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Weed Control Efficiency of Management Practices of Lowland Paddy Production in Sudan Savanna Ecology

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Abstract

Two concurrent experiments were conducted during the wet season of 2012 and 2013 at research farms of the Irrigation Research Stations of Institute for Agricultural Research (I.A.R), Ahmadu Bello University, Talata Mafara (12° 34' N; 06° 04'E) and Kadawa (11°39`N; 08°02'E) in the Sudan Savanna ecological zone of Nigeria to assess the efficiency of rice production practices in controlling weeds in rice. The treatment consisted of four (4) weed management practice (Oxadiazon at 1.0 kg a.i ha^{-1} [pre-emergence], orizo-plus [propanil 360 g/l + 2,4-D 200 g/l] at 2.8 kg a.i ha^{-1} [post emergence at 3 WAS], manual weeding [at 3 and 6 WAS] and weedy check [control]); three (3) each of seeding method (Drilling, Dibbling and Broadcast) and seed rate (40 kg ha^{-1}; 70 kg ha^{-1}; 100 kg ha^{-1}). The experiment was laid in a split plot design replicated three times. Weed management practice was assigned to the main plots while the combination of seeding method and seed rate to the subplots. The result indicated that weedy check was consistent in recording the highest weed growth in terms of weed dry weight and weed cover score. Manual weeding at 3 and 6 WAS was significantly more efficient in controlling the weeds followed by oxadiazon at 1.0 kg a.i ha^{-1} then orizoplus at 2.8 kg a.i ha^{-1}. Broadcast method of seeding recorded significantly lower values for weed control efficiency and weed growth when compared with drilling and dibbling seeding methods at both locations and years of study. A higher than 40 kg ha^{-1}seed rate increased weed suppression by decreasing weed dry weight indicating better weed suppression.

Keywords: Weed control efficiency, weed dry weight, lowland paddy

1. Introduction

Weeds constitute one of the most important constraints to rice production especially in tropical Africa (Akobundu, 1987). Weeds and shortage of labour for their removal have been identified by Chikoye *et al*. (2004) as the two most important production constraints in small holder farms in the northern Guinea savanna (NGS) of Nigeria. In fact, the crop production system has been characterized by control of weeds. Losses due to infestation of weeds are greater than the combined losses caused by insect pests and diseases in rice (Nasimul, 2010). Reduction in yield of rice caused by weeds ranges from 10-100% (Akobundu, 1987; David, 2009; Nasimul, 2010; Chauchan *et al*., 2011; Mahajan and Chauchan, 2011; Chauchan, 2012).

Several weed control methods are being employed to reduce the menace of weeds in rice fields. Manual weeding twice, the most popular, is considered an effective weed control method despite the fact that it requires a lot of energy and resources and consumes time. Competition may also set in between crop plant and weeds when weeding is delayed in attempt to wait for newly emerging weeds to grow to a seasonable conspicuous size. Weeding also competes with other farm activities in which most a times is postponed to later date allowing weeds to grow to mature stage (Chikoye *et al*., 2004; Nasimul, 2010). The attempt to control weeds through frequent cultivation is also associated with increased soil erosion. Although appropriately selected herbicide may perform an important role in reduction of weed infestation, increasing weed resistance to herbicides which moves the agro-ecosystem to low species diversity as well as the negative effect of herbicides on environment such as ground and surface water pollution are of greater concern (Abdin *et al*., 2000; Pandey , 2009; Eskandari and Kazeem, 2011 and Ghanizadeh, 2011). However herbicides alone may not provide season-long control due to weed specie diversity and successive emergence coupled with environmental effects that reduce herbicide efficacy duration.

Ordinarily, the primary effect of increasing or decreasing plant population either by varying seed rates or seeding method may lead to an increase or decrease in competition between adjacent plants (Hay and Walker, 1989; Zimdahl, 2004). Farmers use different seed rate and methods in order to obtain good crop establishment, reduce cost, labour, menace of weeds, pests and diseases (Oyewole *et al*., 2010). Apart from reducing the cost of production in terms of seed inputs, low seeding rate ensure establishment of vigorous and competitive plants, production of high number of productive tillers and reduce the incidence of pests and diseases (Hay and Walker,1989; Gopal *et al*., 2010 and Chauchan, 2012).

