Rice Research: Open Access

Ismaila et al., J Rice Res 2014, 2:2
http://dx.doi.org/10.4172/jrr.1000122

Research Article Open Access

Influence of water depth and seedling rate on the performance of late season lowland rice (*Oryza sativa* L) in a Southern Guinea Savanna ecology of Nigeria

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Abstract

A three year field experiment was conducted between 2010 and 2012 at the irrigated lowland experimental field of National Cereals Research Institute in Edozhigi (9°04N, 6°7E) of the Southern Guinea savannah ecological zone of Nigeria, to determine the effect of different water depths and seedling rates on yield and yield components of lowland rice. The trial was laid out in a split plot and arranged in a randomized complete block design by six regimes of water depths (5 cm, 10 cm, 15 cm, 20 cm, saturated soil and continuous flow of water at 2 cm depth) was accommodated in the main plot while the seedling rate of 2, 4 and 6 per stand constituted the sub-plots. The results indicated that both grain yield and yield components of rice were enhanced while the water level increased to 20 cm, although both tiller and height were negatively affected by higher water level at the early stage of growth but it was later compensated at later stage. Water depth of 15 - 20 cm revealed higher grain yield of 5051.8, 4700.4 and 4066.0 kg ha^{-1} which was 84.4%, 85.2% and 84.7% higher than yields obtained from saturated plot in 2010, 2011 and 2012 respectively. Rice yield and yield components were significantly affected by different seedling rates and six seedlings per stand gave grain yield that is 13.1%, 27.8% and 14.4% higher than 2 seedling rate in 2010, 2011 and 2012, respectively. It is therefore concluded that maintaining water depth between 15 to 20 cm and seedling rate of 4 to 6 enhanced yield and yield components of lowland rice

Keywords: Water depth; Seedling rate; Performance; Lowland rice

Introduction

Rice is a semi aquatic plant that can be grown in standing water and dry land conditions. It was reported by Fogleman [1] that rice is grown under many different conditions and production systems, but submergence in water is the most common method worldwide. Most varieties of rice grow well and produce better yield when those are grown in flooded soils rather than non-flooded soils [2].

In farming systems of low land rice, water control is the most important practice that determines efficacy of production inputs such as nutrients, herbicides, pesticides, farm machineries, microbial activity and mineralization rate. Water plays a pivotal role in the management of rice systems. Different rice agro-ecosystems are mostly classified based on their hydrology and extent of water availability. Juraimi *et al.* [3] considered water as the most important component for sustainable rice production, especially in the traditional growing areas. Therefore, reduction or large removal of water from field can significantly decrease sustainability of rice production.

Irrigated lowland systems comprise 55% of the total rice area and provide 70% of the global rice production while rain-fed lowland and flood-prone areas constitute 35% of the total rice area, covering 4.7 million hectares in Asia but providing only 25% of global rice production because of various abiotic challenges associated with rain-fed ecosystems [4]. Chopra and Prakash [5] reported that 57% of rice is grown on irrigated lands, 25% on rain-fed lowlands, 10% on the uplands, 6% in deepwater and 2% in tidal wetlands while the report of Alan [2] indicated that irrigated rice ecosystem accounts for 75% of the global rice production.

Although, rice is a water loving crop, but continuous flooding could be stressful to the crop particularly during the seedling establishment stage when increase in water depth could jeopardize the performance of the crop. It is therefore very imperative to determine the safe limit for water depth that will give better rice performance, hence this study. The study was conducted with the main objectives of determining the response of lowland rice yield and yield components to different depths of ponded water and appropriate seedling rate that gives better rice grain yield.

Materials and Methods

The experiment was conducted at Edozhigi lowland rice research field of National Cereals Research Institute, Badeggi, Bida, (Latitude 09^0 45' N and Longitude 6^0 07' E at an elevation of 75 meters above sea level). Niger State is in the Southern Guinea Savannah ecological zone of Nigeria between 2010 to 2012 late seasons. The average annual rain fall was 1287.5, 1158.3 and 1158.6 mm in 2010, 2011 and 2012 respectively, while the peak of rain fall was between July to September annually (Figure 1). During the three years of field experimentation, rain fall began in April and ended in October except for 2010 when rain fall extended to November.

