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Rice Production under Different Weed Management Technologies Adopted by Rice Farmers in Katsina State, Nigeria

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Abstract
This study investigated the adoption and profitability of weed management technologies for rice production, namely; oxidiaxon, pendimethalin, hoe weeding and farmers' practice which comprised recycling of paddy previous harvest as seeds, use of hoe for land preparation, fertilizer broadcasting and use of family labour, only to mention a few. Data were collected using structured questionnaire administered to 294 randomly selected respondents across four locations, namely; Dandume, Albasu, Gyazama and Dantakari. Data were analysed using descriptive statistics and gross margin analysis. The majority (96%) of the respondents had annual income ranging between less than ₦100, 000 and more than ₦150,000; 76% had extension contact and all had access to agricultural credit. The gross margin analysis indicated that rice production under different weed management technologies in the four locations was profitable with an average gross margin of ₦69,232.80, ₦90,592.80, ₦141, 073.30 and ₦22,789.30 per ha. with average return of 0.50, 0.70, 1.00 and 0.80 per naira invested for Dandume, Albasu, Gyazama and Dantakari, respectively. Also, rice production under pendimethalin weed management was more profitable in all the four locations whereas conventional farmers' practice had the lowest profit. It was concluded that farmers should be encouraged to adopt the pendimethalin weed management technologies in rice production to reduce yield losses associated with weed infestation.

Keywords: Weed management technologies, Rice farmers, profitability, Profit margin.

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Introduction

The demand for rice (*Oryza sativa*) in Nigeria has assumed a steady rise in the last decades compared to other cereal crops such as sorghum and millet (Onwalu, 2012). In Nigeria, the estimated annual rice demand is about 5 million metric tonnes, while local production is about 2.21 million metric tonnes (Adekule, 2013). The annual deficit of 2.79 million metric tonnes is bridged by importation of rice commodity. The annual importation takes a

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considerable share of the Nigeria's foreign exchange. For instance, the country spends an average of ₦360 billion annually on rice importation (Adekule, 2013) contributing to dwindling foreign exchange.

Policy makers in the agricultural sector are keen to reverse the trend by encouraging local production to meet demand for consumption of the commodity thereby saving the foreign exchange and creating job opportunities. In view of this, efforts have been made by the government of Nigeria and none governmental organizations to ensure that farmers have access to improved production technologies such as weed management technologies through extension services. For instance, the government of Nigeria initiated the Presidential Initiative on Rice in 2001 with the aim of achieving self-sufficiency and export (Lançon *et al.,* 2003). In 2009, the federal government initiated the Nigerian National Rice Development Strategy to raise rice production from 3.4 million metric tonnes to 12.8 metric tonnes by 2018 (Longtau, 2003).

The majority of rice farmers in Nigeria depend on traditional technologies with utilization of productivity enhancing inputs leading to a national average yield of 1 to 2.5 tonnes per hectare (Nwite *et al*., 2008). In view of this, profitability of small holder farmers' has important implication for any development strategy adopted in Nigeria. An improvement in understanding its profitability can greatly aid policy makers in formulating and enhancing policies as well as judging the efficacy of present and past reforms.

Rice production is hindered by a number of factors and one of such factors is weed. Of all the constraints limiting the production of this crop, weeds, appear to have the most deleterious effect causing between 75 and 100% reduction in potential paddy rice yield (Akobundu, 2011; Imeakparia, 2011; Lavabre, 2011). Yield reduction due to weed competition is greater in direct-seeded than in transplanted rice. Inadequate land preparation, use of short-stature early maturing cultivars and increased fertilizer use have resulted in severe weed problems in direct – seeded rice. The limited data available indicate that production losses can reach 30-40% for fields that are poorly weeded (Anon, 1988). With direct seeding, the germination of rice seeds and the emergence of weeds take place almost at the same time. Therefore, weed control at the early stages of the crop growth is important (Street and Lanham, 2016). Different weed management systems for rice production are available, namely oxidiaxon, pendimethalin, hoe weeding and farmers' practice.

