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EFFECT OF WEED CONTROL METHODS ON GROWTH AND YIELD OF RICE (*Oryza sativa* VAR. FARO 52)

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ABSTRACT

Field experiment was conducted at Usmanu Danfodiyo University Teaching and Research Fadama Farm, Sokoto during the 2017/2018 dry cropping season to evaluate the effect of different weed control methods in irrigated lowland rice (FARO 52). The experiment consisted of five (5) weed control methods; T_1- Hoe weeding at 3,6,9 weeks after transplanting (WAT), T_3 – Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4- Pendimethalin + 1 hoe weeding at 3 WAT, T_5- Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 – Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT with weedy check (T_2) arranged in a randomized complete block design (RCBD). Data were collected on growth, yield and weed parameters. There was no significant difference ($p \geq 0.05$) in plant height, leaf number at 3 WAT. Significant difference existed for plant height, number of leaves, days to booting, days to heading, number of spikelets per spike, number of spike per panicle, number of seeds per panicle, 1000 grain weight and yield per plot. T_3 recorded the highest mean value for plant height (114.7cm), leaf number (27) and yield (2.4t/ha) and the lowest in weedy check.

Keywords: Rice; yield; herbicide; hand hoe; weed intensity

INTRODUCTION

Nigeria is the largest producer of rice in West Africa (Nwaobiala, 2015). However, of the almost 7 million metric tons of rice consumed annually in Nigeria, only about 3.8 million metric tons is produced domestically (FAO, 2022). Weed infestation is the most deleterious factor responsible for poor yield of rice in Nigeria and other rice-producing countries in Africa and causes 48 to 100% yield reduction (Adeyemi *et al*., 2017). Weeds cause more loses to agriculture than all pests added together (Gella *et al.*, 2013). Traditional manual weeding is the most popular method of weed control in Nigeria. This is, however, tedious, inefficient, time-consuming and associated with a high demand for labour (Daramola *et al*., 2020). Herbicides have been recently used to replace manual weeding, they can effectively control several weed species (Helgueira *et al*., 2018; Zakaria *et al*., 2018). However, prolonged use of herbicides with same mode of action can result in development of herbicide resistance in weeds (Malik and Singh, 1995). Therefore, farmers require the knowledge on exactly how and when to apply herbicides to achieve environmentally safe and effective weed control (Haefele *et al*., 2000). No one method is suitable to control weeds completely all seasons; hence an integrated weed management system is advised. Plant height plays a role in the competitive ability of rice (Garrity *et al*., 1992). Traditional tall cultivars exert a greater smothering effect on weeds (Prasad, 2011). Weed infestations can also interfere with combine operation at harvest and can significantly delay harvesting and drying costs. There is a need to investigate whether growth parameters such as plant height, leaf number, days to booting and flowering are being affected by weed control methods adopted. This will help farmers to make decisions on cultivar selection and harvest timing. The aim of the research was to evaluate the effects of different weed control methods on growth and yield parameters of low land transplanted rice (VAR. FARO 52).

MATERIALS AND METHODS

Study Area

The study was conducted at Usmanu Danfodiyo University Teaching and Research Fadama Farm, Sokoto, located on the latitude $13^0 11$'N and longitude $5^0 20$'E during the 2017/2018 dry cropping season. The study area falls under the Sudan savannah ecological zone and has a dry climate. Rainfall is usually erratic and begins by May and ends by October. The dry season starts by October and last up to April and may extend to May or June.

Treatments and Experimental Design

The experiment comprised of six (6) treatments of different weed control measures which are: T_1- Hoe weeding at 3, 6 and 9 weeks after transplanting (WAT), T_2- Weedy Check, T_3 – Pendimethalin + 2 hoe weeding at 3 and 6WAT + 2, 4-D at 9 WAT, T_4- Pendimethalin + 1 hoe weeding at 3 WAT, T_5- Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 – Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT. Treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times.

Field Layout

Three (3) blocks (Replication) were created with measurement of 12 x 5 m separated by a leeway of 1 m between blocks. Each block comprised of 6 plots measuring 5 x 2 m which were replicated three times giving a total of 18 plots. Irrigation canals were constructed within each leeway. The total area of the research was 17 x 12 m which gives 204 m^2.