The trial was laid out using a split plot design by six levels of water (5 cm, 10 cm, 15 cm, 20 cm, saturated soil and free flow of water) as the main plots while three seedling rates (2, 4, and 6 seedlings per stand) constituted the sub-plots. The main plot size was 10 m x 4 m while the sub – plot was 3 m x 4 m, the net plot was 2.8 m x 4 m by

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Received January 31, 2014; **Accepted** February 24, 2014; **Published** February 26, 2014

Citation: Ismaila U, Kolo MGM, Odofin JA, Gana AS (2014) Influence of water depth and seedling rate on the performance of late season lowland rice (*Oryza sativa* L) in a Southern Guinea Savanna ecology of Nigeria. J Rice Res 2: 122. doi: 10.4172/jrr.1000122

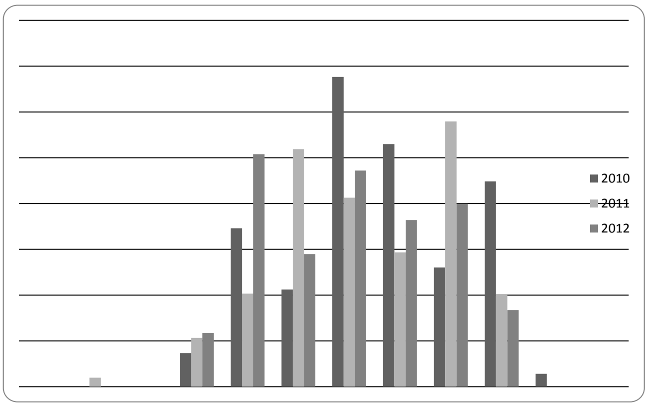

Figure 1: Monthly Mean Rain fall data (mm) between 2010-2012 at the experimental site.

three replicates. The experiment was conducted between September to December which represents the late cropping season in Nigeria.

Water management

Irrigation water was supplied through a channel that had its source from the perennial River Kaduna. The water was let into the field through the alley way and 3-inch PVC pipe was connected from the alley way to each plot serving as water inlet pipe. White plastic indicator was fixed at the middle of each plot to monitor the water level, while 10 cm plastic hose of 3-inches diameter was connected to each plot to drain the excess water when the maximum water level was attained.

Agronomic practices

The land was mechanically ploughed, harrowed and leveled but the bonds round the perimeter of the plots were manually constructed with a hoe. The FARO 57 rice seeds used in the study were obtained from the Seed Unit of National Cereals Research Institute, Badeggi. A nursery was established on August 20th, 30th and 21th of 2010, 2011 and 2012 respectively. Rice seedlings were transplanted 30 days after seeding (DAS) according to expatiate seedling treatments at the spacing of 20 x 20 cm. Each sub-plot received a uniform application of 40 kg/ha N, 40 kg/ha P_2O_5 and 40 kg/ha K_2O one week before transplanting. Additional 40 kg/ha N was applied at panicle initiation stage. The source of N, P_2O_5 and K_2O was urea (46% N), single super phosphate (18% P_2O_5) and muriate of potash (60% K_2O) respectively. The field was flooded to various heights as dictated by the treatments at 15 days after transplanting (DAT).

Fertilizer application was by broadcast after proper drainage of water from the plots. The plots were then flooded immediately after fertilizer application. The plots were finally drained one week before harvest and harvesting was done when the grains were hard and turned yellowish/brown, which occurred at between 30-45 days after flowering or one month after 50% flowering.

Rice parameters

The rice plant height was taken at four intervals (30, 45, 60 and 75 DAT) using metric rule which was measured from the ground level to apex of the tallest leaf. Rice tiller count was taken from 1m2 quadrant at four intervals (30, 45, 60 and 75 DAT). Number of panicles per m2 was also taken from 1m2 quadrant (averaged over 3 - quadrants thrown at random at 100 DAS). Days to 50 % flowering were determined when 50 % of the rice in each plot had flowered.

Rice grain yield was obtained from the net plot; the chaff was separated from the grain by soaking in water for two minutes. After proper steering, the floating chaff and the grain were collected and dried separately and weighed using weighing balance. Obtained grain was converted into tonnes per hectare. Percentage chaff was determined using the following formula.

$$\%\ \text{Chaff} = \frac{\text{Chaff weight}}{\text{Total harvest}} \times 100$$

The weight of 1000 grains was determined by taking the measurement of 100 grains using an electrical digital weighing balance and the results were multiplied by 10 to give 1000 grains weight.

Data Analysis

Experimental data were subjected to Analysis of Variance (ANOVA) using the M-Stat-C version 1.3 statistic package and significant means were compared using Duncan Multiple Range Test at 5% probability.

