Journal of Research in Weed Science

Journal homepage: www.jrweedsci.com

JRWS

Orginal Research Article

Growth and yield of direct seeded upland rice varieties as influenced by weed management and organic manure application

Danmaigoro O [a*], Halilu A.G[b], Izge A.U[a]

a Department of crop science, Faculty of Agriculture, Federal University Dutse, Jigawa, Nigeria

b Department of soil science, Faculty of Agriculture, Federal University Dutse, Jigawa, Nigeria

ARTICLE INFORMATION

Received: 11 December 2018

Revised: 5 February 2019

Accepted: 7 February 2019

Available online: 7 February 2019

DOI: 10.26655/JRWEEDSCI.2019.3.2

KEYWORDS

Herbicide
Grain Yield
Poultry manure
Rice
Variety

ABSTRACT

Field experiments were conducted on the research farm of Federal University Dutse in the Sudan savannah ecological zone Nigeria to evaluate the performance of upland rice varieties as affected by herbicide and poultry manure application. The two locations lie in the Sudan savanna ecological zone with a mean annual rainfall of 600 mm distributed between May and October. The treatments consisted of three rates of poultry manure (0, 5 and 10 t/ha) and five weed control treatments factorially combined in the main plot while two upland varieties of rice (Nerica and Faro 48) in the sub-plot. The treatments were laid out in a split-plot design with three replications. Application of pendimentaline+one hoe weeding at 6 WAS produced significantly greater plant height, leaf area, leaf area index, length panicle, panicle weight per plant, biological yield and the grain yield of rice than the other rates comparable with the hoe weeded control while the weedy check had the least. The application of 10 t/ha of poultry manure gave significantly greater plant height, leaf area, leaf area index, length of panicle, number of grain per panicle, harvest index and the grain yield of rice than the lowest rates (0 and 5 t/ha). It can be concluded that rice farmers in the sudan savanna zone of Nigeria can adopt 10 t/ha of manure, pendimentaline+one weeding control at 6 weeks after sown and the Faro 48 rice variety since the combination of these treatments gave better weed control, growth and yield of paddy rice.

Introduction

Presence of weeds is one of the most important limiting factors in direct seeded rice (DSR) fields and these crops are very sensitive and vulnerable to weed competition during early part of its growing season (Rao et al. 2007). Generally in DSR the weeds and rice germinate and grow

Corresponding author, email: odanmaigoro@gmail.com (Danmajoro O).

simultaneously, so the proper time and method for weed management in such crops is very complicated (Khaliq and Matloob, 2011). The simultaneous appearance of crop and weeds leads to pressure on the crop through interference and competition to achieve water and nutrient sources, so that yield losses usually occurs when weeds emerge earlier or simultaneously with crop (Aldrich, 1987). The effective and proper weed management program in a direct seeded rice production system is essential for achieving higher productivity and profitability (Jaya Suria et al. 2011). Rao et al. (2007) described the various weed management strategies in direct seeded rice in Asia. These strategies include agronomic practices as land preparation, seeding rates, application of different fertilizer, water and irrigation management, using the competitive cultivars, as well as manual, mechanical, and chemical weed management. A smart choice for weed management methods depends upon different factors including soil type, weather and climatic conditions, the farmer's economic situation, technology available and is evaluated in terms of the cost of weed management in comparison with the estimated value of the resulting yield increase. Manual weeding, although efficient in controlling weeds, has been restricted due to several factors which include drudgery, labour scarcity and destruction of the crop plants. The estimated losses due to weeds in West Africa range from 33-75% in lowland and 70-100% in upland rice varieties (Ismaila et al. 2013). Weed interference in rice is known to reduce grain yield by affecting grains per panicle. In Nigeria the average yield reduction due to uncontrolled weed growth in rice ranged from 80-100% (Boansi, 2014). Although, chemical weed control in upland rice is less developed in Tropical Africa and Latin America than in Asia, it however offers the most practical way of controlling weeds in these crops. The main factor that has made chemical weed management more popular than manual and mechanical weed management is less drudgery that is associated with the chemical than cultural methods. In spite of substantial fertilizer use in crop yields are not increasing correspondingly, which reflect low fertilizer use efficiency (FUE). Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients (Mehdizadeh et al. 2013). In contrast to chemical fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration (Deksissa et al. 2008). It was also reported that poultry manure more readily supplies Phosphorus to crops than other organic manure sources (Garg and Bahla, 2008). Organic fertilizers including farmyard manure, sheep manure and poultry manure may be used for the crop production as a substitute of the chemical fertilizers because the importance of the organic manures can not be overlooked. Todays, there is growing interest in the use of organic manures due to depletion in the soil fertility (Hamma and Ibrahim, 2013). Economic premiums for certified organic grains have been driving many transition decisions related to the organic farming (Delate and Camberdella, 2004). Continuous and excessive use of agrochemicals creates potential contamination effect in the environment (Oad et al. 2004; Mehdizadeh et al. 2017). Production of agrochemicals needs a large amount of energy and money (Gellings and Parmenter, 2004). However, an organic farming with or without chemical fertilizers seems to be possible solution for these situations (Prabu et al. 2003). The application of both organic and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental risks (Jaya and Barber, 2017). This research was done in order to improve the productivity of rice using poultry manure which is less expensive and generally available and affordable to farmers and to assess the effectiveness of chemical weed control measure on rice under improved varieties of rice.

