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Participatory Evaluation and Determination of N and P Fertilizer Application Rate on Yield and Yield Components of Upland Rice (NERICA-4) at Bambasi District, Benishangul-Gumuz Regional State

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Abstract

Declining soil fertility is one of the major problems causing yield reduction of rice in Benishangul Gumuz Regional state. Therefore, field experiments were carried out at Bambasi District Assosa Zone, to evaluate and determine the effects of N and P fertilizer rate application on growth, yield and yield components of upland rice. The fertilizer treatments considered in the study was consist of four levels of N (0, 46, 92 and 138 kg N ha^{-1}) and four levels of P (0, 23, 46, and 69 kg P_2O_5 ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications at Sonka FTC and on three farmers fields consisting of a total of 16 treatments (mother trial). The results of the study revealed that most of yield and yield components of rice were significantly (P<0.05) affected by the main effect of N on mother and baby trails. Except grain per panicle, straw and grain yield; other parameters are not affected by the main effect of P fertilizer rate application. The highest grain yield (3244 kg ha^{-1}) was recorded from 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} and the lowest grain yield (1415.6 kg ha^{-1}) was recorded from the control treatment. Partial budget analysis also indicated that the highest net return (28548 Birr ha^{-1}) was obtained from the application of 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} fertilizer rate. Thus, from the result of this study, it can be concluded that the application of 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} was found to be superior both agronomically and economically for rice NERICA-4 variety under main cropping season in the study area.

Keywords: N and P fertilizer; Grain yield; Partial budget analysis; Rice NERICA-4 variety

Introduction

The cultivation of rice in Ethiopia is of more recent history than its utilization as a food crop [1]. The cultivation of rice in Ethiopia was first started at the Fogera and Gambella plains in the early 1970s. Currently, the Fogera, Gambella, Metema, and Pawe plains located in the northern, northwestern, and western regions are developing into major rice-producing areas in Ethiopia [2]. Several research activities have been conducted at such rice producing areas. Benishangul Gumuz Regional State is one of the potential regions in Ethiopia with ample rainfall. It is estimated to be 4.9 million hectares of land is potential for rain fed rice production. About two million hectares is highly suitable and the rests are suitable and moderately suitable both for upland and low land rice ecosystems.

Rice production in Bambasi district was first realized by settler community through informal rice seed exchange from other regions. Following this, on station and on farm research activities were started a few years back under rain fed condition in other districts with similar environment of Assosa zone. Except the breeding, other research components like agronomic aspects of rice are found at infant stage. Across location, varietal selection research activities reveal that rice is a well adaptable commodity for the region because of long rainfall duration (MoA).

Rice research activity has been conducted in the region for the past few years and some promising varieties have been adopted. Among the released NERICA varieties, NERICA-4 had better yield advantage over the others under on-station and on-farm conditions (Assosa ARC, Completed activity Report). Yet, improvement of its production has not been possible due to low soil fertility and inadequate nutrient management among other factors [1]. Continuous cropping, high proportions of cereals in the cropping system, and the application of suboptimal levels of mineral fertilizers by farmers aggravates the situation in the area (MoA).

So far, efforts regarding the determination of optimum fertilizer level of upland rice in the area are minimal. The national blanket fertilizer recommendation for rice is 100 Urea and 100 DAP kg ha^{-1}. Among major plant nutrients, Nitrogen (N) and Phosphorus (P) are the most determinant nutrients available in Ethiopia as they are required in large quantity by the crop. However, there are no scientific findings for N and P fertilizer application rates for the area. These further imply the need for participatory evaluation and determination of optimum rate of N and P fertilizers for upland rice production and for the improvement of farmers knowledge and skills on optimum utilization of inputs i.e., most of the farmers use under optimum fertilizer rate application (50 kg DAP ha^{-1})

In order to solve the above-mentioned problems, FRG based research activity was conducted on Farmers Training Center (FTC) and farmers field condition in collaboration with relevant stake-holders to select and evaluate the best performing fertilizer rates. Thus, the present investigation was proposed with the objectives of evaluating the effects of applied N and P fertilizer rates on yield and yield components of upland rice (NERICA-4 variety) under Nitosol condition and to determine the optimum N and P fertilizer rates for upland rice in the area in terms of yield increase and economic return.