There is the need therefore for an ecological approach to weed control instead of relying totally on chemical control methods. Various weed management approaches and agronomic principles need to be integrated to achieve effective, sustainable and long term weed control in direct seeded rice. The efficiency of a given management practice on weed suppression depends on weed type and crop cultivar. For an integrated weed

management programme to be viable, accurate information on the efficiency of a given management practice in suppressing the weeds is a pre-requisite. The objective of this study was to determine the efficiency of rice production practices in controlling weeds in rice.

2. Materials and Methods

A field experiment was concurrently conducted in each of the wet seasons of 2012 and 2013 at research farms of the Irrigation Research Stations of Institute for Agricultural Research (I.A.R), Ahmadu Bello University, Talata Mafara (12^{o} 34' N; 06^{o} 04'E) and Kadawa (11^{o}39`N; 08^{o}02'E) in the Sudan Savanna ecological zone of Nigeria.
The treatments consisted of four weed management practices (oxadiazon at 1.0 kg a.i ha^{-1} applied pre-emergence, Orizoplus [a proprietary mixture of proponil 360 g/l and 2,4-D 200 g/l] at 2.8 kg a.i ha^{-1} post emergence at 3 WAS, manual weeding at 3 and 6 WAS and unweeded control); three each of seeding method (Drilling, Dibbling and Broadcast) and seed rate (40 kg ha^{-1}, 70 kg ha^{-1} and 100 kg ha^{-1}). The treatments were laid in a split plot design replicated three times. Weed management practice was allocated to the main plots while seeding method and seed rate were factorially combined and allocated to the sub-plots. The seed was sown as per seeding method and seed rate of treatments at 20 x 20 cm spacing in both drilled and dibbled plots
Inorganic fertilizer was applied by broadcast at the rate of 60 kg ha^{-1} N; 60 kg ha^{-1} P_2O_5; 60 kg ha^{-1} K_2O at planting using a compound fertilizer NPK 15:15:15, the second application of 60 kg ha^{-1} N was done at 6 WAS using urea (46%) as a source of N. The manual weeding was done as per the treatment at 3 and 6 WAS. Hoe weeding was done in drilled and dibbled plots while hand pulling was employed in the broadcast plots. The crop was harvested at maturity when the entire plants have turned yellow and grain fully filled and at hard dough stage.
Weed cover score was taken by visual observation using a scale of 1 – 9 where 1 means least cover and 9 means highest cover. Weed dry matter was taken from 1.0 m x 1.0 m quadrat placed randomly within each net plot at harvest. The weeds were dried in an oven to a constant weight,

(i) **Weed Control Efficiency (WCE):** It is a derived parameter that compares different treatments of weed control on the basis of weed dry weight across them. It is an estimate of weed competition/control in crops.

$$\mathbf{WCE} = \frac{DMC - DMT}{DMC} X\ 100$$

Where, DMC is weed dry matter in control treatment;
DMT is weed dry matter in a weed control treatment (Das, 2008).
Data collected from the observations were subjected to statistical analysis of variance (ANOVA) as described by Steel and Torrie (1984) and differences between treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability as described by Gomez and Gomez (1984).

3. Results

Table 1 presents the effect of weed management practice, seeding method and seed rate on weed cover in rice at Talata Mafara and Kadawa in 2012 and 2013. Weed management practices exhibited a significant influence on weed cover score in all years of study and locations. At both locations and each year of study and the mean of both years weed cover was found to be significantly higher in the weedy check compared to all other treatments. Also in the mean of both years at Talata Mafara, oxadiazon at 1.0 kg a.i ha^{-1} resulted to significantly lower weed cover score than propanil + 2,4 D at 2.8 kg a.i ha^{-1} but at par with manual weeding at 3 and 6 WAS. Seeding method significantly influenced weed cover score in all the years of the experiment and locations. At Talata Mafara in both years and their mean drilling method significantly reduced the weed cover compared to where dibbling and broadcast methods that were statistically similar. At Kadawa in each year of the study and mean of both years dibbling resulted to significantly higher weed cover score than drilling and broadcast methods though at par with broadcast in 2013. Varying the seed rate of rice did not show significant influence on weed cover score at both locations and years. Significant interaction was observed between weed management practice and seeding method on weed cover score in wet season rice at Kadawa in 2013. Table 2 shows that except with manual weeding at 3 and 6 WAS where drilling method resulted to significantly lower weed cover score compared to other methods, variation in seeding method did not significantly influence weed cover score in all the weed management practices. Both herbicide treatments and manually weeded plots had statistically similar weed cover scores in dibbled and broadcast seeding methods, however, in the drill seeding method the herbicide treatment resulted in significantly higher weed cover score than the manual weeding. The lowest value for weed cover score was from drilled plots manually weeded twice
The results obtained on the influence of weed management practice, seeding method and seed rate on weed dry matter in rice during 2012 and 2013 wet season at Talata Mafara and Kadawa is presented in Table 3. The weedy check consistently produced significantly higher amount of weed dry matter than all other treatments in all the years and locations of the experiment. At Talata Mafara in both the years of study and their mean, plots supplied with oxadiazon at 1.0 kg a.i. ha^{-1} had significantly higher weed dry matter than those manually weeded at 3 and 6 WAS but both were at par with those supplied with propanil + 2,4 D at 2.8 kg a.i ha^{-1} in 2012 and 2013. At