Physical and chemical properties of soil in the experimental site

Composition of soil samples were collected from 0 to 30 cm of each block before transplanting. The samples were air-dried, ground to be passed through a 2 mm sieve. The samples were analyzed for selected physicochemical properties, namely, organic carbon, total nitrogen (N) soil pH, available phosphorus (P), available K, cation exchange capacity (CEC) and texture.

Organic carbon content of the soil was determined using the volumetric method Walkley and Black [6] as described by guide to laboratory establishment for plant nutrient analysis in Food and Agriculture Organization of the United Nations [7]. Total soil nitogen was analyzed by Micro-Kjeldahl digestion method with sulphuric acid. The pH of the soil was determined using 1:2.5 (weight/volume) soil samples to water ratio using a glass electrode attached to a digital pH meter.

Cation exchange capacity was measured after saturating the soil with 1M ammonium acetate (NH4OAc) and displacing it with 1M NaOAc [8]. Available phosphorous was extracted by the Olsen method, and phosphorous analyzed using spectrophotometer.

Particle size distribution was done by the hydrometer method according to FAO [7]. To determine exchangeable potassium in the soil, the soil samples were extracted with 0.5 N ammonium-acetate at pH 7.0 and the exchangeable potassium was determined with a flame photometer according to Hesse [9] (Table 1).

Soil characteristics measurement	
Texture	
Sand %	94.2
Silt %	1.2
Clay %	4.6
Textural class	Sand loam
pH (H_2 0)	4.6
Organic matter (g kg^{-1})	1.2
Available P (ppm)	6.3
Exchangeable bases (cmo1kg^{-1})	
ECEC (mg kg^{-1})	13.1

Table 1: Physcio - Chemical properties of soil of the experimental site, Edozhigi.

	2010				2011				2012			
Days after transplanting												
Treatment	30	45	60	75	30	45	60	75	30	45	60	75
Water depth cm												
5	48.9^{e}	67.7^{c}	91.5^{b}	114.8^{c}	49.0^{f}	67.5^{d}	92.8^{b}	114.4^{b}	48.4^{d}	65.3^{e}	86.2^{c}	113.4^{d}
10	51.2^{d}	70.2^{c}	91.8^{b}	111.4^{d}	50.7^{e}	70.2^{c}	92.4^{b}	114.6^{b}	50.5^{c}	68.9^{c}	91.1^{b}	115.6^{c}
15	53.7^{c}	71.9^{b}	93.7^{b}	117.3^{b}	53.7^{c}	72.7^{b}	104.2^{a}	119.6^{a}	53.8^{b}	74.3^{b}	105.2^{a}	120.5^{b}
20	55.4^{b}	90.6^{a}	110.6^{a}	119.2^{a}	54.7^{b}	73.5^{a}	103.9^{a}	120.0^{a}	54.6^{b}	76.7^{a}	104.9^{a}	125.8^{a}
Cont. flow	60.3^{a}	65.8^{d}	92.9^{b}	113.0^{c}	61.7^{a}	66.9^{d}	80.4^{c}	108.2^{c}	60.9^{a}	67.5^{d}	76.3^{d}	99.8^{e}
Saturated	48.0^{f}	72.2^{b}	78.8^{c}	112.6^{d}	52.0^{d}	60.9^{e}	72.2^{d}	108.3^{c}	49.3^{d}	56.5^{f}	67.0^{e}	91.1^{f}
CV	1.9	13.7	14.4	3.8	1.7	1.6	1.4	1.0	1.5	3.2	2.7	1.7
SE	0.3	3.3	4.5	1.5	0.6	0.4	0.4	0.4	0.4	0.5	1.8	0.7
Seedling rate (S)												
2	43.8^{c}	55.5^{c}	60.6^{b}	111.6	45.1^{c}	54.9^{c}	70.1^{c}	108.8^{a}	45.1^{c}	58.3^{c}	73.3^{c}	104.4^{c}
4	55.7^{b}	70.8^{b}	108.7^{a}	114.8	56.7^{b}	69.9^{b}	100.4^{b}	116.9^{b}	55.6^{a}	67.4^{b}	90.3^{b}	111.8^{b}
6	59.2^{a}	92.8^{a}	110.3^{a}	117.8	59.1^{a}	81.1^{a}	102.5^{a}	116.8^{b}	58.1^{b}	78.9^{a}	101.8^{a}	116.9^{a}
CV	1.8	13.7	14.4	3.8	1.7	1.6	1.4	1.0	1.5	3.2	2.7	1.69
SE	0.2	2.4	3.2	1.0	0.2	0.3	0.3	0.3	0.2	0.5	0.6	0.4
W X S	S	S	NS	NS	S	S	S	S	S	S	S	S

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

Table 2: Effects of water depth and seedling rate on plant height (cm) in late season sown rice in 2010- 2012.