Material and Methods

Implementation site

A field experiment was conducted under rain fed conditions during the main rainy season. The site is located in Bambasi District at Sonka FTC and one FRG around Sonka FTC villages. The altitude ranges of the district are from 1300-1570 m.a.s.l. The Bambasi district receives an average annual rainfall of 1358 mm of which 1128.5 mm were received between May and October during the cropping season. The average yearly mean minimum and maximum temperatures are 14.5 and 28.8°C, respectively.

Treatments and design of the field

The fertilizer treatments considered in the study was consist of four levels of N (0, 46, 92 and138 kg N ha^{-1}) and four levels of P (0, 23, 46, and 69 kg P_2O_5 ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications at Sonka FTC and on three farmers field consisting of a total of 16 treatments (mother trial). The same set of the treatments was also conducted on three farmers' field (as replication) of FRG members. The field was oxen plowed two times before laying the experimental plots on the field. A 3 m × 3 m (9 m^2) plot size was used as an experimental plot. Sowing of NERICA-4 variety was on month of June made on farmers calendar by hand drilling the seeds at a rate of 60 kg ha^{-1} in rows spaced 20 cm apart. Nitrogen was applied in three equal splits, where is 1/3 of the N rate was applied basal at planting, 1/3 at beginning of tillering and the remaining 1/3 was applied at panicle initiation stage as urea (46% N). Unlike N, the total dose of P was applied basal as triple super phosphate (46% P_2O_5) during sowing.

Soil sampling and analysis

A composite soil samples was collected from the experimental plots in a diagonal pattern from the depth of 0-20 cm before planting. Uniform slices and volumes of soil were obtained in each sub-sample by the vertical insertion of an auger after which the sub-samples were made in to a composite soil sample. Then, the composite soil samples were dried, ground using a pestle and a mortar and allowed to pass through a 2 mm sieve and analyzed for the selected soil physico-chemical properties mainly organic carbon, total nitrogen, soil pH, available phosphorus, cation exchange capacity and Potassium using standard laboratory procedures.

Data collection and analysis

The whole agronomic parameters like date of emergence, date of heading, date of maturity, number of tiller per plant, plant height, panicle length, number of panicle per plant, number of effective tiller per plant, number of filled grain per panicle, number of unfilled grain per panicle, 1000 seed weight and yield per plot and kilogram per hectare were recorded. The whole trials have been harvested manually by FRG members and finally the grain was properly cleaned and weighed and the data collected from the treatments were analysed by the researchers using SAS. The partial budget analysis was done following the method described in CIMMYT [3].

Results and Discussion

Analysis of selected soil physico-chemical properties before planting

Analysis of soil physico-chemical properties before planting is presented in Table 1. The soil type of the trial sites of this study ranges from the very strongly acidic (pH 4.78) to strongly acidic (pH 5.42) class indicating the possibility of Al toxicity and deficiency of certain plant nutrients. The exchangeable K of the soil before the application of the treatments ranges from 0.192 to 0.91 Cmol (+) kg^{-1}. Except one location, all experimental soils had deficient to adequate K content.

Soil Parameters	Sonka Village	Village 46	Village 49	Sonka FTC
Available P (Bray II) (ppm)	3.72	3.4	3.4	3.2
Total N %	0.17	0.17	0.15	0.13
K (Cmol(+) kg-1)	0.91	0.42	0.192	0.216
CEC (Cmol(+) kg-1)	26.74	29.02	17.2	23.6
Organic carbon %	2.77	2.49	1.68	2.22
pH	5.42	5.22	4.78	5.25

Table 1: Some soil chemical characteristics of sample taken before planting.

According to Landon, available soil P level of less than 10 ppm is rated as low, 11-31 ppm as medium and greater than 18 mg kg^{-1} is rated as high. Thus, most trial location had very low to medium available P. Following the rating of total N of >1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and <0.1% as very low N status as indicated by Landon, All the experimental soils qualify for low total N. Similarly, the organic carbon (OC) content of the soil was also low in accordance with Landon, who categorized OC content as very low (<2%), low (2- 4%), medium (4-10%), high (10-20%).