Materials and methods

Field trials were be conducted during the wet seasons of 2016 and 2017 at the Research Farm of the federal university Dutse to evaluate the performance of upland rice varieties as affected by weed control treatments and application of poultry manure. Sample of poultry manure to be used for experiment was analyzed in the laboratory to determine their chemical properties. In each location and prior to land preparation and manure application, soil samples at 20 different spots on the field was randomly collected from a depth of 0–30 cm in two locations using soil auger. The composite sample was analyzed in the laboratory to determine their physical and chemical properties using standard procedures as described by Black (1965). Data on rainfall distribution, temperature, sunshine and relative humidity for 2016 wet season was collected in both locations. The treatments were consists of five weed control treatments (Propanil+2,4D, Pendimentaline+one hoe weeding at 6 WAS, Pendimentaline+propanil+2,4-D, Hoe weeding at 3 and 6 WAS and Weedy check), three rates of poultry manure (0, 5 and 10 t/ha) and two rice varieties (Nerica and Faro 48). The treatments was laid out in a split plot design in three replication such that a factorial combination of the poultry manure rates and three control treatments and the weedy check were assigned to the main plots while rice varieties were assigned in the sub-plots. The net plot size was 3 x 4 m and gross plot size was 4 x 4.5 m.

The experimental areas were harrowed and levelled. Raised seed beds of were marked out to constitute experimental gross plots.The plots were separated by an unplanted discard area of 1 m while replicates were separated by 2 m unplanted discard area. The herbicides were applied using a CP3 knapsack sprayer fitted with a green deflector nozzle, at a pressure of 2.1 kg/cm^2 to deliver spray liquid volume of 240 L/ha at 2 weeks after sowing. Poultry manure was applied two weeks before sowing as per treatment. It was uniformly incorporated on the ridges and later spread on the plot. The rice seeds was dressed before sowing with APRON STAR WS (Thiamethoxam: 200 g/kg, Mefenoxam: 200 g/ha and Difenoconazole: 20 g/kg) at the rate of 3 kg seed per 10 g of the chemical. Rice seeds were sown 20 cm apart and at 20 cm intra-row spacing by dibbling. The rice seedlings were thinned at 2 WAS. Two hoe weeding were carried out on the weeded control plots at 3 and 6 WAS using a manual hoe. Harvesting was done when the crop reached physiological maturity i.e when most leaves turned brown and the rice panicle had a pronounced brown colour. The plants in the net plots harvested by cutting the panicle from the base with knife and threshed by beating the panicle with stick in order to detach the grains from the spikelets. The dried grains for each net plot were weighed using E200 mettler balance and the value recorded on per kilogram and per plot basis.

Data Collection and Analysis

Plant height

The heights of five tagged plants was taken by measuring the plants from the basal ground level and to the base of flag leaf using a metre rule before flowering and to the tip of panicle after flowering. The average height was computed for a single plant height in cm.

Leaf area

This refers to the assimilatory surface of rice plant that intercepts the sunlight. This was determined by using the equation 1.

$$\text{Equation 1.} \quad LA = L \times B \times K$$

Where L= length of the leaf (cm), B= breath of the leaf (cm) and K= constant and a value of 0.70.

