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Effect of different levels of NPK fertilizer on the growth and yield of lowland rice genotypes in Anwai, Delta state

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Abstract

This study examined the effect of different levels of NPK (15:15:15) fertilizer on the growth and yield of rice (*Oryza spp.*) under the soil of Anwai in Delta State. Growth Parameters measured at different growth stages (2, 4, 6, 8, 10 and 12 weeks after planting) include plant weight (cm) and number of tillers. Yield parameters assessed at harvest include number of grain/panicle, panicle length, and 1000 seed weight (g). There were significant differences among treatments for plant height and number of tillers. The results showed that there were significant differences (P≤ 0.05) among treatments for number of grain/panicle, panicle length and 1000 seed weight of rice. At 0.15kg level of fertilizer application, the highest mean values of 166.40, 35.6 and 36.6g for number of grain/panicle, panicle length and 1000 seeds weight of rice per plant were recorded, respectively. The result of this study showed that there were significant differences among different fertilizers and 0.15kg level of fertilizer application performed better than other levels evaluated. Thus, 0.15kg level of fertilizer application can be recommended to the farmers who are interested in growing rice.

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Introduction

Rice is a staple food for more than half of the world's seven billion people (Mohanty, 2013). It is the second-highest in production and consumption in the world. Rice ranks second after wheat in the world of cereals grain production (FAO, 2009). More than half of the world's population depends on rice as food. The utilization of rice is increasing and the inequity between domestic productions has been increasing in sub–Saharan Africa (Oikeh *et al.,* 2008). About 80% of rice in Africa is produced by small–scale farmers for their own utilization and local market (WARDA, 2007). World rice production is spread across at least 114 countries (FAO, 2013) and rice is grown on 144 million farms worldwide, more than for any other crop.

Fertilizer management represents one of the most expensive inputs to a successful rice crop production, especially in submerged soils (Fageria *et al.,* 2012). Profitable rice grain yields are dependent on proper and effective NPK fertilizer use management (Fageria *et al.,* 2011). NPK fertilizer is subjected to many loss processes when it is applied to the rice, and these loss processes that operate in the soil-water environment can be quite enormous and understanding of the behavior of wetland rice soils (Fageria *et al.,* 2012). Rice requires a lot of nutrients for proper growth and yield. Agbato (2003) reported that inorganic fertilizer recommendations for rice vary with the type of soil in which it is grown. Generally, an application of 15:15:15 compound fertilizer at the rate of 0.56 tones/ha should be made at planting time and at 6weeks after planting. Rice requires at least 16 elements from soil, air and water for normal growth development). Poor and declining soil fertility remain the most important biophysical (abiotic) stress that accounts for the decline in agricultural productivity, particularly in a rice-growing environment in Sub-Saharan Africa (Sanchez *et al.* 1997; Issaka, 2008; Senayah *et al.,* 2008; Buri *et al.*, 2011; Abe *et al.*, 2010). Another notable and critical factor contributing to low agricultural productivity, especially rice, is the low use of fertilizers (Buri *et al.,* 2010; IFDC, 2012). The role of fertilizer cannot be over-emphasized in the development of crops in Nigeria (FAO, 2004) and the use of fertilizer in the production of rice will not only improve yield but will also increase the income of local farmers. Therefore the objective of this study is to determine the effects of different levels of NPK fertilizer on the growth and yield of rice.

Materials and methods

Experimental site

The experiment was conducted during the 2019 planting season at the Faculty of Agriculture Research Farm, Delta State University, Asaba campus. Asaba is located at 0.6°14'N and 0.6°49E of the equator. Asaba lies in the tropical rain forest zone in Anwai, Oshimili south local government area of Delta state. The area is within the rainforest zone of Nigeria. It has distinct dry and wet seasons, the dry season runs from early November to the end of March, while the raining/wet season runs between mid-March to mid-November. There is usually a dry short spell in August popularly referred to as "August break". There are usually rainy peaks in July and September; the annual rainfall ranges between 1500mm-2000mm. The temperature is moderately high (23.8°-37.3°C) throughout the year; there is a slight variation in the daily temperature from January to September. The maximum temperature is usually experienced between February and March, just before the onset of rainfall, while the lowest temperature is obtained during the July-September periods (NIMET, 2021).