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Oxidiaxon is a selective pre-emergence herbicide for control of annual grasses and broadleaf weeds. It shows promise in rice, turf, orchards, peanuts, soybeans and ornamentals for control of grasses and broadleaf weeds (Allison, 2015). Studies conducted to determine the growth responses of rice to pre-application of oxadiazon showed that oxadiazon at 1.0 and 1.5 kg ha^{-1} was applied to four rice varieties ('IR64', 'IR72', 'RC09', and 'RC18'), which were grown in saturated and aerobic (30% of saturation) soils (Bouman and Tuong, 2001; Bhagirath *et al.,* 2011; Singh *et al.,* 2009; Zhao *et al.,* 2006). Rice phytotoxicity symptoms were greater when the herbicide was applied to saturated than to aerobic soils. Oxidiazon at 1.0 kg ha^{-1} reduced rice shoot biomass by 22 to 36% in aerobic condition and 43 to 56% in saturated condition when compared to the control.

Pendimethalin is also a selective herbicide used to control most annual grasses and certain broadleaf weeds in field corn, potatoes, rice, cotton, soybeans, tobacco, peanuts and sunflowers. It is used as both pre-emergence, that is before weed seeds have sprouted and early post-emergence (Moody, 2011). It is used to control annual grasses and certain broadleaf weeds which interfere with growth, development, yield and quality of crops by competing on nutrients, water and light (Moody, 2012). Field studies were conducted from 2005 through 2007 to determine the response of three rice cultivars to three application timings and two formulations of pendimethalin in a stale seedbed rice production system. Pendimethalin formulation was applied to rice 0, 3, and 7 days after planting. No visual injury was detected for any cultivar (Carvey III *et al.,* 2014).

Traditional manual hoe weeding is the most popular method of weed control in Nigeria. This is however, time consuming, labor-intensive and generally expensive. It is estimated that about 40-60% of production cost is spent on manual weeding (Remison, 2009). Rice; being a closely sown crop also makes mechanical weeding difficult and some degree of crop damage is unavoidably involved in manual weeding. In addition hand weeding allows weeds with similar morphological characteristics to rice to escape detection and hence removal in direct-seeded rice fields (Dingkuhn *et al.,* 2001). Weeding cannot be done at a time when labour is unavailable but this may not coincide with the optimum weeding time for minimizing weed competition.

Farmer's practice in weed management for rice production follows management practices that are being followed by farmers and which are passed from one generation to the other in order to effectively manage weeds in their rice field (Moody, 2011). The management

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includes preparing and leveling the main fields uniformly without undulations, maintaining the heights of the field bunds at one inch, storing water continuously up to 15 days from planting. In large scale rice production in Nigeria, chemical weed control represents a practical and economical alternative to hand weeding (Akobundu, 2011). This is because the use of herbicides ensures effective weed control during the period of labour shortage when weeding coincides with other farm work (Imeokparia and Okunsanya, 2007).

Previous reports by various weed scientists (Bayer and Hill, 1989; Castin and Moody, 2009; Diop and Moody, 2008; Moody, 2012; Imeokparia, 2011) have indicated that weed control with herbicides is feasible and proved more economical if well adopted by farmers. However, all-season weed control has been difficult to obtain in the area due to poor extension services and costs. Also, differences in weed flora and their pattern of emergence during crop growth can influence the performance of herbicides generally. In the Nigerian Sudan savanna with its diverse weed flora, selective herbicides with wide spectrum of activity are profitable for rice production, particularly in Katsina State.

Profitability of rice production under the different weed management systems is yet to be established, especially in the study area (Ezedinma, 2001). Unlike previous studies on profitability of rice production, this study is interested in evaluating profitability of rice production under different weed management technologies to establish the most profitable weed management technologies in the area. The objective of this paper therefore, was to contribute towards better understanding of the profitability of rice production in Nigeria while taking into consideration weed management technologies. The specific objectives were to describe socio-economic characteristics of rice farmers, determine costs and return from adoption of weed management technologies and identify constraints of rice farmers in the area.