Participatory fertilizer rate evaluation and selection criteria

Farmers have set their own selection criteria for different rate of fertilizer application for NERICA-4 rice variety as indicated in Table 2. Grain yield was proposed as very important selection criteria for the male and female farmers and also from yield components panicle length and tillering capacity were considered for their selection criteria. There were not any difference opinions between female and male farmers in criteria setup. The second important trait was disease resistance because they have awareness about the above or below optimal level of fertilizer rate application have a negative impact on rice. Farmers considered diseases resistance trait in relation to fertilizer rate of application as the second selection criteria due to the problem of brown spot and blast diseases occurrences on rice plants. The pathogen brown spot aggravated with low rate of fertilizer application while rice blast in contrary aggravated when the rate of fertilizer is applied above the optimum level. In order to control the two commonly occurred diseases, the agronomic practice such as maintaining the fertility status of the soil may have vital contribution for rice production and hence optimum rate of fertilizer application have to be considered for farmers as the second selection criteria. Panicle length was the third most important selection criteria for

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farmers as it was one of the yield component traits for the increment of yield. For plant height farmers, have given the last score because as the plant height increases the tendency to lodge increases and hence it has negative impact for rice yield increment.

Selection criteria	Grain yield	Plant height	Panicle length	Tillering capacity	Disease Resis.	Total score	Rank
Grain yield	-					4	1
Plant height	Grain yield	-				0	5
Panicle length	Grain yield	Panicle length	-			2	3
Tillering capa.	Grain yield	Tillering capacit.	Panicle length	-		1	4
Disease resists.	Grain yield	Disease resists.	Disease resist	Disease r	-	3	2

Table 2: Pairwise ranking of farmers' selection trait at Bambasi for fertilizer rate application of upland NERICA -4 rice variety at Bambasi district, 2014.

The direct matrix ranking for fertilizer rate application in Table 3 revealed that treatments 138-69 and 92-46 kg N-P_2O_5 ha^{-1} respectively ranked first based on farmers selection criteria and they did not differentiate between the two plots in regarding to the response for fertilizer application. Plot number 5 (138-0 kg N-P_2O_5 ha^{-1}) was the second most important farmers selection criteria and the least farmers preferences were plot number 3, 6 and 12 i.e., 0-23,0-46 and 0-0 N-P_2O_5 kg ha^{-1}, respectively.

Selection criteria	Relative weight	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12	Plot 13	Plot 14	Plot 15	Plot 16
Grain	3	12	9	6	12	15	6	9	15	9	12	15	6	12	9	9	9
Yield.		-4	-3	-2	-4	-5	-2	-3	-5	-3	-4	-5	-2	-4	-3	-3	-3
Plant Height.	2	10	8	6	10	10	6	8	10	8	10	10	6	10	8	8	8
		-5	-4	-3	-5	-5	-3	-4	-5	-4	-5	-5	-3	-5	-4	-4	-4
Panicle	3	12	9	6	12	15	6	9	15	9	12	15	6	12	9	9	9
Length.		-4	-3	-2	-4	-5	-2	-3	-5	-3	-4	-5	-2	-4	-3	-3	-3
Tillering	2	10	8	6	10	10	6	8	10	8	10	10	6	10	8	8	8
Capacity.		-5	-4	-3	-5	-5	-3	-4	-5	-4	-5	-5	-3	-5	-4	-4	-4
Disease Resistance.	3	15	12	12	12	12	12	15	15	15	12	15	12	12	12	12	12
		-5	-4	-4	-4	-4	-4	-5	-5	-5	-4	-5	-4	-4	-4	-4	-4
Total score		59	46	36	56	62	36	49	65	49	56	65	36	56	46	46	46
Rank		3	6	7	4	2	7	5	1	5	4	1	7	4	6	6	6

Table 3: Direct matrix ranking fertilizer rate application for upland NERICA-4 rice varieties by group of farmers at Bambasi district, 2014. Rating of performance of a variety for fertilizer rate application based on selection criteria: 5=excellent, 4=very good, 3=good, 2=poor and 1=very poor. Relative weight of a selection criteria: 3=Very important, 2=Important 1=less important, the numbers in the bracket is the result of farmers give to the selected criteria out of 5. Plot 1(92-0), Plot 2(46-46), Plot 3(0-23), Plot 4(138-23), Plot 5(138-0), Plot 6(0-46), Plot 7(46-0), Plot 8(138-69), Plot 9(0-69), Plot 10(92-69), Plot 11(92-46), Plot 12(0-0), Plot 13(92-23), Plot 14(46-69), Plot 15(138-46) and Plot 16(46-23).