Land preparation and experimental design

Land clearing and preparation were done with local implements such as cutlass, hoe, spade and rake, measuring tapes and pegs. NPK fertilizer was applied at the rate of 0.0, 0.10, 0.13 and 0.15 kg/ha treatments. Six lowland rice genotypes, namely: (Swana sub 1, Faro 4, Faro 37, Faro 66, Faro 67 and Faro 44), were used for the experiment and it was laid out in a Randomized Complete Block Design (RCBD) in a manner following conventional methods. Each block will have four treatments: 0.0, 0.10, 0.13 and 0.15 kg/ha, replicated three times. The seeds were planted at 20 × 20 cm apart. Application of fertilizer was done 21 days after planting (DAP), while the second application of fertilizer was done at 51 DAP. Growth and yield parameters will be taken at the different growth stages such as:

Plant height (cm): measured from soil level to the tip of the flag leaf.

Tiller number: the number of tillers per genotype will be counted at 2, 4, 6, 8, 10 and 12 weeks after planting (WAP).

Number of tillers per plant: the number of tillers on each genotype will be counted at 2, 4, 6, 8, 10 and 12 weeks after planting (WAP).

Number of panicles/plant: The number of panicles will be counted for each of the selected plants and their mean will be calculated.

Number of grains/ panicles: Number of filled grains of five will be randomly selected panicles from each of the selected plants will be taken and their mean will be calculated.

Length of the panicle: Length of five selected panicles for each of the selected plants will be taken in cm and their mean will be calculated.

1000 seed weight: 100 seeds were counted for each genotype in each replication and then their weight will be taken in grams which will be multiplied by 10 and their mean will be calculated.

Data analysis

All data were subjected to analysis of variance and difference among mean will be separated using least significant difference at 5% level of probability using SAS (2010).

Results and discussion

Initial Soil physiochemical properties analysis

The result showed that the soil used for the field experiment is sandy loam texture, slightly acidic and low in total Nitrogen (N), low in available phosphorus (P) (Table 1). As a result of its low essential macronutrients, the soil can be regarded as poor soil for rice production.

Table 1. Initial soil physiochemical properties analysis.

Soil Parameter	Nutrient Status
PH (H_2O) 1:2	6.0
Organic matter (gkg-1)	1.26
Total Nitrogen 9gkg-1)	0.31
Available phosphorus	42.99
Exchangeable bases (Como/kg-1)	
K	0.15
Mg	0.60
Ca	1.20
Na	1.00
Exchangeable Acidity	2.2
CEC	5.15
Particle size (gkg-1)	
Sand	81.8
Silt	9.4
Clay	8.8
Textural	Sandy Loam

The total Nitrogen (Number of 0.31kg^{-1} of soil is less than the critical level of 1.5kg^{-1} (Enwezor *et al.,* 1998), while the available phosphorus (P) of 42.99mgkg^{-1} is less than the critical level of 8.10mgkg^{-1} (Agboola, 1982). The PH of 6.0 was moderate for rice production.

Effect of different levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NPK 15:15:15 on plant Height (cm) of rice at different sampling periods

The response of plant height of rice to the different levels applied is shown in Table 2. There were gradual increases in plant height of rice with age.

There were significant differences in plant height by the fertilizer levels applied. At two weeks after planting 0.15kg/had the highest plant height, followed by the plant that received 0.10kg while 0.0kg (control) had the lowest plant height. At 4 weeks after planting, the plant that received 0.13kg had the highest plant while the rest had similar plant height with the control. At 6 weeks after planting, the plant that received 0.15kg had the highest plant, followed by plant height that received 0.13kg while 0.0kg (control) had the lowest plant height. At 8 weeks after planting, the plant that received 0.10kg had the highest plant height, followed by the plant that received 0.15kg while 0.0 (control) had the lowest plant height. At 10 weeks after planting, the plant that received 0.13kg had the highest plant, followed by the plant that received 0.15kg while 0.0kg (control). This result showed that higher fertilizer levels increased the plant height of rice. This result agreed with an earlier study that stated that rice production could be increased with higher levels of fertilizer application, especially NPK (FAO, 2004).