	2010				2011				2012			
Days after transplanting												
Treatment	30	45	60	75	30	45	60	75	30	45	60	75
Water depth cm												
5	104^{c}	242^{d}	348^{d}	370^{d}	109.9^{c}	239^{d}	338^{d}	381^{c}	106^{c}	248^{d}	305^{d}	322^{d}
10	93^{c}	339^{c}	476^{c}	426^{c}	93.2^{d}	332^{c}	480^{c}	412^{b}	92^{d}	315^{c}	486^{c}	526^{c}
15	89^{d}	431^{a}	553^{b}	497^{b}	89.0^{e}	441^{a}	563^{a}	574^{a}	85^{e}	423^{b}	553^{b}	573^{b}
20	87^{e}	419^{b}	561^{a}	549^{a}	88.8^{e}	419^{b}	555^{b}	578^{a}	86^{e}	454^{a}	558^{a}	587^{a}
Cont. flow	112^{b}	237^{e}	324^{e}	347^{e}	117.1^{b}	221^{e}	314^{e}	269^{d}	129^{a}	192^{e}	152^{e}	137^{e}
Saturated	126^{a}	216^{f}	285^{f}	332^{f}	121.7^{a}	194^{f}	220^{f}	186^{e}	123^{b}	140^{f}	84^{f}	76^{f}
CV	3.8	3.6	4.1	3.4	7.0	2.5	1.8	2.4	3.5	9.5	2.5	4.4
SE	1.3	3.7	5.8	4.8	2.4	2.3	3.6	3.9	2.1	7.9	3.3	6.5
Seedling rate (S)												
2	130^{a}	402^{a}	472^{a}	532^{a}	394^{a}	394^{a}	454^{a}	472^{a}	122^{a}	343^{a}	388^{a}	402^{a}
4	98^{b}	345^{b}	418^{b}	390^{c}	322^{b}	322^{b}	408^{b}	387^{b}	100^{b}	290^{b}	351^{b}	364^{b}
6	78^{c}	196^{c}	383^{c}	339^{d}	207^{c}	207^{c}	373^{c}	342^{c}	89c	252^{c}	331^{c}	345^{c}
CV	3.9	3.6	4.1	3.4	2.6	2.6	1.8	2.4	3.5	9.5	2.5	4.2
SE	0.9	2.6	4.1	3.4	1.9	1.8	1.7	3.9	0.8	6.6	2.1	3.7
W X S	S	S	S	S	S	S	S	S	S	NS	S	S

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT). NS –not significant, S - significant, at P ≤ 0.05

Table 3: Effect of water depth and seedling rate on tiller m-2 in late season sown rice in 2010 - 2012.

Results

The rice plant height was significantly affected by both water depth and seedling rate at all sampling periods in the three years of study (Table 2). At the early stage of growth (30 DAT), the highest plant height was obtained when the field was under continuous flow of water, but as plant growth progressed toward maturity, the water depths of 15–20 cm produced significantly taller plants than the other treatments. This result was consistent in the three years of study.

For seedling rates, higher seedling rate of six gave significant higher plant height at all the sampling periods (Table 2).

Water depth and seedling rate had significant effect on rice tillering at all the sampling periods (Table 3). Saturated plots gave better rice tillers at the early stage of growth (30 DAT) than the other treatments (Table 3). However, as growth progressed, significant tiller number was attained along with increased water depth.

The water depth and seedling rate have decisive bearing on rice yield components considered in the current study (Table 4). Days to 50 % of flowering were attained earlier in the plots not flooded and the days increased by elevation of water depth while the higher seedling rate of six showed significant lower days to 50 % flowering than the rest. The number of panicles per m^2 was significantly higher in 20 cm water depth while seedling rate of six revealed higher number of panicles per m^2 (Table 4).