Methodology

Study area

Katsina State covers an area of about 23,983 square kilometers with a projected population of 6,401,783 (projected from the 2006 census). The state is located in the North-western part of the country and lies in between latitudes 11^{o} 03′ and 13^{o} 05′ N and longitudes 07^{o} 21’ and 09^{o} 02′ east of Greenwich Meridian and bordered by Kaduna State to the South, Niger republic to the North, Zamfara state to the West and Kano and Jigawa States to the East. It has two climate seasons; rainy and dry seasons and has a mean average rain fall of about

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400-1300mm. The climate favours maize, rice, beans, groundnut and guinea corn. Major livestock in the state are cattle, sheep, goats and donkeys.

Sampling technique

It is difficult to estimate the population of rice farmers in Katsina State. Multistage sampling procedure was used to select respondents for this study. First, was the purposive selection of two predominantly rice farming local government areas (L.G.As) of Katsina State namely Dandume and Danja L.G.As. The second stage involved random sampling of two rice farming semi-urban communities from Dandume namely Albasur and Dandume, two communities from Danja namely Gyazama and Dankari which gave a total of four communities. The third stage involved simple random selection of 50% of the sampling frame of 588 rice farmers, which gave a sample size of 294 rice farmers. Primary data were employed in the study. Data were collected with use of a structured questionnaire administered to respondents.

The data collected were on the socio-economic characteristics of the rice farmers, quantity and costs of inputs such as rice seeds, fertilizer, labour, herbicides, fungicides, and also quantity of rice harvested, price of rice, cost of transportation, socio-economic variables such as age, gender, educational level, household size, farm size, farming experience, extension contact, amount of credit obtained and membership of association of farmers. Lastly, data on constraints encountered in rice production by the farmers were obtained.

Data analysis

The data obtained were subjected to Gross Margin Analysis. This was used to determine profitability of the four weed management technologies in the four locations of the study area.

Model specification: estimation of gross margin analysis is expressed as:

GM = TR – TVC;
Where: GM = Gross Margin (₦/ha),
TR = Total Revenue (₦/ha),
TVC = Total Variable Cost (₦/ha.),

Return per Naira invested was calculated as:
ATR/AVC.

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Where: ATR = Average total revenue (₦/ha.),

AVC = Average variable cost (₦/ha.).

Results and Discussion

Socio-economic Characteristics of Rice Farmers

Table 1 reveals that 25% of the respondents were within the age bracket of 31-35, defined by FAO (2010) as economically productive in a population, while 19% fell within the age group (above 61 years). This implies that the respondents are still economically active and in their productive ages. Educational level of the respondents shows that 30% were holders of primary school education, followed by secondary school education (25%). Most of the respondents (45%) had farm size of between 1 and 5 hectare. Also, the majority (64%) of the respondents were males. It can be inferred that male dominated rice farming. Thirty two percent (32%) of the respondents had farming experiences ranging between 11 and 15 years. The result showed that 42% of the respondents had between 11 and 15 persons in their households. Early marriage and large household size are common practice in the study area. The result further indicates that the respondents had varying annual income. About 33% of the respondents had their income ranging from ₦100,000 - ₦150,000 per annum and only 1% had above ₦1,100,000.

The result shows that 30% of the respondents had 1-2 extension contacts per year and 24% had no contact at all. This suggests that extension workers should do more to sensitize farmers on the importance of adoption of improved rice production technologies. There were 39% of the respondents who belonged to one or two associations. Access to credit was relatively easier as 45% accessed between ₦50, 000 and ₦90,000. Overwhelmingly, all the respondents had access to credit. This means that farmers had adequate support for rice production.

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Table 1: Socio-economic characteristics of the respondents

Socio-economic characteristics	Percentage (n = 294)
Age (years)	
15-20	11
21-25	5
26-30	11
31-35	25
36-40	16
41-45	13
46 and above	19
Gender	
Male	64
Female	36
Education	
Non-formal education	27
Primary education	30
Secondary education	25
Tertiary education	18
Farm size (ha)	
1-5	45
6-10	32
11-15	18
16 and above	5
Farming experience (years)	
<5	11
5-10	32
11-15	32
16-20	12
21-25	4
26-30	5
31 and above	5
Household size	
1-5	31
6-10	25
11-15	42
16 and above	3
Income (Naira/annum)	
<100,000	23
100,000-150,000	33
151,000-160,000	18
161,000-170,000	7
171,000-180,000	12
181,000-190,000	3
191,000-1,000,000	3
1,100,000 and above	1
Extension contact (visit/annum)	
No visit	24
1-2	30
3-4	27
5 and above	19
Membership of association (number of assoc. belong)	
Non-member to any (0)	6
1-2	39
3-4	29
5 and above	26
Credit (amount of Naira received)	
<100,000	45
100,000-150,000	36
151,000 and above	19
Total	**100**