Kadawa, manual weeding at 3 and 6 WAS recorded significantly lower weed dry matter than other treatments but at par with the application of propanil + 2,4 D at 2.8 kg a.i ha^{-1} in 2012. Seeding method exhibited significant influence on weed dry matter in both years and their mean at Talata Mafara and also the mean of the two years at Kadawa. At Talata Mafara broadcast method resulted to significantly higher weed dry matter compared to dibbling but at par with drilling method which was in turn similar to dibbling method throughout. However, the mean results of Kadawa indicated a significantly higher weed dry matter production in broadcast plots than that from drilled and dibbled plots. Varying the seed rate did not significantly affect the weed dry matter production throughout years of study and both locations.

Table 4 shows weed control efficiencies of the weed management practices, seeding methods and seed rates in rice at Talata Mafara and Kadawa in 2012 and 2013 wet seasons. At Talata Mafara in both years of study manual weeding at 3 and 6 WAS was found to significantly control the weeds more efficiently compared to the application of propanil + 2,4-D at 2.8 kg a.i ha^{-1} but at par with application of oxadiazon at 1.0 kg a.i ha^{-1} in 2012. In the mean of the years, however, both herbicide treatments had statistically similar weed control efficiency but each was significantly lower than manual weeding. At Kadawa in both years and their mean, manual weeding at 3 and 6 WAS significantly controlled weeds more efficiently than all other treatments. Varying the seeding method significantly influenced the efficiency with which the weeds were controlled in all the years and locations of the experiment. At Talata Mafara, in both years and their mean, drilling method resulted in significantly higher weed control efficiency than broadcast method but had similar weed control efficiency with the dibbling method in the two years. At Kadawa in both years of the study and means of the years, dibbling and drilling methods resulted to significantly higher weed control efficiency than broadcast methods except in 2012 where dibbling was comparable to broadcast method. Varying the seed rate did not significantly influence the weed control efficiency throughout the years of study. Interaction of weed management practices and seeding method on weed control efficiency was significant at Kadawa in 2013 and is presented in Table 5. Application of oxadiazon at 1.0 kg ha^{-1} was found to control weeds more efficiently in drilled and dibbled rice compared to broadcast rice. With propanil + 2,4-D at 2.8 kg a.i ha^{-1} drilling method had significantly higher weed control efficiency than broadcast method but similar to dibbling method. In both drilling and broadcast methods comparable weed control efficiencies were recorded unlike with the dibbling method where the herbicide mixture showed a significantly lower efficiency than oxadiazon at 1.0 kg ha^{-1}. In all seeding methods, however, the manual weeding at 3 and 6 WAS treatment recorded significantly higher weed control efficiency.

4. Discussion

The best weed suppression and higher efficiency observed in the manual weeding at 3 and 6 WAS practice through higher weed control efficiency may not be unconnected to repeated weeding employed at 3 and 6 WAS which resulted in the reduction of the weeds population. Weeds that have escaped control during the first weeding must have been controlled at the second weeding. On the other hand, could be due to fact that weed seed bank have over the years been deposited in the soil through seed dispersal and that the weeds emerged in succession at different times in the singly applied measures. Akbar *et al*. (2011) reported a maximum reduction of total weed density of 94.9% by hand pulling treatment compared with the untreated weedy check. Although highest weed reduction was obtained by manual weeding at 3 and 6 WAS, the involvement of intense labour with its associated tedium may render it uneconomical and unfeasible.

The superiority of the line seeding methods over broadcast methods in weed suppression could possibly be due to the differences in the canopy architecture between the two seeding methods. Drilling and dibbling methods provide a better shading effect on the weeds by forming more closed and continuous canopy compared to broadcast method which gave a sparse canopy with weak shading effect on the weeds. Phuong *et al*. (2005) found higher weed density in broadcast method than in row seeding methods.