In pairwise ranking of farmers selection criteria plot number 8 (138-69 kg N-P_2O_5 ha^{-1}) was the first farmers preference due to its best performance for a given amount of fertilizes application. The second farmers' preference plot was plot number 11 (92-46 kg N-P_2O_5 ha^{-1}) and the least was plot number 3(0-23 kg N-P_2O_5 ha^{-1}). For the rate of fertilizer application through overall direct and pairwise preference ranking methods plot number 8 was among the best preferred plots while plot number 3 was the least farmers preference (Table 3).

Effect of N and P fertilizer rates on yield and yield components upland rice (NERICA-4)

The analysis of variance showed that there was a significant ($P<0.05$) main effect of nitrogen and phosphorus fertilizer rates on growth, yield and yield components upland rice such as number of fertile tiller, plant height, 1000 seed weight, number of filled grains and grain per panicle of rice on mother. However, on the baby trial number of tillers, panicles, grains per panicle, straw and grain yield of rice was significantly different due the application of N fertilizer. Number of grain per panicle on mother and baby trial; number of fertile tiller per plant on mother trail; straw and grain yield on baby trail had significant difference higher with the P fertilizer application. On the other hand; Panicle length, straw and grain yield on mother trail and panicle length and plant height on baby trail were significantly(P<0.05) affected by the main effects of N and P fertilizer rates as well as by their interaction (Tables 4-6).

Treatments	NTm^{-2}	NPm^{-2}	PH	GPP	NUFG	NFG	ETPP	TGW
Nitrogen (kg ha^{-1})								
0	144.85	94.1a	68.7b	140.0b	23.8a	116.18b	3.07ab	25.47ab
46	136.61	79.3ab	69.2b	144.7b	17.7ab	128.65ab	3.23a	27.30a
92	133.02	68.5b	74.2ab	151.1ab	16.4b	133.82a	2.70b	27.11a
138	120.15	83.7ab	79.1a	162.2a	20.0ab	142.12a	3.27a	24.94b
LSD (5%)	Ns	16.4	5.86	15.82	6.25	15.6	0.49	2.08
Phosphorus (P_2O_5) (kg ha^{-1})								
0	140	85.5	70.9	138.2b	17.3	122.5b	2.98	26.44
23	134.3	78.2	72.1	147.4ab	17.9	129.4ab	3.3	26.24
46	132	86.1	76	161.9a	21.1	139.9a	2.92	25.79
69	128.3	75.7	72.2	150.5ab	21.6	128.8ab	3.07	26.34
LSD (5%)	Ns	Ns	Ns	15.82	Ns	15.6	Ns	Ns
CV (%)	20.3	24.2	9.7	12.7	4.6	14.4	19.3	9.5

Table 4: Effect of N and P rates on yield and yield components of Upland rice (NERICA-4) in 2012-2014 cropping season at sonka FTC. Ns=Non significant at P (0.05). NTm^{-2}=Number of tiller per square meter, NPm^{-2}=Number of panicle per square meter, PH=Plant height (cm), GPP=Grain per panicle, NUFP=Number of unfilled grain per panicle, NFGPP=Number of filled grains per panicle, ETPP=Effective Tiller per plant, TGW=Thousand grain weight (g).

