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Research Paper

Yield and Economic Evaluation of Post Emergence Herbicides and Fertilizer Rates on Lowland Rice Varieties in Gashua, Yobe State Nigeria

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ABSTRACT: *Poor weed control is one of the major factor for yield reduction of rice depending on the type of weed flora and their intensity. To tackle these challenges and increase the production of rice in the study area there is a need to evaluate appropriate herbicide that can control the weeds and adequate nutrient that will improve the productivity and profitability of the lowland rice varieties Field trials were conducted on the research farm of the Federal University Gashua and Yobe State Agricultural Development Project Damaturu Sub-station in Sudan savannah ecological zone of Nigeria, to evaluate the performance of lowland rice as influenced by weed control treatments, N.P.K. Rate and varieties. The treatments consist of three post emergence herbicide Orizon Plus®, Pendimentalin and Oxidozon , hoe weeding and a weedy check which constitute the five weed control treatments, four rates of N.P.K Fertilizer (0,40 80 and 120t /ha) and the three lowland rice varieties giving a total of 60 treatments. Treatments was laid out on the basis of a split plot design with a factorial combination of weed control treatments and N.P.K assigned to the main plots and the varieties allotted to the subplots. The treatments was replicated three times. The results shows there was significant difference among the weed control treatments for panicle area and panicle yield at both locations.The result shows also there was no significant difference between rice varieties for the panicle area and panicle yield in both locations. Orizon plus produced the highest panicle area than other weed control treatments. 120kg/ha of NPK fertilizer application produced the highest for panicle area and panicle yield. Oxidozon produced the more grain yield than other weed control treatment. The rice variety affected grain yield only. The results also reveals that there was no significant difference among the interactions. There was no significant difference between the NPK fertilizer application treatments and varieties on the weed control efficiency for the two locations. The result shows that 2 hoe weeding (219,850) produced the highest gross margin. The results for NPK fertilizer application shows that 80kg/ha (212,350) produced the highest gross margin. This shows that higher gross margin for NPK was due to low yield and vice versa.*

KEYWORDS*: Rice, Herbicide, Fertilizer, Economics and Yield*

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I. INTRODUCTION

Rice (Oryza sativa L.) is one of the oldest cultivated human food crops. Rice is the third most widely grown cereal in the world after wheat and maize and the single most important food for more than half of the world's population F.A.O. (2013). It is an important dietary energy and protein source throughout the globe because it constitutes the main energy supply food in most countries of the world (Bos *et al*., 2005). A substantial area of rice production in the world lies in the tropics with the highest concentration in Asia. Statistics showed that 486million metric tonnes of milled rice was produced worldwide in 2012 out of which Africa accounted for only 17.3million metric tonnes of milled rice, Nigeria is the second largest producer of rice in the continent, with the total production of 2.6 million tonnes in 2012 F.A.O. (2013).

Weed infestation in low rice fields remains one of the constraints limiting their productivity. Farmers have adopted many techniques which include agronomic practices as land preparation, seeding rates, fertilizer application, water management, competitive cultivars, as well as manual, mechanical, and chemical weed control.

In spite of substantial fertilizer use, the crop yields are not increasing correspondingly, which reflect low fertilizer use efficiency (FUE). N.P.K. as a balanced fertilizer source, as it contains nitrogen, phosphorus, potassium in adequate amount can aid in early development of rice plant for competitive advantages against the weeds plant if applied at appropriate rate and time.

Rice production in Nigeria is seriously constrained by weed infestation. For the competitive abilities, weeds have serious negative effect in crop production and are responsible for great losses in crop yield (Mamun *et al.,* 1993). The probable yield loss due to unrestricted weed competition was 28.28% in broadcast AMAN rice variety (Karim *et al.,* 1998). Weeds under adverse condition affect plant height, leaf architecture, tillering habit, shading ability and growth pattern of the rice crops. Poor weed control is one of the major factors responsible for yield reduction of rice depending on the type of weed flora and their intensity (Amarjit *et al.,* 1994). Weed competition reduced the grain yield by 68-100% for direct seeded rice, 16-48% for transplanted AMAN rice variety and 22.36 % for modern Boro rice variety (Mamun *et al*., 1993).

Weeds compete with crops for space, light, water, nutrients and other growth requirements and are certainly the major sources accounting for the adverse effects on crop growth and yield (Sharma, 2001).