Leaf area index (LAI)

This refers to the assimilatory surface per unit of ground area covered by the plant and was calculated using the equation 2.

$$\text{Equation 2.} \quad LAI = \frac{L \times B \times k}{A}$$

Where: L= length of the leaf (cm), B= breath of the leaf (cm), K= 0.70, A= Area covered by the leaves (cm^2).

Length of panicle per plant

The panicle length was taken from the five tagged plants per net plot at harvest by measuring the panicle from the base of the panicle to the tip using a metre rule and the average was recorded.

Weight of panicle per plant

Weight of panicle per plant from the five tagged plants after harvest and the average was taken to give number of grains per panicle.

1000 grain weight (g)

After threshing and winnowing in the air, 1000 grain was counted and weighed on a mettler balance model 1210, to obtain the 1000 grain weight.

Grain yield

Harvested paddy from each net plot was threshed after sun drying, winnowed and grain yield obtained from net plot was weighed on a mettler balance and converted to per hectare basis expressed in kg/ha.

Biological yield

Harvested paddy from each net plot after sun drying was weighed on a mettler balance and converted to per hectare basis expressed in kg/ha.

Statistical Analysis of Data

Data collected was subjected to analysis of variance (ANOVA) using SAS software package and differences among treatments means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results and discussion

Grain yield

The effect of weed control treatments, poultry manure and variety on the grain yield of rice (Kg/ha) was significant (Table 1). In 2016 application of pendimentaline+hoe-weeding at 6 WAS, produce similar yield of rice with hoe-weeding control. While in 2017, all the weed control methods has similar grain yield of rice while the weedy check produced the lowest yield. Application of 10 t/ha of poultry manure gave statistically highest grain yield of rice while no application of pultry manure had the lowest grain yield of rice similar trend was observed in 2017. Also the effect of variety was significant. The variety FARO 48 produced highest grain yield of rice while NERICA 8 had the lowest yield.

Panicle length

The effect of weed control treatment, poultry manure and variety on panicle length of rice (cm) was significant (Table 2). Application of all weed control treatments produced similar panicle length of rice while the weedy check produced the shortest length. Similar trend was observed in 2017. Application of poultry manure was only significant in 2017 where 5 and 10 t/ha of manure gave similar panicle length. The effect of variety was not significant on the panicle length of rice in both seasons.

Panicle weight per plant

The effect of weed control treatments, poultry manure and variety on the panicle weight per plant of rice was significant (Table 3). Effect of all the weed control treatments on panicle weight/plant was statistically at par with hoe weeding control 3 and 6 WAS. While weedy check produced the lowest value for panicle weight per plant. Effect of poultry manure on the panicle weight per plant was not significant in both seasons. The effect of variety was significant on the panicle weight per plant of rice in both seasons. FARO 48 produced significantly heavier panicle weight than NERICA 8.

Biological yield of rice

The effect of weed control treatments, poultry manure and variety on biological yield of rice was significant (Table 4). Application of pendimentaline+propanil+2,4-D and hoe weeding control at 3 and 6 WAS had similar and highest biological yield of rice while pendimentaline+propanil+2,4-D at 2 WAS post emergence application produced similar lower biological yield of rice. The effects of application of poultry manure was significant on the biological yield of rice however the application of 5 and 10 t/ha of poultry manure produced similar biological yield of rice. FARO 48 produced highest biological yield of rice.

Leaf area (LA)

The effect of weed control treatment, poultry manure and variety on leaf area of rice at 4 and 6 WAS was significant (Table 5). Application of herbicide mixture and hoe weed control had significant effect on leaf area of rice where herbicide mixture and hoe weeding control had similar effect in both seasons. Poultry manure application had significant effect on leaf area of rice. Application of 5 and 10 t/ha produced larger leaf area of rice than the control. The effect of variety on the leaf area of rice was not significant in 2016. However, in 2017, FARO 48 produced larger leaf area than NERICA 8. At 9 WAS, weed control methods had not significant effect on the leaf area of rice in both seasons. Poultry manure application had significant effect on leaf area of rice at 9 WAS where 5 and 10 t/ha produced similar and higher leaf area value than the control. Effect of variety on leaf area of rice was also significant. FARO 48 produced larger leaf area than NERICA 8 in both seasons.