Treatments	NTm^{-2}	NPm^{-2}	GPP	NUFG	ETPP	TGW	SY	GY
Nitrogen (kg/ha)								
0	194.2c	143.2c	111.7b	20.6b	5.32	23.08	4544.8c	1399.4b
46	231.8b	170.6b	112.9b	14.3c	5.65	24.5	5546.3b	2274.1a
92	248.1b	185.8b	126.7ab	27.9ab	5.58	25.26	6220.7ab	2479.0a
138	289.7a	214.6a	130.2a	34.0a	5.95	23.23	7002.1a	2510.8a
LSD (5%)	25.29	21.34	15	9.04	Ns	Ns	993	443.23
Phosphorus (P_2O_5in kg ha^{-1})								
0	230.9ab	167.8b	108.6b	22.47	5.17	24.07	4978.3b	1754.5b
23	251.2ab	183.9ab	119.9ab	21.67	5.18	23.23	5979.4a	2159.1ab
46	226.9b	172.4ab	123.2ab	25.33	5.43	24.22	5923.6a	2398.0a
69	254.7a	189.9a	129.8a	27.37	6.72	24.55	6432.6a	2351.8a
LSD (5%)	Ns	Ns	15	Ns	Ns	Ns	993	443.23
CV (%)	12.59	14.34	14.95	44.81	35.15	13.4	29.7	24.55

Table 5: Effect of N and P rates on yield and yield components of Upland rice (NERICA-4) on Baby trail Bambasi district, 2012-2014. Ns=Non significant at P (5%). NTm^{-2}=Number of tiller per square meter, NPm^{-2}=Number of panicle per square meter, GPP=Grain per panicle,

NUFP=Number of unfilled grain per panicle, NTPP=Number of tiller per plant, ETPP=Effective tiller per plant, TGW=Thousand grain weight (g), SY= Straw yield (kg ha^{-1}) and GY=Grain yield (kg ha^{-1}).

Nitrogen rates (kg ha^{-1})	Phosphorus rates (P_2O_5 in kg ha^{-1})	Mother trail (FTC)			Baby trail	
		Panicle Length(cm)	Straw Yield (kg ha^{-1})	Grain Yield (kg ha^{-1})	Panicle Length(cm)	Plant height (cm)
0	0	13.6d	6333.5b	1415.6f	19.6abc	58.3g
	23	14.8cd	7926.0b	1861.3de	19.1abcd	67.5def
	46	17.7bc	8259.5ab	2117.3cde	17.4cd	65.4efd
	69	18.9ab	9518.5ab	2160.7bcde	18.6bcd	67.4def
46	0	17.5bc	10111.0ab	2245.6bcd	18.1bcd	61.3fg
	23	18.0bc	10537.0ab	2312.0bc	17.9bcd	73.7cde
	46	18.5ab	8000.0b	2231.9bcd	16.9d	72.8cde
	69	17.8bc	7389.0b	2130.4cde	19.6abc	71.3cde
92	0	19.4ab	11203.5ab	1790.0ef	17.7bcd	70.5cde
	23	17.9bc	7463.0b	2151.1bcde	17.5cd	73.1cde
	46	21.9a	15524.0a	3244.0a	21.5a	85.0ab
	69	18.1bc	8092.0ab	2503bc	18.4bcd	78.5bc
138	0	18.5ab	11944.5ab	2521.8b	19.9abc	71.7cde
	23	17.9bc	12944.5ab	2443.7bc	18.4bcd	75.1cd
	46	20.1ab	12240.5ab	2125.7cde	20.3ab	74.1cde
	69	18.7ab	12074ab	2357.0bc	17.8bcd	87.3a
LSD (5%)		3.47	4098.6	214.21	2.65	8.71
CV (%)		11.4	24.6	5.77	8.48	7.24

Table 6: Interaction effect of Nitrogen and Phosphorus rate application on yield and yield components of Upland rice (NERICA - 4) at Bambasi District, 2012 - 2014.

Plant height

Plant height responded highly significantly to the increasing application levels of N fertilizers eects. Increasing the levels of N up to 138 kg ha^{-1} increased rice plant height significantly ($P \le 0.01$) from 68.7 cm in the control to 79.1 cm with the application of 138 kg N ha^{-1} While; plant height didn't significantly affect by applied P fertilizer in mother trail (Table 4).The promotion of rice plant height in the present study due to applications of N fertilizers is apparent as N is essential for plant growth since it is a constituent of all proteins and nucleic acids. Similar results reported by Halima et al. [4].