Addressing weed competition using herbicides is a critical requirement for rice production throughout the world (Malcolm, 2004). This involves the use of chemicals (herbicides) to kill undesirable vegetation. Herbicide could be selective or non-selective, contact or systemic, pre-emergence, post-emergence or pre-plant incorporated (Ado, 2007). It has been shown that herbicides used at recommended rates offered good weed suppression and increased crop yield of rice (Grichar *et al*., 2004). Weed can be selectively controlled using chemicals without injury to the crop. Pre-emergence application of herbicides protects crops from the adverse effects of early weed competition. Crop fertilization refers to fertilizer application according to the crop demands, while soil fertilization is targeted to replenish its fertility level. The strategy of efficient fertilizer management program involves a correct decision on the right rate, source, time, and place of fertilizer application (Bruulsema *et al*., 2009). The amount of fertilizers to be applied for a target yield may be determined by soil testing, nutrient response or missing element trial techniques.

In order to improve the productivity of rice using N.P.K Fertilizer which is easily available to farmers and to assess the effectiveness of chemical weed control measure on rice under local and improved varieties of this crop this research achieved the following objectives:

1. To determine the best rate of N.P.K Fertilizer for optimum yield of lowland rice varieties;
2. to determine the efficacy and weed control efficiency of three post emergence herbicides;
3. to determine the best variety that may suppress the weeds and give the highest yield of paddy rice; and

4 evaluate the profitability of post emergence herbicide and fertilizer rates on three varieties of rice

II. MATERIALS AND METHODS

Field trials was conducted during the wet seasons of 2016 at the Research Farm of the Federal University Gashua and Yobe Agricultural Development Project Damaturu sub-station research farm to evaluate the performance of upland rice varieties as affected by weed control treatments, N.P.K rate and varieties. The two locations lie in the Sudan Savanna ecological zone of Nigeria with a mean annual rainfall of less than 600mm distributed between May and October. The hottest months are those proceeding the rain (March and April) while the coldest months are December and January.

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 in the 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 (1968).

The treatments consists of five weed control treatments (OrizoPlus®, Pendimentalin and Oxidason two hoe weeded control, a weedy check, four rate of N.P.K (0, 40, 80 and 120/ha) and three rice varieties). The treatments was laid out in a split plot design in three replication such that a factorial combination of the four rate of N.P.K and five weed control treatments and the weedy check were assigned to the main plots while three rice varieties were assigned in the sub-plots. The net plot size was 3m x 4m ($12m^2$) and gross plot size will be 4m x 4.5m ($18m^2$)

The experimental areas were harrowed and levelled. Raised seed beds of 4.5m x 4.0m ($18m^2$) were marked out to constitute experimental gross plots. The net plot size was 4.m x 3.0m ($12.m^2$). The plots were separated by an unplanted discard area of 1m while replicates were separated by 2m unplanted discard area. The three rates of herbicide were applied using a CP3 knapsack sprayer fitted with a green deflector nozzle, at a pressure of $2.1kg/cm^2$ to deliver spray liquid volume of 240L/ha at 2WAS.

The rice seeds was dressed before sowing with APRON STAR WS (Thiamethoxam: 200g/kg, Mefenoxam: 200g/ha and Difenoconazole: 20g/kg) at the rate of 3kg seed per 10g of the chemical. Rice seeds was sown 20cm apart and at 20cm intra-row spacing by dibbling. The rice seedlings were thinned at 2WAS.The fertilizer was applied according to the experiment rate at 2 weeks after planting. Two hoe weeding was carried

out on the weeded control plots at 3 and 6WAS using a manual hoe. To calculate the weed control efficiency weed dry weight was first determined. This was taken by sampling the weeds from the portion of plots randomly selected by throwing a $1m^2$ quadrate and the weeds will be collected from inside quadrant, oven dried and weighed and the weight converted to kg per hectare and recorded on plot basis.

Weed Control Efficiency (W.C.E.): This was calculated using the formula.

$$\text{WCE} = \frac{\text{Weed dry weight in weedy check} - \text{Weed dry weight per treatment}}{\text{Weed dry weight in weedy check}} \times 100$$

(Das, 2008).

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 were 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 plots were then weighed using E200 mettler balance and the value recorded on per kilogram and per plot basis. Harvest was made at maturity (when the entire plants have turned golden brown, and the panicle has dried). The freshand dry weight of all harvested plant parts was determined.