Leaf Area Index (LAI)

Effect of weed control treatments, poultry manure and variety on leaf area index at 9 WAS and 12 WAS was not significant. However the effect of poultry manure on the leaf area index 9vWAS was significant. Application of 10 t/ha of poultry manure resulted in higher LAI value with is similar to 5 t/ha. The variety had not significant effect on the LAI value of rice in both seasons. Similar trend was observed at 12 WAS. However FARO 48 gave higher LAI value.

Plant height of rice

The effects of weed control treatment, poultry manure and variety on the plant height of rice were at par with weedy check while hoe weeding control (3 and 6 WAS) resulted in taller plant at 4 WAS in both seasons. However, in 8 and 12 WAS there was non significant effect of weed control treatment on the plant height of rice in both seasons. Effect of poultry manure application on plant height of rice was significant at 8 WAS where 5 and 10 t/ha of poultry manure produced tallest plant while the control had the shortest in both seasons. There is no significant effect of variety on the plant height of rice throughout the sampling period.

The herbicide mixtures applied in the experiment sufficiently control weed infestation in treated plot. Danmaigoro et al. (2015) and Yahaya (1993) have reported reduction in weed dry matter production due to herbicide application in crops. Pendimentaline+ supplementary weeding at 6 WAS and two hoe weeding at 6 WAS gave effective control of weeds, compare with pendimenthaline in mixtures with others herbicides. This Shown inability of herbicide mixture to provide proper weed control that can last throughout the crop life cycle and the necessity of supplementary hoe weeding. This result contrary to the finding of Yahaya (1993) and Mahadi et al. (2013) who reported the effective and broad spectrum weed control by herbicide mixtures. Rice plants in the weedy check plots had lower crop vigour this may be due to adverse effect of weed competition for growth resources and the ability of the weeds to suppress the rice. Mahadi et al. (2013) reported similar finding in maize. Application of pendinmentaline+propanil+2,4-D at 2 WAS post emergence and pendimetaline+one hoe weeding control at 6 WAS applied post-emergence gave longer panicle, however panicle weight similar to hoe weeding control at 3 and 6 WAS. The most effective and promising weed control treatments with a combination of pendimenthaline+one supplematary hoe weeding at 6 WAS control which significantly reduce weed cover score throughout the period of trails and were comparable to the hoe weeding at 3 and 6 WAS. Adeyemi (1996) reported that weed cover score and weed dry weight reduced with increase in the effectiveness of weed control treatment or methods. In this present study, the plot that received higher rates of poultry manure recorded increased weed infestation due to increases in soil fertility status of these plots which provided enough nutrients to the weed species. The increase in rice yield due to high rates of poultry manure was can be attributed to improve soil fertility. Organic manure has been reported to influence soil texture, structure water holding capacity, soli aeration, nutrient retention and soil microbial activity. Danmaigoro et al. (2015) reported that application of poultry manure at 10 t/ha significantly increases panicle length, 1000 grains weight and grain yield of rice.

Table 1. The effect of weed control treatments, poultry manure and variety on Grain yield (kg/ha), Panicle length (cm) and panicle weight per plant of rice.

Treatment	Grain Yield of rice		Panicle length (cm)		Panicle weight per plant (g)	
	2016	2017	2016	2017	2016	2017
Weed Control (W) (Kg.a.i/ha)						
Propani**l**+2,4D (1.8+1.2)	3302b	2744ab	20.06b	18.64a	6.03b	5.54a
Pendimentaline+one hoe weeding at 6 WAS (1.8)	4161a	3345a	21.50b	19.37a	6.71ab	5.56a
Pendimentaline+propanil+2,4-D (1.8+1.8+1.2)	4171a	3407a	21.72b	19.54a	7.27ab	5.99a
Hoe weeding at 3 and 6 WAS	3274b	2500a	21.78a	19.57a	6.39ab	5.15a
Weedy check	3353b	2691ab	22.11a	20.04a	7.67a	6.12a
SE±	235.4	211.7	0.49	0.52	0.44	0.47
Poultry Manure (M) (t/ha)						
0	1888c	1193c	18.65b	20.30b	5.36a	6.74a
5	3477b	4441b	19.66a	21.67a	5.75a	6.65a
10	4451a	5323a	20.70a	22.33a	5.90a	7.06a
SE±	182.2	164,02	8.91	7.25	0.38	0.36
Variety (V)						
Faro 48	3932a	3380a	21.4	19.34	7.25a	6.15a
Nerica 8	3372b	2495	21.50	19.52	6.38b	5.19b
SE±	66.9	133.9	0.31	0.33	0.28	0.29
Interaction						
W×M	NS	NS	NS	NS	NS	NS
W×V	NS	NS	NS	NS	NS	NS
V×M	NS	NS	NS	NS	NS	NS
W×M×V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of each sets of treatments group are not significantly different at $P \leq 0.05$ using DMRT. NS: No significant.