Table 2. Interaction effect of different N. P. K. fertilizer levels and genotypes on plant height (cm) of rice.

N.P.K	Genotypes	Weeks after planting					
Fert. (kg)		2	4	6	8	10	12
0.0	Swana sub 1	12.98	25.00	38.58	52.33	70.22	96.60
	Faro 4	12.90	23.13	49.22	51.72	84.20	107.90
	Faro 37	12.70	24.64	33.57	48.55	67.45	80.50
	Faro 44	12.16	24.98	44.08	58.38	83.67	99.14
	Faro 66	13.45	24.38	35.52	50.00	71.61	92.33
	Faro 67	14.32	28.13	34.94	53.33	74.42	104.00
	Mean	13.08	25.51	35.99	52.55	76.93	98.30
0.10	Swana sub 1	24.27	35.02	44.26	66.00	76.22	94.78
	Faro 4	25.23	36.55	54.15	66.47	81.44	92.33
	Faro 37	15.50	29.15	47.27	56.15	45.89	55.44
	Faro 44	25.05	38.22	54.62	68.30	80.22	110.11
	Faro 66	24.12	35.55	57.01	68.70	109.00	133.44
	Faro 67	27.00	38.22	51.23	79.65	112.22	172.67
	Mean	25.14	37.12	56.43	69.21	84.17	109.79
0.13	Swana sub 1	25.13	36.33	66.50	78.33	88.44	115.89
	Faro 4	26.28	37.33	50.89	72.33	85.56	112.84
	Faro 37	16.55	37.81	57.55	70.11	84.11	94.55
	Faro 44	26.16	37.16	69.33	71.22	97.56	115.22
	Faro 66	25.24	36.16	50.33	78.50	111.22	129.67
	Faro 67	27.13	36.66	66.55	72.89	95.36	133.67
	Mean	26.08	37.57	61.86	75.56	88.70	113.68
0.15	Swana sub 1	23.16	35.16	55.00	35.83	80.67	120.67
	Faro 4	23.70	34.73	63.32	21.21	84.00	117.45
	Faro 37	22.88	24.05	42.66	28.67	72.17	84.11
	Faro 44	22.29	34.39	69.46	30.61	89.97	113.00
	Faro 66	23.60	34.77	63.00	30.89	94.44	102.22
	Faro 67	26.45	38.22	67.00	50.83	94.78	125.11
	Mean	23.61	35.22	67.07	33.00	51.93	101.25
Fertilizer		**	**	Ns	**	**	**
Genotypes		**	**	**	**	*	**
Fertilizer X genotypes		**	*	**	**	**	ns

Where ** = (P<0.01), * = (P<0.05) and ns = Not significant.

Effect of different levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NPK 15:15:15 on number of tillers at different sampling periods

The response of number of tillers to the different levels is shown in Table 3. There were gradual increases in number of tillers with plant age. There were no significant differences among the levels of applied as affected by the plant number of tillers. At 2 weeks after planting, all the levels had a similar number of tillers with the control. At 4 weeks after planting, the plant that received 0.10kg and 0.13 had the highest number of tillers followed by the plant that received 0.10 and 0.13 while 0.0 (control). At 6 weeks after planting, the plant that received 0.15 had the highest number of tillers followed by the plant that received 0.13kg while the plant that received

0.0kg had the lowest number of tillers. At 8 weeks after planting, the plant that received 0.15kg had the highest among the rest, followed by the plant that received 0.10kg while the plant that received 0.13kg had the lowest number of tillers. At 10 weeks after planting, the plant that received 0.15kg had the highest number of tillers followed by the plant that received 0.0 control and 0.13kg while the plant that received 0.10kg had the lowest number of tillers. This also agreed with an earlier study which stated that rice production could be increased with higher levels of fertilizer application, especially NPK (IITA, 2002).