At physiological maturity, all plants in the plot were harvested to determine grain yield and yield components. After threshing and winnowing in the air, 1000-grain was counted and weighed on a mettler balance model 1210, to obtain the 1000grain weight.The remaining portion of the field was harvested, threshed, and combined with grain from the 2.0 x2.0 m^2 quadrant to estimate grain yield at 14% moisture content. Harvested plant samples (straw and grain) were shredded, sub-sampled, and oven-dried at 65 °C to a constant weight to determine their weigh and converted to per hectare basis expressed in kg/ha.

Data collected was analysed with Analysis of Variance (ANOVA) as described by Steel and Torrie (1984) using SAS software package and differences among treatments means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability Duncan 1955). Gross margin analysis was used to calculate the costs and returns from paddy obtained from both trials to determine which treatment was more profitable.

$$GM = TR - TVC$$
$$TR = Yr * Pr$$

Where:

GM = Gross margin (₦/ha)
TR = Total revenue (₦/ha)
TVC = Total variable cost (₦/ha)
Yr = Output of rice crop (kg/ha)
Pr = Unit price of rice (₦/kg) and

$$TVC = \sum_{n} P_i X_{i\ i-j}$$

Where:

P_i = unit price of the i^{th} input (₦/kg)
X_i = quantity of the i^{th} input (/ha

III. RESULTS AND DISCUSSION

Table 1: Effects of post emergence herbicides on fertilizer on yield characters of rice varieties in Gashua during the raining seasons at two locations

Treatments	Panicle (M2)		Grain yield/panicle		100 -grain weight	
Weed control	L1	L2	L1	L2	L1	L2
Weedy check	376.65b	327.825b	76b	70b	19b	17b
2 hoe weeding	406.35a	353.675a	93a	85a	24a	22a
Pendimethalin	409.05a	356.025a	95a	87a	25a	23a
Oxidizon	407.7a	354.85a	91a	84aa	23a	21a
Orizon plus	409.05a	356.025a	92a	85a	24a	22a
Coefficient of variation	12.6	15.3	11.9	14.9	13.1	15.5
NPK Fertilizer Application						
0	304.3b	270.00b	90b	82b	19c	17c
40	411.75a	366.4575a	94a	87a	22b	20b
80	417.15a	371.2635a	95a	88a	23b	21b
120	421.2a	374.868a	97a	89a	26a	24a
Coefficient of variation	12.6	15.3	11.9	14.9	13.1	15.5
Varieties						
VI	370a	362a	99a	91a	21a	19a
VII	375a	365a	100a	92a	21a	19a
VIII	379a	366a	102a	94a	21a	19a
Coefficient of variation	12.6	15.3	11.9	14.9	13.1	15.5
Interactions						
WXF	NS	NS	NS	NS	NS	NS
Wx V	NS	NS	NS	NS	NS	NS
FxV	NS	NS	NS	NS	NS	NS

The cost of (input/ha) for like land preparation, seeds, fertilizers, labour, herbicides and others was noted and recorded.

Table 1 shows thateffects of weed control, fertilizer application, rice varieties on panicle area and panicle yield of rice. The resultsshows there was significant difference among the weed control treatments for panicle area at both locations. At L1, Orizon plus(409.05), pedimentalin(409.05), Oxidozin (407.7), and 2hoe weeding(406.35) were significantly at par and were significantly higher than weedy check. At L2, Orizon plus (356.02) have the highest panicle area than other weed control treatments, and it is significantly the same as pendimethalin (352.02), Oxidozon (354.84), 2hoe weeding (353.67), but significantly higher than the weedy check(327.82). This result corroborates with Berhan *et al;* 2021.

The application of NPK fertilizer also shows significant difference for panicle area at both locations. At L1, 120kg/ha produced the highest panicle area (42.12) and is significantly the same with 80kg/ha (417) and 40kg (411) and were significantly higher than the control. At L2, the results reveals that 120kg/ha produced the highest panicle area, and was statistically at par with 80kg/ha (371.26) and 40kg/ha (366.45) and are statistically higher than the control.The result shows also there was no significant difference between rice varieties for the panicle area in both locations. There was also no significant difference among the interactions.

For panicle yield, the results shows there was significant difference among the weed control treatments at both locations. At (L1),pedimentalin (95.0), 2hoe weeding(93.0), Orizon plus(92.0) and Oxidozon(91.0) were significantly at par, and statistically produced more panicle yield than the weedy check(76.0). The trend is also the at L2 with pedimentalin (87.0) producing the highest panicle yield followed by 2hoe weeding (85.0), Orizon plus(85.0) and Oxidozon(84.0) but they were significantly the same, and statistically produced more panicle yield than the weedy check(70.0).