The percentage chaff was lower in flooded plots than that of unflooded (Table 4). The 20 cm water depth showed significant lower % chaff which was consistent throughout the three years of study

	Days 50% flowering			Panicle m^{-2}			% chaff		
Treatment	2010	2011	2012	2010	2011	2012	2010	2011	2012
Water depth cm (W)									
5	69.9^{c}	70.8^{c}	71.1^{d}	191.0^{d}	187.8^{d}	185.3^{d}	7.9^{c}	8.0^{c}	7.8^{c}
10	74.6^{b}	74.4^{b}	76.0^{c}	290.3^{c}	285.7^{c}	269.0^{c}	8.0^{c}	7.7^{c}	7.9^{c}
15	78.9^{a}	80.9^{a}	80.7^{b}	398.1^{b}	384.8^{b}	368.7^{b}	6.8^{d}	7.0^{d}	6.5^{d}
20	79.6^{a}	81.6^{a}	83.4^{a}	464.7^{a}	441.7^{a}	406.6^{a}	6.9^{d}	6.7^{d}	6.2^{d}
Cont. flow	67.0^{d}	66.7^{d}	67.2^{e}	121.8^{e}	110.7^{e}	90.6^{e}	12.7^{b}	13.4^{b}	12.1^{b}
Saturated	65.4^{e}	64.4^{e}	66.2^{f}	101.8^{f}	53.1^{f}	34.3^{f}	14.6^{a}	15.6^{a}	14.6^{a}
CV	2.1	0.7	1.1	5.7	1.9	3.0	7.9	4.5	4.6
SE	0.5	1.1	0.2	4.9	3.0	1.7	0.5	0.4	0.4
Seedling rate (S)									
2	79.5^{a}	79.6^{a}	79.6^{a}	200.3^{c}	193.6^{c}	184.8^{c}	8.4	7.7	7.9
4	72.1^{b}	72.1^{b}	72.1^{b}	267.7^{b}	255.3^{b}	237.7^{b}	7.9	8.3	7.5
6	66.1c	67.7^{c}	70.7^{c}	315.9^{a}	282.9^{a}	254.7^{a}	8.0	7.9	8.0
CV	2.1	0.8	1.1	5.6	1.9	3.0	7.9	4.5	4.6
SE	0.4	0.1	0.2	3.4	1.1	1.6	0.8	0.6	0.4
W X S	S	S	S	S	S	S	S	S	S

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT). NS –not significant, S - Significant

Table 4: Effect of water depth and seedling rate on yield components in late season sown rice in 2010 – 2012.

	2010				2011				2012			
Days after transplanting												
Treatment	30	45	60	75	30	45	60	75	30	45	60	75
Water level cm (W)												
5 cm	85.5^{c}	78.4^{c}	72.8^{c}	68.1^{c}	52.9^{c}	94.1^{c}	83.9^{c}	73.1^{c}	62.1^{c}	95.8^{c}	85.8^{c}	83.7^{c}
10 cm	63.5^{d}	58.4^{d}	50.2^{d}	64.5^{d}	50.7^{c}	79.4^{d}	62.1^{d}	51.2^{d}	49.5^{d}	79.9^{d}	76.6^{d}	72.1^{d}
15 cm	38.7^{e}	34.7^{e}	30.9^{e}	38.6^{e}	34.7^{d}	42.0^{e}	34.7^{e}	28.4^{e}	30.1^{e}	52.1^{e}	42.4^{e}	39.7^{e}
20 cm	26.9^{f}	20.2^{f}	17.7^{f}	15.4^{f}	32.1^{e}	32.1^{f}	30.1^{f}	25.4^{f}	24.9^{f}	43.9^{f}	37.4^{f}	38.5^{f}
Con't flow	121.4^{b}	110.1^{b}	130.8^{a}	145.2^{b}	90.6^{b}	126.1^{b}	113.5^{b}	114.6^{b}	103.1^{b}	224.3^{b}	3204.1^{b}	4283.8^{b}
Saturated	152.9^{a}	122.0^{a}	110.6^{b}	220.1^{a}	127.7^{a}	152.7^{a}	159.5^{a}	148.1^{a}	171.91^{a}	277.4^{a}	4574.6^{a}	4919.2^{a}
CV	2.6	7.1	54.8	11.2	11.5	4.09	14.7	5.9	3.43	5.9	5.9	4.4
SE	0.7	1.7	12.6	3.4	2.7	0.72	3.9	1.0	1.60	4.8	36.1	47.2
Seedling rate (S)												
2	143.7^{a}	124.6^{a}	118.0^{a}	164.7^{a}	88.7^{a}	140.1^{a}	127.0^{a}	111.1^{a}	97.6^{a}	169.5^{a}	1474.0^{b}	1691.6^{a}
4	67.6^{b}	60.7^{b}	49.5^{b}	70.4^{b}	58.0^{b}	71.7^{b}	67.7^{b}	59.7^{b}	66.3^{b}	125.8^{b}	1338.9^{a}	1562.8^{b}
6	33.1^{c}	26.6^{c}	39.0^{c}	40.7^{c}	47.7^{c}	51.4^{c}	47.2^{c}	49.6^{c}	56.9^{c}	91.5^{c}	1197.6^{c}	1464.0^{c}
CV	2.6	7.1	54.8	11.2	11.5	4.09	14.7	5.9	3.43	5.9	5.9	4.4
SE	0.5	1.2	8.9	2.4	1.7	0.85	2.8	1.0	0.59	1.8	18.5	16.3
W X S	S	S	S	S	S	S		S	S		S	S

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT). NS –not significant, *

Table 5: Effect of water level and seedling rate on weed dry matter (g m-1) in late season sown rice in 2010 - 2012.