In this study, weed dry matter was found to be higher in the lower seed rate of 40 kg ha^{-1} compared to the highest seed rate of 100 kg ha^{-1}. This indicated poor weed suppression in the lower seed rate which could be due to reduced plant populations and density that might have provided favorable environment for weed establishment growth and survival. Higher seed rate on the other hand, resulted to rapid canopy development and consequently, suppressing weeds more effectively. The use of higher seed rate suppressed more weeds by giving the crop plant a competitive advantage over weeds through smothering effect due to fast canopy development and/or giving the densely populated plants the competitive ability to draw limited resources at a faster rate (Mohler, 1996; Guilarmo *et al*., 2009; Mahajan *et al*., 2010). On the other hand however, Zimdahl (1983) and Krikland *et al.* (2000) stated that higher seed rate under stressful environmental conditions may not always be able to increase the weed competiveness of a crop due to greater intra-specific competition between crop plants. The higher efficiency in weed control obtained from the combination of oxadiazon at 1.0 kg a.i ha^{-1} with drilling or dibbling methods of seeding could be as a result of combined effect of reduced competition at early growth periods by the application of oxadiazon (Ishaya *et al.*, 2004) and canopy closure by the seeding methods (Zimdahl, 2004). Higher plant density gives the plant a more competitive advantage over the weeds. Phuong *et al*. (2005) stated

that reduced plant density may provide a favourable environment for weed growth giving it a better and enhanced condition to germinate, grow and develop a vigorous population. Reduction in severe weed competition in direct seeded rice calls for improved management practices such as, manipulation of seeding method that will effectively reduce the problem of drudgery, herbicide resistance in weeds, and environmental pollution.

5. Conclusion

Manual weeding controlled weeds more efficiently followed by the use of oxadiazon at 1.0 kg a.i. ha^{-1}. The line sowing methods were more efficient in controlling weeds than broadcast method. From the results of this study it could be concluded that for higher efficiency in weed control, lowland rice should be drilled or dibbled and manually weeded at 3 and 6 WAS.

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Table 1. Effect of weed management practice, seeding method and seed rate on weed cover score in rice at Talata Mafara and Kadawa during 2012 and 2013 wet seasons

	Weed cover score					
	Talata Mafara			**Kadawa**		
Treatment	2012	2013	Mean	2012	2013	Mean
Weed management (W)						
Oxadiazon at 1.0 kg a.i ha^{-1}	2.5c	3.5b	3.6c	1.7c	3.5b	2.6bc
Propanil + 2,4 D at 2.8 kg a.i ha^{-1}	3.8b	3.0bc	3.4b	1.4c	3.2bc	2.2c
Manual weeding at 3 and 6 WAS	3.4b	2.9c	3.2bc	3.2b	2.9c	3.1b
Weedy check	7.4a	8.7a	8.1a	6.2a	8.3a	7.3a
SE±	0.27	0.52	0.31	0.27	0.51	0.36
Seeding method (S)						
Drilling	3.7b	4.2b	3.9b	2.6b	4.0b	3.3b
Dibbling	4.6a	4.7a	4.6a	3.7a	4.6a	4.2a
Broadcast	4.6a	4.8a	4.7a	3.0b	4.8a	3.9b
SE±	0.16	0.19	0.13	0.18	0.19	0.14
Seed rate kg ha^{-1} (R)						
40	4.4	4.7	4.5	3.1	4.5	3.8
70	4.3	4.5	4.4	3.2	4.4	3.8
100	4.2	4.5	4.3	3.0	4.2	3.7
SE±	0.16	0.19	0.13	0.18	0.19	0.14
Interaction						
W x S	NS	NS	NS	NS	**	NS
W x R	NS	NS	NS	NS	NS	NS
S x R	NS	NS	NS	NS	NS	NS
W x S x R	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. ** = significant at 1% level of probability. NS = Not significant.