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Costs and Returns Per Hectare

The variable cost in the analysis include seeds, fertilizers, herbicides, fungicides, bags (sacks), land preparation/ridging, planting, weeding, fertilizer application, herbicides application, harvesting and threshing. In Tables 2, 3, 4 and 5, the differences in the total variable cost of production between the technologies (oxadiazon, pendimethalin, hoe weeding and farmers' practice) employed in rice production was attributable to the differences in costs of the variable inputs across the four locations. The results in the Tables show that labour and fertilizer inputs accounted for greater parts of the total variable costs incurred in all the technologies. Labour costs accounted for 58.97, 52.44, 46.45 and 57.71% for oxadiazon, pendimethalin, hoe weeding and farmer practice plots/technologies respectively in Dandume, while in Albasur, labour costs accounted for 53.18, 61.79, 73.85 and 73.85% in all the technologies respectively. In Gyazama and Dantakari locations, labour costs accounted for 59.17, 62.16, 77.05, 66.90, 59.18, 62.14, 76.31 and 67.80% in all the technology plots respectively. Fertilizers were 22.87, 24.15, 18.0 0, 22.60, 22.78, 23.90, 18.00 and 22.0% for all the technologies in Dandume and Albasur, fertilizer costs accounted for 22.96, 24.11, 18.06 and 22.73% for all the technologies, while in Gyazama and Dantakari, the farm gate price of paddy rice (₦ 80/kg) was used in estimating the revenue component of the gross margin.

Dandume

The gross margin analysis as indicated in Table 2, shows that from one hectare of land cultivated, the total cost of production for oxadiazone, pendimethalin, hoe weeding and farmer practice technologies were ₦136,372.99 ₦130,212.99, ₦173,352.99, ₦137,670.00 and gross revenue of ₦221,600.00 ₦245,600.00, ₦228,000.00 and ₦117,600.00, thus making gross margin of ₦85,227.01, ₦116,387.01, ₦55,247.01 and ₦20,070.00/ha respectively. The results revealed that pendimethalin, oxadiazon and recommended hoe weeding performed better in terms of revenue generated. The negative gross margin obtained for the farmers' practice, implies rice cultivation under farmers practice of weed management is not profitable.

In terms of returns per Naira invested, for every one Naira invested on the weed management using oxadiazon, pendimethalin and hoe weeding a net gain of 62, 90 and 15 kobo were obtained respectively, while for farmer practice a net loss of 32 kobo (-0.32) was incurred.

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Table 2: Costs and returns analysis of weed management intervention in rice production in Dandume

Location: Dandume								
Treatment								
Costs/Returns Items	Oxadiazon	%	Pendimethalin	%	Hoe weeding	%	Famer's practice	%
(1) Cost/ha(₦)								
Seed	8,000.00	5.87	8,000.00	6.19	8,000.00	4.61	8,000.00	5.81
Fertilizer	31,200.00	22.87	31,200.00	24.15	31,200.00	18.00	31,200.00	22.66
Fungicide	1,250.00	0.91	1,250.00	3.23	1,250.00	0.72	1,250.00	0.91
Herbicide (Oxadiazon)	12,600.00	9.24	4,200.00	2.48	-	1.85	-	-
Bag (Sacks)	2,240.00	1.64	2,480.00	1.92	2,320.00	1.43	1,200.00	0.87
Labour								
Land Preparation	21,250.00	15.58	21,250.00	16.45	21,250.00	12.26	19,250.00	13.98
Planting	29,500.00	21.63	29,500.00	22.83	29,500.00	17.02	13,750.00	9.98
Fertilizer Application	7,583.33	5.56	7,583.33	5.87	7,583.33	4.37	10,000.00	7.26
Weeding	-	-	-	-	52,500.00	2.88	33,250.00	24.15
Herbicide Application	5,000.00	3.67	5,000.00	3.87	-	-	-	-
Harvesting	8,750.00	6.42	8,750.00	6.77	8,750.00	5.05	8,500.00	6.17
Threshing	8,333.33	6.11	8,333.33	6.45	8,333.33	4.81	8,500.00	6.17
Transportation	2,666.33	1.96	2,666.33	2.06	2,666.33	1.54	3,000.00	2.18
Total Variable Cost (TVC)(₦)	₦136,372.99		₦130,212.99		₦ 173.352.99		₦137,670.00	
(2) Returns (₦)								
Average yield (kg/ha)	2770		3070		2850		1470	
Average Price (kg/ha)	80.00		80.00		80.00		80.00	
Gross Revenue (₦ /ha)	221,600.00		245,600.00		228,000.00		117,600.00	
Gross Margin (GR - TVC)(₦)/ha	85,227.01		116,387.01		55,247.01		-20,070.00	
Return/Naira Invested	0.62		0.90		0.15		-0.32	