Application of NPK fertilizer also shows significant difference for panicle yield at both locations. At (L1) 120kg/ha (97.0) produced the highest amount of panicle yield, and statistically at par with 80kg/ha (95.0) and 40kg/ha(94.0) and were significantly higher than control (90.0). At L2, similar results were obtained with 120kg/ha (89.0) produced the highest amount of panicle yield, and statistically at par with 80kg (88.0) and 40kg

(87.0) and were significantly higher than control (82.0). There was no significantdifference for rice varieties on panicle yield in the two locations. Also no significant difference was recorded among the interactions.The results from this findings is line with (Berhan et 2021) who discovered that there was signifance difference among two types of herbicide to inhibit rice weed growth and also have direct effect on yield and related characteristics.

Table 2: Effect Post Emergence Herbicides and Fertilizer Rates on Yield and weed control Efficiency in Gashau during the 2016 raining season at two locations.

Treatments	**Grain yield (kg/ha)**		**Straw yield (kg/ha)**		**Weed control efficiency (%)**	
Weed control	L1	L2	L1	L2	L1	L2
Weedy check	1916e	1326e	216e	288e	9.4e	12.2e
2 hoe weeding	3939d	3304d	279d	351d	18.58d	24.1d
pendimethalin	4031c	3396c	506c	578c	46.48c	60.4c
Oxidizon	4207a	3572a	791b	864b	55.38b	71.9b
Orizon pus	4119b	3884b	872a	945a	70.15a	91.1a
Coefficient of variation	21.3	20.0	27.6	6.4	23.0	19.5
NPK Fertilizer Application						
0	3372d	2737d	494d	530d	35.81a	39.03a
40	3418c	2783c	592a	629a	36.15 a	39.40a
80	4136a	3501a	525b	562b	36.23 a	39.49a
120	3937b	3302b	509c	545c	35.94 a	39.17a
Coefficient of variation	16.2	12.19	16.43	14.46	13.98	15.78
Varieties						
V1	3818a	4081.6a	567a	530b	36.28a	39.54a
V11	3619ab	4042.8a	565a	562a	36.26a	39.40a
V111	3572b	4086.4a	578a	545ab	35.81a	39.49a
Coefficient of variation	18.6	16.7	14.5	15.7	16.9	13.97
Interactions						
WXF	NS	NS	NS	NS	NS	NS
Wx V	NS	NS	NS	NS	NS	NS
FxV	NS	NS	NS	NS	NS	NS

Table 2 shows the effects of weed control, fertilizer application, and rice varities on the grain yield and weed control efficiency. The result shows that there was statistical difference between all the weed controltreatments on grain yield in both locations. At L1, Oxidozon produced the highest grain (4207) followed byOrizon (4119) with weedy check (1916) producing the least grain yield.Result at L2 also reveals that oxidizon produced the highest grain (3572), and was statistically different from all other treatments followed by orizon plus (3884), pedimentalin (3396), 2hoe weeding (3304), and weedy check producing the least grain yield. This results is in line Bajwa et al 2014 who discovered that weed control have effects on grain yield. The result is also similar to Khan et al, 2012.

Result also shows there was statistical difference among fertilizer application on the grain yield in the both locations. The fertilizer application shows that 80kg (4136) produced the highest grain yield, and significantly different from 120kg (3937), and 40kg (3418) at (L1) and the trend was also similar at L2 with 80kg (3501) producing the highest grain yield, and statistically different from 120kg (3302), and 40kg (2783) and the control produced the least.This result is in line with Usman *et al*, 2019 who discovered that grain yield was determined under optimum yield condition on rice varities.

There was significant difference among rice varieties for grain yield at L1 with V1 producing the highest grain yield (3818) and were statistically higher than the other varieties, and this was followed by V11(3619) and V111(3572) respectively. There was significant difference at L2 for varieties. This results is similar with that of

Usman*et al* 2019 on rice varities yield in Yobe state. The results also reveals that there was no significant difference among the interactions.