Cultural Practices

The land was tilled and levelled manually with the use of hand hoe, rice seedlings were transplanted 3 weeks after sowing manually, a spacing of 25cm x 25cm was adopted during transplanting, pre-emergence herbicide (Pendimethalin 300EC) was applied immediately after transplanting as per treatment and a post-emergence herbicide (2,4-D) was applied at 9WAT. Hand weeding was done with a hoe as per treatment. Plants were irrigated to full saturation point using a water pumping machine twice a week. A fertilizer recommendation of 120kgN: 60kgP_2O_5: 60kgK_2O was adopted. NPK 15:15:15 was applied as basal application and Urea was applied in two split doses at 3 and 9WAT. All herbicides were applied using a CP15 knapsack sprayer and were calibrated using Area-Volume method.

Tagging of plants for data collection

Three (3) rice plants from each plot were tagged for data collection on growth parameters.

Data Collection

Growth parameters such as plant establishment count, number of leaves per plant, plant height, days to first booting, days to 50% and 100% booting, days to first head, days to 50% and 100% heading and yield attributes such as number of spikelets/spike, number of seeds/panicle, 1000 seed weight, yield/ha were measured and recorded. A quadrat measuring 0.25 m^2 was used to obtain weed density. Collected weed samples were oven dried at 80^oC for 48 hours and weighed for dry weight. Weed parameters were calculated using the following formulae:

1. Weed Control Efficiency (WCE)

$$WCE = \frac{weed\ weight\ in\ control - weed\ weight\ in\ a\ treatment}{weed\ weight\ in\ control}$$

2. Weed Persistence Index (WPI)

$$WPI = \frac{weed\ weight\ in\ treated\ plot}{weed\ weight\ in\ control\ plot} \times \frac{weed\ count\ in\ control}{weed\ count\ in\ treated\ plot}$$

3. Weed Intensity (WI) (%)

$$WI = \frac{weed\ population}{weed + crop\ population} \times 100$$

Data Analysis

The mean values for plant height, leaf number, days to first booting, days to 50 and 100% booting, days to first head, days to 50 and 100% heading, number of spikelets per spike and seeds per panicle, weed density and weed weight were collected and subjected to Analysis of Variance (ANOVA) using SPSS. Means having significant difference were separated using Least Significant difference (LSD) at 5% significant level.

RESULTS AND DISCUSSION

Results presented in Table 1 indicated no significant difference ($p \geq 0.05$) among treatments for plant height and leaf number at 3WAT. This is probably due to low weed crop competition at this early growth stage. Significant difference ($p<0.05$) exists for plant height and leaf number at 6, 9 and 12 WAT. At 12 WAT, P + 2HW at 3 and 6 WAT + 2,4-D had the highest mean value for plant height. P + 2HW at 3 and 6 WAT + 2,4-D also had the highest mean value for leaf number, then T_6 which was statistically at par with T_1 and T_5 followed by T_4. From the results obtained, plants in T_3 grew taller (114.7cm) and had more leaf (27) due to frequency and combination of different weed control measures which tends to increase plant height and this tally with the findings of Arif *et al*. (2004). Weedy Check produced the shortest plants at 6, 9 and 12WAT and had least number of leaves. When crops are highly infested with weeds, it harbours pest which later causes leaf loss and defoliation due to high weed-crop competition.

Table 1: Effect of weed control methods on plant height and leaf number of rice at 3,6,9 and 12 WAT at Sokoto in 2017/2018 dry season.

Treatments	Plant Height (cm) at WAT				Number of Leaves at WAT			
	3	6	9	12	3	6	9	12
T_1	20.7	50.7^{a}	91.7^{a}	101.7^{b}	4.7	9.7^{ab}	18.7^{ab}	23.0^{b}
T_2	18.3	31.7^{c}	48.3^{b}	35.0^{d}	4.0	4.7^{b}	4.0^{c}	3.3^{d}
T_3	22.3	40.7^{b}	74.0^{ab}	114.7^{a}	7.7	10.7^{a}	20.0^{a}	27.0^{a}
T_4	21.7	51.7^{a}	62.0^{b}	89.0^{c}	4.3	7.3^{ab}	15.3^{b}	19.7^{bc}
T_5	23.7	57.0^{a}	90.0^{a}	98.0^{bc}	6.3	11.3^{a}	15.0^{b}	18.3^{c}
T6	20.7	50.7^{a}	90.0^{a}	103.0^{b}	4.3	7.3^{ab}	15.3^{b}	19.7^{bc}
LSD (0.05)	6.69	8.65	22.08	10.25	5.17	5.45	3.99	6.41
Sig	NS	*	*	*	NS	*	*	*