Table 2**:** Interaction between weed management practice and seeding method on weed cover score at Kadawa in 2013

	Seeding method		
Weed management	Drilling	Dibbling	Broadcast
Oxadiazon at 1.0 kg a.i ha^{-1}	3.2b	3.8b	3.4b
Propanil + 2,4 D at 2.8 kg a.i ha^{-1}	3.1b	2.8b	3.7b
Manual weeding at 3 and 6 WAS	1.5c	3.3b	3.8b
Weedy check	8.3a	8.5a	8.2a
SE±		0.39	

Means followed by the same letter are not significantly different at 5% level of probability using DMRT

Table 3. Effect of weed management practice, seeding method and seed rate on weed dry matter of rice at Talata Mafara and Kadawa during 2012 and 2013 wet seasons

	Weed dry matter (kg ha^{-1})					
	Talata Mafara			**Kadawa**		
Treatment	2012	2013	Mean	2012	2013	Mean
Weed management (W)						
Oxadiazon at 1.0 kg a.i ha^{-1}	591.4b	791.2b	691.3b	693.9b	1144.7b	919.3b
Propanil + 2,4-D at 2.8 kg a.i ha^{-1}	422.7bc	565.7bc	494.2c	496.1bc	1249.2b	872.7b
Manual weeding at 3 and 6 WAS	342.7c	458.6c	400.6c	402.2c	410.8c	406.5c
Weedy check	1422.2a	1908.5a	1665.4a	1695.9a	2505.1a	2100.5a
SE±	38.59	42.65	40.24	54.59	135.86	134.74
Seeding method (S)						
Drilling	701.0ab	925.2ab	813.1ab	817.8	1247.6	1032.7b
Dibbling	593.6b	811.0b	702.3b	695.2	1305.4	1000.3b
Broadcast	789.6a	1056.8a	923.2a	950.8	1429.3	1150.1a
SE±	55.42	80.72	44.00	65.73	72.85	43.19
Seed rate kg ha^{-1} (R)						
40	744.1	1019.0	881.8	877.7	1283.9	1080.8
70	661.5	875.1	768.4	782.0	1366.7	1074.4
100	678.6	898.3	788.4	806.2	1331.7	1068.5
SE±	55.41	80.72	44.00	65.73	72.85	43.19
Interaction						
W x S	NS	NS	NS	NS	NS	NS
W x R	NS	NS	NS	NS	NS	NS
S x R	NS	NS	NS	NS	NS	NS
W x S x R	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. NS = Not significant.

Table 4: Effect of weed management practice, seeding method and seed rate on weed control efficiency (%) in rice at Talata Mafara and Kadawa during 2012 and 2013 wet seasons

Treatment	Weed Control Efficiency (%)					
	Talata Mafara			**Kadawa**		
	2012	2013	Mean	2012	2013	Mean
Weed management (W)						
Oxadiazon at 1.0 kg a.i ha^{-1}	65.5a	64.9b	65.2b	57.3c	52.9b	56.5b
Propanil + 2,4 D at 2.8 kg a.i ha^{-1}	57.2b	56.5c	56.8b	66.0b	47.1b	55.1bc
Manual weeding at 3 and 6 WAS	72.1a	71.7a	71.9a	72.5a	83.5a	78.0a
Weedy check	0.0c	0.0c	0.0d	0.0c	0.0c	0.0d
SE±	2.20	2.30	2.25	1.91	4.31	3.11
Seeding method (S)						
Drilling	55.6a	54.0a	54.8a	51.5a	50.0a	50.7a
Dibbling	48.2ab	47.9ab	48.1b	47.7ab	48.1a	48.1a
Broadcast	42.8b	42.8b	42.8c	44.6b	39.5b	42.3b
SE±	2.58	2.74	1.64	2.59	1.77	1.08
Seed rate kg ha^{-1} (R)						
40	47.2	46.4	46.8	47.3	44.9	46.1
70	47.8	48.0	47.4	48.2	46.1	47.2
100	51.1	51.4	51.3	49.2	46.5	47.9
SE±	2.58	2.74	1.64	2.59	1.77	1.08
Interaction						
W x S	NS	NS	NS	NS	**	NS
W x R	NS	NS	NS	NS	NS	NS
S x R	NS	NS	NS	NS	NS	NS
W x S x R	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within the same column and treatment group are not significantly different at 5% level of probability using DMRT. ** = significant at 1% level of probability. NS = Not significant.

Table 5**:** Interaction between weed management practice and seeding method on weed control efficiency at Kadawa in 2013

	Seeding method		
Weed management	Drilling	Dibbling	Broadcast
Oxadiazon at 1.0 kg a.i ha^{-1}	62.8b	60.3b	35.6e
Propanil + 2,4 D at 2.8 kg a.i ha^{-1}	54.3bc	48.1cd	39.2de
Manual weeding at 3 and 6 WAS	88.3a	84.3a	83.3a
Weedy check	0.0f	0.0f	0.0f
SE±		3.55	

Means followed by the same letter (s) are not significantly different at 5% level of probability using DMRT

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