffa, SW Ethiopia

Treatments	Tiller no.	Plant h. (cm)	Panicle L. (cm)	Culm L. (cm)	Straw Yield (Kg/m^2)	Yield (Qt/ha)	1000sw (gm)
T1	10.20	100.30	39.80	60.53	1.50	63.82	37.10
T2	6.20	89.40	18.60	70.80	1.20	40.19	38.33
T3	6.87	89.40	18.23	71.17	0.80	31.63	37.27
T4, control	7.40	90.30	18.97	71.30	1.03	48.17	36.53
Mean	7.67	92.35	23.90	68.45	1.13	45.95	37.31
LSD (5%)	1.90	11.54	36.90	37.74	0.54	20.20	2.03
CV	12.26	6.26	27.20	27.60	23.93	22.02	2.72

NB: T1 = weeding 15-20 DAE, 30-35 DAE, 45-50 DAE; T2 = weeding 20-25 DAE, 35-40 DAE, 50-55 DAE; T3 = weeding 30-35 DAE, 45-50 DAE, 60-65 DAE; T4 = farmers practice(control) 20-25 DAE; LSD=least significant difference; CV=coefficient of variation

Table 3. Weed species identified in Rice research field, Kaffa zone, Southwest Ethiopia

Broad leaved weeds	***Grassy weeds***	***Sedges***
Hygrophila auriculata	*Cynodon nlemfuensis*	*Cyperus assimilis*
Amharanthus caudatus	*Digitaria abyssinica*	*Cyperus esculantus*
Amharanthus spinosus	*Eriocloa fatmensis*	*Cyperus difformis*
Commelina benghalensis	*Pennisetum clandestium*	*Cyperus rotundus*
Commelina latifolia	*Phalaris paradoxa*	
Xanthium spinosum	*Setaria pumila*	
Oxygonum sinuatum		
Nicandra physalodes		
Oorchorus olitorius		
Sonchus asper		
Launoea cornuta		

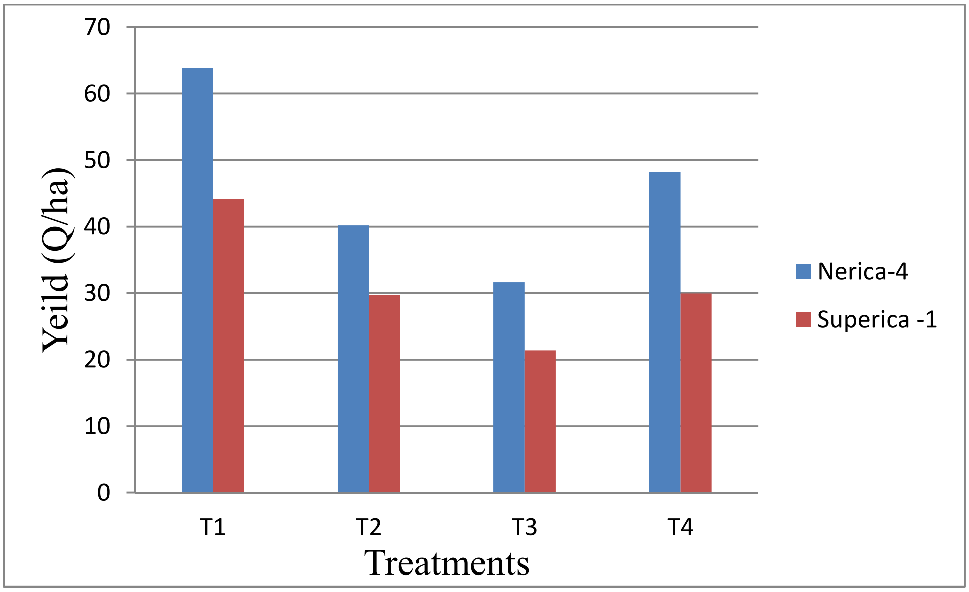

Figure1. Effect of weeding time on grain yield of rice superica-1, at kaffa zone, southwest Ethiopia

NB. T1 = weeding 15-20 DAE, 30-35 DAE, 45-50 DAE; T2 = weeding 20-25 DAE, 35-40 DAE, 50-55 DAE; T3 = weeding 30-35 DAE, 45-50 DAE, 60-65 DAE; T4 =s farmers practice(control) 20-25 DAE;