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT

*Means within the same column having different letters differ significantly at p≤ 0.05

Stand Establishment Count

There was significant difference ($p<0.05$) for stand establishment count at 3WAT and harvest as shown in Table 2. Stand establishment count at 3WAT was statistically similar among weed control methods (T_1, T_3, T_4, T_5, T_6) which might be due low weed interference at this stage. At harvest, T_1 had the highest mean value and was statistically at par with T_3, T_4 and T_6. Loss of stands was noticeable towards the harvest period. This might be due to the weed - crop competition, pests invasion caused by weed presence, allelopathy by weeds and environmental influence such as turbulent winds.

Table 2: Effects of weed control methods on stand establishment count at 3WAT and harvest

Treatments	Stand Establishment Count at 3WAT No./ 10 m^2	Stand Establishment Count at Harvest No./ 10 m^2
T_1	156.7^{a}	146.7^{a}
T_2	146.2^{b}	53.0^{c}
T_3	152.3^{ab}	143.0^{ab}
T_4	152.3^{ab}	133.0^{ab}
T_5	155.0^{a}	119.7^{b}
T6	156.7^{a}	141.3^{ab}
LSD (0.05)	6.41	25.52

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT

*Means within the same column having different letters differ significantly at p≤ 0.05

Days to Booting and Heading

Significant difference exists among treatments for days to first 50 and 100% booting and heading ($p \leq 0.05$) as shown in Table 3. It took longer days (123 and 137 days) for plants in the weedy check to get to booting and heading stage. This could be as a result of weed interference which distorts harvest timing and operation as reported by Jabran *et al.* (2010).

Table 3: Effects of weed control methods on days to first booting, days to 50% booting, days to 100% booting, days to first head, days to 50% heading and days to 100% heading of rice at Sokoto in 2017/2018 dry season.

Treatments	Days to First Booting	Days to 50% Booting	Days to 100% Booting	Days to First Head	Days to 50% Heading	Days to 100% Heading
T_1	110^{b}	113^{b}	116^{b}	128^{b}	132^{b}	136^{b}
T_2	123^{a}	127^{a}	131^{a}	137^{a}	143^{a}	148^{a}
T_3	100^{c}	113^{b}	121^{a}	124^{b}	128^{b}	133^{b}
T_4	110^{b}	113^{b}	118^{b}	122^{b}	127^{b}	132^{b}
T_5	107^{bc}	113^{b}	120^{b}	123^{b}	127^{b}	132^{b}
T6	111^{b}	110^{b}	117^{b}	121^{b}	127^{b}	131^{b}
LSD (0.05)	7.65	8.81	9.59	8.066	5.89	5.08
Significance	*	*	*	*	*	*

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT
*Means within the same column having different letters differ significantly at $p \leq 0.05$

Panicle Characteristics and Yield attributes

Significant difference exists among treatments for number of spikelets per spike and seeds per panicle at ($p \leq 0.05$) as shown in Table 4. Number of spikelets per spike was statistically similar amongst the weed controls (T_1, T_3, T_4, T_5, T_6) which indicates that weed control does not in any way increase the spikelets per spike of the rice crop. Number of spikelets per spike is more or less a genetic character in plants. T_3 recorded the highest mean value (2.4t/ha) for yield, although it was statistically at par with T_1, T_5 and T_6 as shown in Table 4. This signifies that the higher frequency of weed control operations undertaken, the more yield obtainable; although, this might come with its own financial implication. Weedy check had the lowest number of seeds per panicle (108) which reflects poor grain filling and the lowest mean value (0.4t/ha) for yield, this could be as a result of the stiff competition between weeds and the crop for nutrient, sunlight, air and moisture which was similar to the findings of Jabran *et al*. (2010). Weeds tend to reduce the leaf number in plants, thereby affecting their net photosynthetic rate and dry matter accumulation as also reported by Carey and Kells (1995). All treatments excluding weedy check were statistically similar for 1000 grain weight.