Table 3. Interaction effect of different N.P.K fertilizer levels and genotypes on the number of tillers (%).

		Weeks after planting					
N.P.K Fert. (kg)	Genotypes	2	4	6	8	10	12
0.0	Swana sub 1	10.75	24.79	29.20	35.10	38.98	40.39
	Faro 4	15.20	22.00	23.30	28.60	33.52	35.41
	Faro 37	10.54	20.23	21.60	29.00	29.35	32.49
	Faro 44	19.64	23.68	26.70	31.10	34.71	34.46
	Faro 66	10.50	14.66	20.40	27.60	31.47	34.52
	Faro 67	10.94	25.49	27.50	29.20	36.80	36.00
	Mean	10.81	20.90	23.63	33.40	31.52	36.00
0.10	Swana sub 1	18.55	28.65	35.65	45.70	63.80	67.50
	Faro 4	19.00	25.22	25.22	47.30	68.70	61.60
	Faro 37	10.54	26.90	26.90	47.40	55.10	60.70
	Faro 44	20.78	28.83	28.83	49.70	56.80	72.90
	Faro 66	11.42	17.52	17.52	43.00	55.00	68.40
	Faro 67	11.58	21.58	21.58	40.90	56.70	60.00
	Mean	16.09	25.63	25.63	41.01	54.04	64.34
0.13	Swana sub 1	20.73	33.43	41.77	54.90	68.40	85.00
	Faro 4	15.50	28.52	36.30	54.60	61.20	73.80
	Faro 37	17.06	19.35	31.00	42.70	53.20	61.50
	Faro 44	25.94	29.71	34.08	50.60	66.00	72.60
	Faro 66	22.42	33.47	35.50	53.50	69.90	71.30
	Faro 67	25.58	35.95	32.20	59.10	66.60	76.40
	Mean	20.77	33.70	35.70	53.60	63.30	73.47
0.15	Swana sub 1	20.30	25.74	36.30	49.70	67.00	72.60
	Faro 4	23.00	29.06	31.20	39.70	65.30	77.20
	Faro 37	10.46	22.06	32.30	38.70	53.20	65.50
	Faro 44	20.54	27.74	35.40	47.00	56.70	71.80
	Faro 66	25.32	29.38	35.30	43.90	69.90	76.00
	Faro 67	23.00	25.16	31.30	42.20	61.70	74.00
	Mean	24.38	26.23	32.30	48.90	63.55	74.20
Fertilizer		**	**	**	**	**	**
Genotypes		**	**	Ns	Ns	**	ns
Fertilizer X genotypes		**	*	**	Ns	ns	*

Where ** = ($P<0.01$), * = ($P<0.05$) and ns = Not significant.

Effect of different levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NKP 15:15:15 on number of grain and panicle length (cm²) of rice at different sampling periods

Response of number of grain and panicle length to the different levels is shown in Table 4. There was gradual increase in number of grain and panicle length with plant age. There were significant differences among the levels applied as affected by the plant number of grain and panicle length. At 2 weeks after planting plant that received 0.15kg had the highest number of grain and panicle length followed by the plant that received 0.10kg while 0.0kg (control without fertilizer) had the lowest number of grain and panicle length.

At 4 weeks after planting, the plant that received 0.15kg had the highest number of grain and panicle length among all the levels applied.

Followed by the plant that received 0.13kg while the plant that received 0.10kg had the lowest number of grain and panicle length. At 6 weeks after planting, the plant that received 0.15kg had the highest number of grain and panicle length followed by the plant that received 0.10kg (NPK (Agbato, 2003).

Table 4. Effect of Different Levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NPK 15:15:15 on number of grain/plant and panicle length.