Albasur

The total cost of production for oxadiazon, pendimethalin, hoe weeding and farmer practice technologies were ₦136,932.99, ₦130,532.99, ₦173,372.99, ₦137,590.00/ha respectively and gross revenue of ₦275,200.00, ₦280,000.00, ₦224,000.00 and ₦161,600.00/ha, thus making gross margin of ₦138,267.00, ₦149,467.01 ₦50,627.01 and ₦ 24,010.00/ha respectively. In this location, application of pendimethalin and oxadiazon generated more income to the farmers than hoe weeding and the farmers practice. The returns per naira invested indicates that for every one naira invested in weed management in rice production, a net gain of ₦1.01, ₦1.15, 29 and 17 kobo was obtained using oxadiazon, pendimethalin, hoe weeding and farmer's practice respectively.

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Table 3: Costs and returns analysis of weed management intervention in rice production in Albasu

Location: Albasur								
Treatment								
Costs/Returns Items	**Oxadiazon**	**%**	**Pendimethalin**	**%**	**Hoe weeding**	**%**	**Farmer's practice**	**%**
(1) Cost/ha(₦)								
Seed	8,000.00	5.84	8,000.00	6.13	8,000.00	4.61	8,000.00	5.81
Fertilizer	31,200.00	22.78	31,200.00	23.90	31,200.00	18.00	31,200.00	22.68
Fungicide	1,250.00	0.91	1,250.00	0.96	1,250.00	0.72	1,250.00	0.91
Herbicide (Oxadiazon)	12,600.00	9.20	4,200.00	3.22	-	-	-	-
Bag (Sacks)	2,800.00	2.04	2,800.00	2.15	2,240.00	1.29	1,600.00	1.16
Labour								
Land Preparation	21,250.00	15.52	21,250.00	16.47	21,250.00	12.26	19,250.00	13.99
Planting	29,500.00	21.54	29,500.00	22.60	29,500.00	17.02	13,750.00	9.99
Fertilizer Application	7,583.33	5.54	7,583.33	5.81	7,583.33	4.37	10,000.00	7.27
Weeding	-	-	-	-	52,500.00	30.28	33,250.00	24.17
Herbicide Application	5,000.00	3.65	5,000.00	3.83	-	-	-	-
Harvesting	8,750.00	6.39	8,750.00	6.70	8,750.00	5.05	8,500.00	6.18
Threshing	8,333.33	6.08	8,333.33	6.38	8,333.33	4.81	8,500.00	6.18
Transportation	2,666.33	1.95	2,666.33	2.04	2,666.33	1.54	3,000.00	2.18
Total Variable Cost (TVC)(₦)	₦136,932.99		₦130,532.99		₦ 173,372.99		₦137,590.00	
(2) Returns (₦)								
Average yield (kg/ha)	3440		3500		2800		2020	
Average Price (kg/ha)	80.00		80.00		80.00		80.00	
Gross Revenue (₦ /ha)	**275,200.00**		**280,000.00**		**224,000.00**		**161,600.00**	
Gross Margin (GR - TVC)(₦)/ha	**138,267.01**		**149,467.01**		**50,627.01**		**24,010.00**	
Return/Naira Invested	1.01		1.15		0.29		0.17	