Table 4: Effects of weed control methods on number of spikelet per spike, number of spike per panicle, number of seeds per panicle, 1000 grain weight and yield of rice

Treatments	Number of Spikelet/Spike	Number of Seeds /Panicle	1000 Grain Weight (g)	Yield (t/ha)
T_1	12.3^a	175^b	21.3^a	2.2^{ab}
T_2	7.7^b	108^c	19.7^b	0.4^c
T_3	11.3^a	176^b	21.3^a	2.4^a
T_4	11.7^a	178^b	21.3^a	2.0^b
T_5	11.0^a	206^a	21.3^a	2.1^{ab}
T6	12.3^a	184^{ab}	21.1^{ab}	2.2^{ab}
LSD (0.05)	2.79	25.96	1.40	0.31
Significance	*	*	*	*

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT

*Means within the same column having different letters differ significantly at $p \leq 0.05$

Weed Parameters

There was no significant difference among treatments for weed density and weed weight at 3WAT as shown in Tables 5 and 6 respectively. This signifies that Pendimethalin application as a pre-emergence herbicide in respective treatments was not statistically able to control weeds before their emergence in comparison to other treatments. This can be as a result of herbicide resistance by weeds present. Although, significant difference exists between the treatments for weed density and weed dry weight at 6, 9 and 12WAT at ($p \leq 0.05$). At 12WAT, T_3 had the least value for weed intensity (8%) which signifies the effectiveness of 2,4-D application. Treatments with hoe weeding had the highest values for weed control efficiency (88 and 84%) due to the fact that weeds can hardly escape removal by human, although uneconomical at a large scale.

Table 5**:** Effects of weed control methods on weed density of rice

Treatments	Weed Density (No/m^2) at different WAT				
	3	6	9	12	Total
T_1	106.3	55.3^{bc}	36.0^c	49.0^{bc}	246
T_2	97.0	124.3^a	163.0^a	187.3^a	571
T_3	81.3	70.0^b	30.0^c	14.7^c	196
T_4	70.7	56.7^b	68.0^b	63.3^b	258.7
T_5	68.0	36.0^c	31.3^c	46.0^{bc}	181.3
T6	64.7	62.3^b	41.0^c	35.7^c	203.7
LSD (0.05)	57.33	23.70	13.63	23.57	
Significance	NS	*	*	*	

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT

*Means within the same column having different letters differ significantly at $p \leq 0.05$

Table 6**:** Effects of weed control methods on weed weight of rice

Treatments	Weed Weight (g) at different WAT				
	3	6	9	12	Total
T_1	12.3	4.7^b	2.3^b	4.0^c	23.7
T_2	12.7	34.0^a	43.3^a	56.7^a	146.7
T_3	10.3	9.3^b	6.3^b	5.0^b	30.9
T_4	4.0	3.3^b	21.0^a	18.0^b	46.3
T_5	4.0	3.3^b	4.0^b	6.3^b	17.6
T6	5.7	5.7^b	4.0^b	8.7^b	24.1
LSD (0.05)	25.53	11.84	23.67	13.63	
Significance	NS	*	*	*	

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT
*Means within the same column having different letters differ significantly at $p \leq 0.05$

Table 7**:** Effects of weed control methods on weed intensity, weed control efficiency, weed persistence index and yield of rice

Treatments	WI (%) at WAT				WCE (%)	WPI	Yield t/ha
	3	6	9	12			
T_1	40	26	18	23	84	0.37	2.2
T_2	38	44	50	54	--	--	0.4
T_3	34	30	16	8	79	0.61	2.4
T_4	31	26	30	28	68	0.70	2.0
T_5	30	18	16	22	88	0.38	2.1
T6	29	28	20	18	83	0.45	2.2

T_1 = Hoe weeding at 3, 6 and 9 WAT, T_2 = Weedy Check, T_3 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT + 2, 4-D at 9 WAT, T_4 = Pendimethalin + 1 hoe weeding at 3 WAT, T_5 = Pendimethalin + 2 hoe weeding at 3 and 6 WAT, T_6 = Pendimethalin + 1 hoe weeding at 3 WAT + 2, 4-D at 9 WAT

CONCLUSION

The study indicated that weed control methods affected the growth and yield of rice. A combination of pre-emergence, post emergence and hoe weeding (T_3) at several time intervals gave the best result in terms of performance of rice. Increased frequency of weeding operations was able to reduce the negative effects of weeds. Days to booting and flowering of rice were delayed in the weedy check (T_2) due to high level of weed infestation. Rice plants that grew taller (T_3) were able to obtain highest yield (2.4 t/ha) which signifies that, taller plants better smoother weeds.

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