(Table 4). The result of this study indicated that seedling rate have no significant effect on % chaff. Weight of Rice grain was significantly higher at 20 cm water depth and decreased with decrease in water depth. Fewer seedling rate of two gave significantly higher grain weight than either four or six (Table 5). The plots that were left unflooded as in free flow and saturated plots, weed competition tended to be higher which could be attributed to low grain weight in those plot (Table 6).

Production of rice grains was significantly affected by both water depth and seedling rate so that the highest grain yield was recorded when the field was under continuous 20 cm of water depth from 15 days after transplanting till maturity (Table 5). The saturated plot had the lowest grain yield across the three years of study.

Weed dry weight was significantly affected by different water depth and seedling rate in the three studies. Lowest weed dry weight was recorded in 20 cm water depth and increased as the water depth decreased. The highest weed dry weight accumulation was recorded in saturated plot, where no ponding was done.

Discussions

Ponding of rice plant at the early stage of development had negative impact on plant height which might be due to the fact that the rice seedlings are too young to stand against stress of flood at this stage. Williams *et al.* [10] observed that growth is always stressful during seedling establishment in standing water so that deep water can jeopardize the rice crop. It is important then, to determine a safe limit for water depths in order avoid unacceptable risks. The result is in agreement with the finding of Tadesse *et al.* [11], who observed shorter rice plant in continuous flooding condition.

The taller rice plants associated with the higher numbers of

	1000 grain weight (g)			Grain yield (kg ha-1)		
Treatment	2010	2011	2012	2010	2011	2012
Water depth cm (W)						
5	29.1[d]	29.1[d]	28.6[b]	3289.1[d]	3245.2[d]	3141.0[d]
10	30.0[c]	30.0[c]	29.7[a]	3551.7[c]	3550.0[c]	3311.3[c]
15	31.3[b]	32.0[b]	32.3[a]	4702.3[b]	4493.1[b]	4066.0[a]
20	31.8[a]	32.5[a]	32.7[a]	5051.8[a]	4700.4[a]	4033.1[b]
Cont. flow	28.3[e]	28.2[e]	28.0[b]	2812.3[e]	2534.3[e]	2103.7[e]
Saturated	27.7[f]	27.6[f]	27.8[b]	990.0[f]	696.2[f]	607.2[f]
CV	2.5	1.8	25.9	3.0	1.3	2.5
SE	0.2	0.3	2.7	34.1	12.5	19.3
Seedling rate (S)						
2	31.3[a]	31.1[a]	31.2[a]	3128.3[c]	3245.2[c]	2616.9[c]
4	29.0[b]	29.3[b]	29.5[b]	3468.9[b]	3550.0[b]	2956.2[b]
6	28.8[c]	29.3[c]	28.6[b]	3601.4[a]	4493.1[a]	3058.1[a]
CV	2.5	1.8	25.9	3.0	1.3	2.5
SE	0.2	0.1	1.9	24.1	9.9	16.60
W X S	S	NS	NS	S	S	S

Means followed by the same letter (s) within a column are not significantly different at 5% level of probability. (DMRT). NS –not significant, S - significant, at P ≤ 0.05

Table 6: Effect of water depth and seedling rate on yield in late season sown rice in 2010 - 2012.

seedling/stand might be due to intra-plant competition for sunlight energy. Similar results were recorded by Gupta [12] who observed that higher seedling/hill gave significant higher plant height. The experiment conducted by Prabha *et al.* [13] to compared one and three seedlings/hill; it was also observed that the higher seedlings/hill gave significant taller plant.

This study indicated that the fewer seedling rates of two lead to significantly better tillers than those of four and six. Williams *et al.* [10] also observed that rice developed more tillers in shallow water depth than deeper water at the early stages of growth. However, Balasubramanian and Palaniappan [14] reported that drainage at maximum tillering stage stimulates vigorous root growth and reduced the development of unproductive tillers. Shrirame *et al.* [15] also found that planting of two seedlings/hill lead to significantly higher number of total tillers over single seedling/hill. Results of the current study are also in line the finding of Prabha *et al.* [13] and Sen *et al.* [16]. The greater number of tillers produced in the 15 – 20 cm water depth and two seedlings/hill might be due to less competition among rice and its weeds in deeper water situation (Table 6) [17].