Gyazama

The gross margin analysis shows that from one hectare of land cultivated, the total cost of production for oxadiazon, pendimethalin, hoe weeding and farmer practice technologies were ₦137,012.00 ₦131,012.99, ₦174,252.99, ₦138,230.00 and gross revenue of ₦284,800.00, ₦328,800.00, ₦312,800.00 and ₦218,400.00/ha respectively. Thus making gross margin of ₦147, 787.01, ₦197, 789.01, ₦138, 547.01 and ₦80, 170.00 /ha respectively. In this location application of pendimethalin generated more income to the rice producers followed by oxadiazon, hoe weeding and the farmer's practice. The result shows that for every one naira invested in weed management using oxadiazone, pendimethalin, hoe weeding and farmer's practice, a net gain of ₦ 1.08, ₦ 1.51, 80 and 58 kobo respectively was realized.

In this location, all technologies generated positive gross margin, however, the analysis

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indicated intensification of weed management practices along with recommended hoe weeding will generate better income to the rice producers than the farmer's practice.

Table 4: Costs and returns analysis of weed management intervention in rice production in Gyazama

Location: Gyazama								
Treatment								
Costs/Returns Items	**Oxadiazon**	**%**	**Pendimethalin**	**%**	**Hoe Weeding**	**%**	**Farmer's Practice**	**%**
(1) Cost/ha(₦)								
Seed	8,000.00	5.89	8,000.00	6.18	8,000.00	4.63	8,000.00	5.83
Fertilizer	31,200.00	22.96	31,200.00	24.11	31,200.00	18.06	31,200.00	22.73
Fungicide	1,250.00	0.97	1,250.00	0.97	1,250.00	0.72	1,250.00	0.91
Herbicide (Oxadiazon)	12,600.00	3.25	4,200.00	3.25	-	-	-	-
Bag (Sacks)	2,880.00	1.30	3,280.00	1.30	3,120.00	0.93	2,240.00	0.96
Labour								
Land Preparation	21,250.00	15.64	21,250.00	16.42	21,250.00	12.30	19,250.00	14.02
Planting	29,500.00	21.71	29,500.00	22.80	29,500.00	17.08	13,750.00	10.01
Fertilizer Application	7,583.33	5.58	7,583.33	5.86	7,583.33	4.39	10,000.00	7.28
Weeding	-	-	-	-	52,500.00	30.39	33,250.00	24.21
Herbicide Application	5,000.00	3.68	5,000.00	3.86	-	-	-	-
Harvesting	8,750.00	6.43	8,750.00	6.76	8,750.00	5.07	8,500.00	6.19
Threshing	8,333.33	6.13	8,333.33	6.44	8,333.33	4.82	8,500.00	6.19
Transportation	2,666.33	1.96	2,666.33	2.06	2,666.33	1.54	3,000.00	1.94
Total Variable Cost (TVC)(₦)	₦137,012.99		₦131,012.99		₦ 174,252.99		₦138,230.00	
(2) RETURNS (N)								
Average yield (kg/ha)	3560		4110		3910		2730	
Average Price (kg/ha)	80.00		80.00		80.00		80.00	
Gross Revenue (₦ /ha)	284,800.00		328,800.00		312,800.00		218,400.00	
Gross Margin(GR – TVC)(₦)/ha	147,787.01		197,789.01		138,547.01		80,170.00	
Return/Naira Invested	1.08		1.51		0.80		0.58	

Dantakari

The gross margin analysis shows that from one hectare of land cultivated, the total cost of production for oxadiazon, pendimethalin, hoe weeding and farmer practice technologies were ₦135,892.99 ₦129,412.99, ₦172,732.99, ₦137,330.00 and gross revenue of ₦169,600.00, ₦166,400.00, ₦160,600.00 and ₦129,600.00/ha respectively. Thus making gross margin of ₦33, 707.01, ₦36, 987.01, -₦12, 732.99 and -₦7,730.00/ha respectively. A net gain of ₦2.86 and 25kobo was obtained for pendimethalin and oxadiazone and net loss

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of 7 and 1kobo were incurred in the recommended hoe weeding and farmer's practice. In this location application of pendimethalin and oxadiazone generated more income to the rice producers, while recommended hoe weeding and the farmer's practice had negative gross margins. The recommended hoe weeding and farmer practice technologies had negative gross margin as reflected in this location and this indicates the intensification of weed infestation resulted in poor yield and negative gross margin.