The result shows that there was statistical difference between all the weed control treatments on weed efficiency at both locations. The results shows that orizon plus produced the highest weed control efficiency (70.15) and it is statically different from oxidizon (55.38), Pendimethalin (46.48), 2hoe weeding(46.48) and weedy check with the least weed control efficiency. At L2, Orixon plus(91.1) produce the highest weed control efficiency and it is significantly different from Oxidizon (71.9), Pendimentalylin (60.4), 2hoe weeding (24.1), and weedy check with the least control efficiency.However, there was no significant difference between the NPK fertilizer application treatments and varieties on the weed control efficiencyfor the two locations. This findings is similar to (Bajwa *et al;*2014) on the effects of fertilizer on weed emergence.The results also reveals that there was no significant difference among the interactions.

Table 3: Profitability analysis of post emergence herbicide and fertilizer rates on three varieties of rice

Treatments	**Mean yield from the 2 locations**	**Gross margin**	**Cost benefit ration**
Weed control			
Weedy check	1621c	37, 600	1.3
2 hoe weeding	3622b	219850	2.5
Pendimethalin	3713.5ab	208,350	2.3
Oxidizon	3889.5ab	216,450	2.3
Orizon plus	4001.5a	209,150	2.1
Coefficient of variation	20.65		
NPK Fertilizer Application			
0	3054.5d	175,550	2.3
40	3100.5c	179,450	2.4
80	3818.5a	212,350	2.3
120	3619.5v	210,950	2.4
Coefficient of variation	14.195		
Varieties			
V1	3949.8b	213,980	2.2
V11	3830.9a	206,090	2.2
V111	3829.2a	208,420	2.2
Coefficient of variation	17.65		
Interactions			
WXF	NS	NS	NS
Wx V	NS	NS	NS
FxV	NS	NS	NS

The results in table 3, shows weed control, fertilizer application, and rice varieties treatments on the gross margin. The result shows that weed control treatment on gross margin varies with herbicides used. The result shows that 2hoe weeding(219,850) produced the highest gross margin and benefit cost ratio, which implies that it will yield more profit or economic benefits compared to Oxidizon(216,450), Orizon plus (209,150), Pendimentalin(208,350), while weedy check (37,600) produced least gross margin which indicates low profit levels. The results is contrary to (Imolama *et al,* 2010)who discovered that the use of herbicides is more beneficial than hoe weeding, which implies that low benefit cost implies higher yield.

The results for NPK fertilizer application shows that 80kg/ha (212,350) produced the highest gross margin, which implies more profit or economic benefits compared to 120kg/ha(210,950), and 40kg/ha(179,450) while control have the least gross margin.This shows that higher gross margin for NPK was due to low yield and vice versa.

The result shows that rice variety V1(213,980) produced the highest gross margin which implies more profit or economic benefits compared to V111(208,420) and V11(206,090) rice varieties respectively. The result from this findings is in line with Imolama *et al,* 2010, who discovered that the use of herbicides and other important parameters are economical and beneficial in Sudan Savanah zone of Nigeria. The findings is also similar to Usman *etal*, 2019 who discovered that higher gross margin was due to low yield.

Table 4: Properties of the soil of the experimental sites in 2016/2017 dry seasons at Gashua

	Locations	
Soil Parameters	Location I	Location II
Particle size distribution (g kg^{-1})		
Clay	16	12
Silt	28	34
Sand	56	54
Textural class	sandy loam	sandy loam
Chemical properties		
pH in water 1: 2.5	5.28	6.83
pH in $Cacl_2$ 1: 2.5	4.78	5.99
ECE (dsm^{-1})	0.014	0.05
Organic Carbon (g kg^{-1})	1.344	0.58
Total N (g kg^{-1})	0.21	0.35
Available P (mg kg^{-1})	9.81	13.95
Exchangeable Cation		
K (cmol kg^{-1})	1.71	0.73
Mg (cmol kg^{-1})	0.92	0.92
Ca (cmol kg^{-1})	8.85	7.70
Na (cmol kg^{-1})	0.87	0.77
H + Al (cmol kg^{-1})	1.2	0.8
ECEC (cmol kg^{-1})	13.55	10.92

IV. CONCLUSION

From the results obtained from this research it can be concluded thatOrizon plus produced the highest panicle area than other weed control treatments. 120kg/ha of NPK fertilizer application produced the highest for panicle area and panicle yield. Oxidozon produced the more grain yield than other weed control treatment. The rice variety affected grain yield only. The result further shows that 2 hoe weeding yield more gross margin than other weed control methods, and 80kg/ha of NPK fertilizer application yielded higher gross margin.

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