Delay in 50% flowering in the water depth of 15 – 20 cm could be due to luxury availability of water that tended to enhance vegetative growth rather than reproductive stage of rice plant. This is not in line with the work of William et al. [10] who reported that despite the slow start, rice in deep water attained maturity about 4 days before the rice in shallow water. They observed that different temperatures had no effects since the deep water was generally cooler than the shallow water. The earlier heading in the saturated soil condition might be due to a a stress reaction.

The higher panicle, grain weight and low percentage chaff observed in higher water depth plots might be due to suppression of weed growth. Since weed is a known enemy of these yield attributes, less competition from weed will definitely enhance their productivity. Several workers Juraimi *et al.* [3], Sariam [18] indicated that production of rice panicles was significantly influenced by flooding. According to Sariam [18] and Siti Mardina [19], production of panicles was significantly higher when the field was under continuous flooding than saturated one. This study is in line with the report of the above authors. The higher number of panicles m^{-2} in all flooded regimes is also observed to be due to the high number of tillers in the same flooding treatments which could also be attributed to low weed infestation. The report by Mohd Razi Ismail *et al*, [20] on growth and yield response of rice variety on different water regimes indicated that rice panicle and 1000 grain weight was higher under flooding condition than saturated condition.

The high percentage chaff in saturated plots might be due to reduced water availability at the flowering stage or the effect of weed infestation in the treatment. In fact, the finding could be caused by shortage of water at the anthesis (flowering) stage, which restricted rice pollination process leading to produce infertile and empty rice grain.

In the current study, flood depth of 20 cm effectively suppressed weed growth (Table 6), which resulted in lower competition between the rice and weed. Kakade and Soner [21] observed that continuous flood of rice field up to flowering significantly increased grain yield over alternation between floods and drying. Yakan and Surek [22] found no significant differences in grain yield among the relevant treatments. On the other hand Borrell [23] compared different irrigation regimes in dry seeded rice production of Australia. The authors found that flooded irrigation from sowing to maturity resulted in the highest grain yield.

Beser [24] conducted an experiment on different irrigation methods and observed that highest rice grain yield in continuous flooding irrigation. Also, the highest values of total biological yield and harvest index were achieved in continuous flooding irrigation. Although Tabbal *et al.* [25] observed no significant difference in the yield between rice grown in flooded condition, alternate flooded conditions and saturated condition.

Generally, grain yield was better with increased water depth which resulted to decreased weed infestation as a result of impact of ponding water on the weed seed and the killing of weed seedlings. This result is in line with the work of Sen [16], who observed that increasing the yield of lowland rice required reducing crop losses from weeds, which in turn require good water management to minimize weed infestation. Bhagat *et al* [26], Pane [27] and Zainal *et al.* [28] indicated that germination of weed seeds was significantly reduced by flooding. Zainal *et al* [28] concluded that flooding is the most effective cultural practice to weed

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control in lowland rice ecology, particularly when fields are continuous flooded to water depth of 7.5 – 15 cm.

The higher grain yield recorded in higher seedling rate of 6 could be due to the fact this rate suppressed weed growth much more than it counterpart.

Conclusion

Results of the current study indicated that performance of lowland rice is enhanced by continuous flood water depth. At the early stage of rice growth, both the height and tillers were negatively affected by flood. It is therefore, advisable to delay introduction of continuous flooding in the rice field beyond 15 DAT when the rice would be strong enough to stand the stress of flooded water. At this stage, either post emergent herbicide application or manual weeding could be carried out before introduction of flooded water to control weeds. The study also showed that transplanting four to six seedling/hill enhanced fast canopy cover hence weed suppression which might likely result to better grain yield of rice.