Table 5: Costs and returns analysis of weed management intervention in rice production in Dantakari

Location: Dantakari								
Treatment								
Costs/Returns Items	**Oxadiazon**	**%**	**Pendimethalin**	**%**	**Hoe weeding**	**%**	**Farmer's practice**	**%**
(1) Cost/ha(₦)								
Seed	8,000.00	5.67	8,000.00	6.18	8,000.00	4.63	8,000.00	5.82
Fertilizer	31,200.00	22.96	31,200.00	24.11	31,200.00	18.06	31,200.00	22.72
Fungicide	1,250.00	0.92	1,250.00	0.97	1,250.00	0.72	1,250.00	0.91
Herbicide (Oxadiazon)	12,600.00	9.27	4,200.00	3.25	-	-	-	-
Bag (Sacks)	1,760.00	1.30	1,680.00	1.30	1,600.00	0.93	1,340.00	0.98
Labour								
Land Preparation	21,250.00	15.64	21,250.00	16.42	21,250.00	12.30	19,250.00	14.02
Planting	29,500.00	21.71	29,500.00	22.80	29,500.00	17.08	13,750.00	10.01
Fertilizer Application	7,583.33	5.58	7,583.33	5.86	7,583.33	4.39	10,000.00	7.28
Weeding	-	-	-	-	52,500.00	30.39	33,250.00	24.11
Herbicide Application	5,000.00	3.68	5,000.00	3.86	-	-	-	-
Harvesting	8,750.00	6.44	8,750.00	6.76	8,750.00	5.07	8,500.00	6.19
Threshing	8,333.33	6.13	8,333.33	6.44	8,333.33	4.82	8,500.00	6.19
Transportation	2,666.33	1.96	2,666.33	2.06	2,666.33	1.54	3,000.00	2.19
Total Variable Cost (TVC)(₦)	₦135,892.99		₦129,412.99		₦ 172,732.99		₦137,330.00	
(2) Returns (₦)								
Average yield (kg/ha)	2120		2080		2000		1620	
Average Price (kg/ha)	80.00		80.00		80.00		80.00	
Gross Revenue (₦ /ha)	169,600.00		166,400.00		160,600.00		129,600.00	
Gross Margin(GR – TVC)(₦)/ha	33,707.01		36,987.01		-12,732.99		-7,730.00	
Return/Naira Invested	0.25		2.86		-0.07		-0.01	

Constraints to Increasing Rice Production

The important constraints to rice production as perceived by the respondents was weed infestation (37%) and diseases and pests infestation (31%) (Table 6). Pests include birds, borers and rodents. About 18% of the respondents consider labour to be another constraint to rice production. From this study, farmers complained that scarcity of fertilizer was in existence in their local market. Other constraints to rice production were also identified by the rice farmers as indicated in the Table.

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Table 6: Major constraints encountered in rice production

Constraint	**Percent (n =** 294**)**
Weed infestation	37
Pest and disease infestation	31
Time consuming	5
Method of fertilizer application	6
High cost of labour	18
Adverse weather	3
Total	100

Conclusion and Recommendation

The gross margin analysis of the weed management treatments in the four locations shows that with adequate weed management, rice production is a profitable venture. These results indicate that intensification of rice production using herbicides such as oxadiazon and pendimethalin supplemented with hoe weeding will reduce or control menace of weeds in rice cultivation in the study area. This will in turn result to high yield and more income to the farmers than the farmers practice. There is opportunity for more profit enhancement under different weed management technologies, since average production return of ₦0.50, ₦0.70, ₦1.00 and ₦0.80 per Naira invested for Dandume, Albasu, Gyazama and Dantakari respectively. In all the four locations, oxadiazon and pendimethalin technologies were found to be more profitable weed management technologies. Farmers using hoe weeding and farmer's technologies were operating at loss; therefore they should be encouraged to adopt oxadiazon and pendimethalin technologies to make more profit because rice production is profitable in the area.

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