Table 2. The effect of weed control treatments, poultry manure and variety on leaf area of rice.

Treatment	Leaf Area of rice					
	2016			2017		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
Weed Control (W) (Kg.a.i/ha)						
Propanil+2,4D (1.8+1.2)	86.06a	108.3	138.7	64.09a	96.60	127.65
Pendimentaline+one hoe weeding at 6 WAS (1.8)	8.389a	108.9	122.5	64.50a	93.32	111.3
Pendimentaline+propanil+2,4-D (1.8+1.8+1.2)	90.33a	109.1	146.7	67.61a	96.87	136.2
Hoe weeding at 3 and 6 WAS	56.50b	98.33	133.8	34.86b	87.76	119.8
Weedy check	77.56a	94.37	137.3	52.28ab	84.74	125.7
SE±	6.36	7.58	11.5	5.9	7.66	3.6
Poultry Manure (M) (t/ha)						
0	35.58b	65.68b	90.98b	55.33b	79.52b	104.6b
5	67.98a	101.6a	128.31a	92.70a	112.23a	138.8a
10	66.45a	108.3a	153.24a	88.57a	119.12a	164.2a
SE±	4.93	0.20	8.91	5.97	6.17	0.11
Variety (V)						
Faro 48	72.71	83.21b	112.5b	47.77b	71.87b	100.6b
Nerica 8	85.02	123.9a	159.1a	65.8a	111.8a	147.7a
SE±	4.02	4.08	7.28	4.48	5.04	2.86
Interaction						
W×M	NS	NS	NS	NS	NS	NS
W×V	NS	NS	NS	NS	NS	NS
V×M	NS	NS	NS	NS	NS	NS
W×M×V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of each sets of treatments group are not significantly different at $P \leq 0.05$ using DMRT. NS: No significant.

Table 3. The effect of weed control treatments, poultry manure and variety on plant height of rice.

Treatment	plant height of rice					
	2016			2017		
	3 WAS	9 WAS	12 WAS	3 WAS	9 WAS	12 WAS
Weed Control (W) (Kg.a.i/ha)						
Propanil+2,4D (1.8+1.2)	28.04ab	98.33	103.06	27.31ab	91.61	127.65
Pendimentaline+one hoe weeding at 6 WAS (1.8)	31.83a	96.17	106.1	30.77a	89.00	111.3
Pendimentaline+propanil+2,4-D (1.8+1.8+1.2)	30.06ab	94.61	106.3	28.50ab	88.06	136.2
Hoe weeding at 3 and 6 WAS	25.50b	93.83	101.5	25.28b	87.83	119.8
Weedy check	27.72a	92.06	102.0	26.64ab	86.11	125.7
SE±	1.52	3.26	2.57	1.47	3.33	3.6
Poultry Manure (M) (t/ha)						
0	26.14	70.77b	77.57c	27.56	78.08b	104.6b
5	28.20	97.50a	90.27b	28.80	102.9a	138.8a
10	28.75	97.30a	97.67a	29.53	103.8a	164.2a
SE±	1.18	2.52	1.99	1.36	2.34	0.11
Variety (V)						
Faro 48	27.46	93.27	104.2	26.04b	87.17	100.6b
Nerica 8	29.80	96.06	106.2	29.35a	89.96	147.7a
SE±	0.96	2.08	1.63	1.30	1.92	2.86
Interaction						
W×M	NS	NS	NS	NS	NS	NS
W×V	NS	NS	NS	NS	NS	NS
V×M	NS	NS	NS	NS	NS	NS
W×M×V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of each sets of treatments group are not significantly different at P ≤ 0.05 using DMRT. NS: No significant.

Conflict of Interest

Authors declare no conflict of interest.

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Cite this article as: Danmaigoro O, Halilu A.G, Izge A.U. Growth and yield of direct seeded upland rice varieties as influenced by weed management and organic manure application. *Journal of Research in Weed Science*, 2019, 2(2), 103-114. DOI: 10.26655/JRWEEDSCI.2019.3.2