The interaction effect of N and P on rice plant height on baby trail was presented in Table 5. The longest rice plant height was obtained for 92 N kg ha^{-1} with the rate of 46 kg P_2O_5 ha^{-1} and 138 N kg ha^{-1} with the rate of 69 kg P_2O_5 ha^{-1}. The shortest (58.3 cm) was recorded form the control plots. The promotion of rice plant height in the present study due to applications of N and P is apparent as N is an essential nutrient for plant growth since it is a constituent of all proteins and nucleic acids, whereas P is essential for production and transfer of energy in plants. Bahmanyar and Mashaee [5] have also observed that rice plant height was enhanced by combined N and P applications.

Straw yield

Increasing the levels of applied N increased straw yield of rice significantly ($P \le 0.01$) up to 138 kg N ha^{-1} on baby trial. Generally, straw yield increased from 4544.8 kg ha^{-1} in the control (no N) treatment to 7002.1 kg ha^{-1} with application of 138 kg N ha^{-1} (Table 5). Increasing the levels of applied P also increased straw yield of rice significantly ($P \le 0.05$) up to 69 kg P_2O_5 ha^{-1}. However, the response in straw yield obtained at all fertilized plots was at par ($P \le 0.05$). The results of the present study are in agreement with the findings of Zaman et al. [6] also reported that increasing rates of P and N increased dry matter accumulation as a result of increased vegetative growth favored by enhanced nutrient uptake by rice plants.

Straw yield was significantly affected by interaction effects of N and P fertilizer rate applications on mother trail (Table 6). Significantly maximum straw yield (15524 kg ha^{-1}) was obtained for 92 N kg ha^{-1} with the rate of 46 kg P_2O_5 ha^{-1}, while the minimum (6333.5 kg ha^{-1})

was recorded form the control plots. The increase in straw yield due to application of increasing rates of N and P fertilizer is apparently attributed to its eect in enhancing vigorous vegetative growth of the rice plant. There was also due to the fact that both nutrients are involved in vital plant functions and contribute to enhance the vegetative growth in the plant. These findings are in line with those reported by and Hasanuzzaman et al. [7].

Grain yield

Nitrogen had a marked eect on grain yield of rice. Grain yield of rice significantly increased ($P \leq 0.05$) from 1399.4 to 2510.8 kg ha^{-1} with an increase in the level of N from the control (no N) to 138 kg N ha^{-1} on baby trail (Table 5). There was no significant difference observed between 92 and 138 kg N ha^{-1} (Table 5). This could mainly be attributed to the increase in the number of panicles per m^2 and total number of grains per panicle. On the other hand, increasing panicle length and plant height might have increased grain yield of rice indirectly by increasing the number of grains per panicle and panicle length, respectively. Uddin et al. [8] reported that the increase in grain yield for application of N is mainly due to improvement in yield components such as number of effective tillers. Behera [9] reported that improvements in grain yields attributed to increments in yield components. Increases in yield components are associated with better nutrition, plant growth and increased nutrient uptake [10]. The magnitude of increase in grain yield over the control due to application of 92 and 138 kg of N ha^{-1} were 77.2% (1079.6 kg ha^{-1}) and 79.4% (1110.6 kg ha^{-1}), respectively. The same result was reported by Halima et al. [4] and Bekele & Getahun [11].

Application of phosphorus fertilizer had also significantly ($P \leq 0.05$) increased the grain yield of rice up to the applied level of 46 kg P_2O_5 ha^{-1} on baby trail (Table 5). However, the response of grain yield obtained at 46 kg P_2O_5 ha^{-1} did not show significant dierences compared with application of 69 kg P_2O_5 ha^{-1}. The magnitudes of increase in rice grain yield over the control due to application of 46 kg and 69 kg P_2O_5 ha^{-1} were 36.7% and 34%. In line with applied N, application of P increased rice grain yield through its eects on major yield attributes such as number of panicles per m-2 and grains per panicle. Zaman et al. [6] also reported similar response in rice yield and yield components to increasing rates of applied P fertilizer. Increase in the magnitude of yield attributes is associated with better root growth and increased uptake of nutrients favoring better growth of the crop [1]. Increasing the level of phosphorus fertilizer was reported to increase grain yield of rice and higher yields due to higher level of phosphorus are results of better root growth and increased uptake of other nutrients favoring better crop growth [12]. Phosphorus application has also improved 1000-grain weight, panicle length and plant height thereby indirectly contributing to increment in grain yield. Successive increase in the levels of P beyond 46 kg P_2O_5 ha^{-1} application showed reduction of grain yield (Table 5 and 6). Zaman et al. [6] also reported similar trends in rice with higher doses of P fertilization. At higher doses of P, reduction of grain yield was caused mainly by the successive reduction in the number of filled grains per panicle and 1000-grain weight of rice.