References

1. Fogleman M (2010) Introduction to Rice.
2. Alan KW (2002) Flooding (weed control in rice) IRRI Makati City, Philippines: In encyclopedia of pest management CRC press.
3. Juraimi AS, Muhammad MY, Begum M, Anuar AR, Azmi M, et al. (2009) Influence of flood intensity and duration on rice growth and yield . Pertanika journal of Tropical Agricultural science 32: 195- 208.
4. Ismail AM, Johnson DE, Ella ES, Vergara GV, Baltazar AM (2012) Adaptation to flooding during emergence and seedling growth in rice and weeds, and implications for crop establishment.
5. Chopra VL, Prakash S (2002) Evolution and Adaptation of Cereal Crops. Science Publishers Inc, NH, USA.
6. Walkley AJ, Black IA (1984) Estimation of soil organic carbon by the chromic acid titration method. Soil Sci, 37: 29-38.
7. FAO (2008) FAO fertilizer and plant nutrition bulletin: Guide to laboratory establishment for plant nutrient analysis. Rome, Italy. Pp. 203.
8. Chapman HD (1965) Cation-exchange capacity. InMethods of SoilAnalysis; Black CA: American Society of Agronomy: Madison, WI, Pp. 891-901
9. Hesse PR (1971) A Text Book of Soil Chemical Analysis. John Murray, London Pp 520
10. Williams JF, Roberts SR, Hill JE, Scardaci SC, Tibbits G (1990) Managing water for weed control in rice. California Agric. 441: 7-10.
11. Tadesse TF, Decchassa NR, Bayu W, Gebeyehu S (2013) Impact of rainwater management on growth and yield of rainfed lowland rice. Woodpecker journal of Agricultural research 2: 108-114.
12. Gupta SK (1996) Effect of planting, seedlings and nitrogen on yield of rice (Oryza sativa). Indian J. Agron, 41: 581-583.
13. Prabha ACS, Thiyagarajan TM, Senthivrlu (2011) System of Rice Intensification Principles on Growth Parameters, Yield Attributes and Yields of Rice (Oryza sativa L.)
14. Balasubramanian P, Palaniappan SP (2007) Principles and Practices of Agronomy, 2nd ed. Agrobis, India. Pp. 291-292.
15. Shrirame MD, Rajgire HJ, Rajgire AH (2000) Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. J. Soils Crops. 10: 109-113.
16. Sen LTH, Ranamukhaarachchi SL, Zoebisch MA, Hasan MM, Meskuntavon W (2002) Effects of early-inundation and water depth on weed competition and grain yield of rice in the Central Plains of Thailand. Conference on International Agricultural Research for Development.
17. Kolo MGM, Umaru I (2012) Weed competitiveness and yield of inter-and intraspecific upland rice (Oryza sativa L.) under different weed control practices at Badeggi, Niger State, Nigeria. African Journal of Agricultural Research 7: 1687-1693.
18. Sariam O (2004) Growth of non-flooded rice and its response to nitrogen fertilization. Ph.D Thesis, Universiti Putra Malaysia. Pp. 260.
19. Siti Mardina I (2005) Kajian paras air berbeza ke atas populasi rumpai dan hasil padi. Final Year Project Paper, Universiti Putra Malaysia. Pp. 74.
20. Mohd Razi I, Kamal Uddin MD, Wan Ahmad Z, Maziah M, Ismail CH (2013) Growth and yield reposnse of rice variety MR220 to different water regimes under direct seeded conditions. WFL Publisher volume 11: 367-371.
21. Kakade BV, Soner KR (1983) Nutrient uptake and yield of rice as influenced by moisture regimes. In : International Rice Commission Newsletter, 32: 38-40
22. Yakan H, Sürek H (1990) Edirne yöresinde çeltik sulaması. Köyhizmetleri Genel Müdürlüsü, Kırklareli Atatürk Aras. Ens. Müd. Yayınları.
23. Borrell AK (1991) Irrigation methods for rice in tropical Australia. Inter. In: Rice Research Notes. 16: 28.
24. Beser N (1997) Trakya Bölgesi'nde degisik ekim ve sulama yöntemlerinin Çeltikte (Oryza sativa L.) verim ve verim unsurları ile kalite karakterlerine etkisi. Ph D Thesis, Trakya University, Edirne, Turkey. Pp. 160.
25. Tabbal DF, Lampayan RM, Bhuiyan SI (1992) Water-efficient irrigation technique for rice. In Proceedings of International Workshop on Soil and Water Engineering for Paddy Field Management, Asian Institute of Technology, Pp. 146-159.
26. Bhagat RM, Bhuiyan SI, Moody K (1996) Water, tillage and weed interactions in lowland tropical rice: A review. Agric. Water Manage. 31: 165-184.
27. Pane H (1997) Studies on ecology and biology of red sprangletop and its management in direct seeded rice. Ph.D. thesis, Universiti Sains Malaysia, Malaysia.
28. Zainal AAH, Mashhor M, Azmi M (2007) The effect of flooding on seed germination of weedy rice (oryza sativa complex, locally called padi angin) under plant house condition.

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