NPK Fert. (kg)	Genotypes	No. of grain/panicle	Panicle length
0.0	Swana sub 1	135.13	23.3
	Faro 4	105.33	24.9
	Faro 37	94.22	25.2
	Faro 44	124.38	25.0
	Faro 66	133.65	27.4
	Faro 67	140.00	29.5
	Mean	123.79	25.1
0.10	Swana sub 1	150.27	27.1
	Faro 4	140.55	26.5
	Faro 37	108.07	22.4
	Faro 44	148.81	28.3
	Faro 66	157.77	26.4
	Faro 67	130.66	29.9
	Mean	147.52	27.3
0.13	Swana sub 1	165.54	27.9
	Faro 4	151.11	27.5
	Faro 37	114.99	23.9
	Faro 44	138.44	27.8
	Faro 66	158.88	28.4
	Faro 67	162.66	25.1
	Mean	152.77	26.8
0.15	Swana sub 1	176.66	32.3
	Faro 4	168.45	36.9
	Faro 37	145.45	28.6
	Faro 44	186.43	38.4
	Faro 66	177.43	35.8
	Faro 67	173.99	77.3
	Mean	166.40	35.6
Fertilizer		**	**
Genotypes		**	ns
Fertilizer X genotypes		* (P<0.05)	**

Where ** = (P<0.01), * = (P<0.05) and ns = Not significant.

Effect of different levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NPK 15:15:15 on 1000 seeds weight (g), seed yield/plant (g), and seed yield m² g /plant of rice

Response of rice to the different levels of NPK fertilizer on 1000 seeds weight (g), seed yield/plant (g), and seed yield m² g /plant is shown in Table 5. There was a significant difference in 1000 seeds weight (g), seed yield/plant (g), and seed yield m² g /plant of rice among the levels applied. At fertilizer Level of 0.15kgїha had the highest mean value of fresh weight. At 0.15kg/ha had the highest mean value for 1000 seed weight of rice. This result agreed with an earlier study that stated that rice production could be increased with higher levels of fertilizer application, especially NPK (Kamai *et al.*, 2020).

Table 5. Interaction effect of different levels (0.0, 0.10, 0.13 and 0.15kg/ha) of NPK fertilizer on the grain yield of rice.

NPK Fert. (kg)	Genotypes	1000 seeds weight (g)	Seed yield/plant (g)	Seed yield m²/(g)
0.0	Swana sub 1	28.6	37.5	614.8
	Faro 4	23.8	21.6	422.3
	Faro 37	21.2	29.6	547.0
	Faro 44	23.0	23.4	448.2
	Faro 66	26.1	29.5	553.8
	Faro 67	24.8	23.1	417.4
	Mean	22.8	28.7	512.3
0.10	Swana sub 1	29.1	24.8	438.4
	Faro 4	27.5	28.3	526.2
	Faro 37	27.2	21.4	426.8
	Faro 44	28.7	20.8	384.6
	Faro 66	26.8	22.2	398.8
	Faro 67	29.8	20.7	395.7
	Mean	27.5	22.9	423.6
0.13	Swana sub 1	30.8	22.1	392.7
	Faro 4	29.6	23.1	420.5
	Faro 37	27.7	23.4	456.8
	Faro 44	29.9	20.0	406.3
	Faro 66	28.0	22.8	437.1
	Faro 67	29.5	21.4	416.4
	Mean	28.7	23.2	446.2
0.15	Swana sub 1	34.8	28.9	578.5
	Faro 4	28.0	24.1	466.2
	Faro 37	29.2	27.4	560.8
	Faro 44	36.7	28.6	549.5
	Faro 66	34.2	29.2	589.3
	Faro 67	30.5	27.2	519.5
	Mean	36.6	29.7	566.3
Fertilizer		**	Ns	**
Genotypes		**	**	**
Fertilizer X genotypes		* (P<0.05)	*	**

Where ** = (P<0.01), * = (P<0.05) and ns = Not significant.

Conclusion

The results of this study showed that NPK fertilizer use, significantly increased rice yield. However, the optimum rate was observed to be at 0.15kg/ha. Therefore for lowlands rice NPK fertilizer application, appropriate fertilizer management when practiced, can result in high rice grain yield of over 7000kg ha-1.

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