The interaction eect of applied N and P fertilizer levels on grain yield was significant ($P \leq 0.05$) on mother trail. The highest mean grain yield 3244 kg ha^{-1} was obtained with the applications of 92 kg N ha^{-1} and 46 kg P_2O_5 ha^{-1}, representing an increase of 129.3% (1828 kg ha^{-1}) over the control treatment on mother trial. Heluf and Mulugeta [1] and Kisetu et al. [13] has also observed enhanced rice grain yield due to N and P fertilization.

Partial budget analysis

The partial budget analysis was done following the method described in CIMMYT [3]. The result of the partial budget analysis for N and P fertilizer rate application has been presented in Table 7. The results of the partial budget analysis showed that the highest net return (28548 Birr ha^{-1}) was obtained from 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} while the lowest net economic return was obtained from the control treatment (no fertilizer) (10832.2 Birr ha^{-1}). Thus, planting rice 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} resulted in 71.8% surplus income from grain sale compared to adopting blanket fertilizer (46 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1}) recommended by Ministry of Agriculture. Thus, 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha^{-1} fertilizer rate application are the most economical fertilizer rates to rice growers compared to the other levels.

Treatment Combination (kg N-P_2O_5 ha^{-1})	Total variable cost (ETB)	Adjusted Yield (kg/ha)		Gross benefit (ETB)	Net benefit (ETB)	Value to cost ratio	Marginal rate of return (%)
		Grain Yield (Paddy Rice)	Straw Yield				
0-0	5075	1019.2	6333.5	15907.2	10832.2	2.1	0
0-23	6012.5	1340.1	7926	20714.7	14702.2	2.4	412.8
0-46	6950	1524.5	8259.5	23185.5	16235.5D	2.3	-
0-69	7887.5	1555.7	9518.5	24205.6	16318.1D	2.1	-
46-0	6560	1616.8	10111	25265.9	18705.9	2.9	225.2
46-23	6742.5	1664.6	10537	26076.5	19334	2.9	344.2
46-46	7425	1607	8000	24087.1	16662.1D	2.2	-
46-69	8107.5	1533.9	7389	22868.1	14760.6D	1.8	-
92-0	7045	1288.8	11203.5	21711.8	14666.8D	2.1	-

92-23	7727.5	1548.8	7463	23091.4	15363.9	2	-
92-46	8410	2335.7	15524	36958	28548	3.4	552.6
92-69	9092.5	1802.2	8092.5	26573.3	17480.7D	1.9	-
138-0	9015	1815.7	11944.5	28668.5	19653.5D	2.2	-
138-23	9697.5	1759.5	12944.5	28465.6	18768.1D	1.9	-
138-46	10380	1530.5	12240.5	25251.6	14871.6D	1.4	-
138-69	10614.5	1697	12074	27250	16635.5D	1.6	-

Table 7: Partial Budget Analysis of N and P fertilizer application rates on rice at Bambasi district, 2014.

Conclusion

In this Experiment, the combination nitrogen and phosphorus fertilizer rate application was increased yield and yield parameters of rice. Accordingly, FRG based research approach that was held at Farmer training center (FTC) played a vital contribution to strengthen the capacity of FTC. This situation was important for technology generation and dissemination to farmers. Thus, it can be recommended that 92 kg N ha^{-1} combined with 46 kg P_2O_5 ha-1 fertilizer rate application was agronomically and economically profitable for rice variety NERICA-4 production. Hence, farmers in the area might be advised to use the optimum fertilizer rate to increase the productivity of rice crop.

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References

1. Heluf G, Mulugeta S (2006) Effects of Mineral N and P Fertilizers on Yield and Yield components of flooded lowland rice on vertisols of Fogera Plain, Ethiopia. Journal of Agriculture and Rural Development in the Tropics and subtropics. 107: 161-176.
2. Mulugeta S (1999) Rice: Potential crop for food security in Amhara Region. The quarterly newsletter of Ethiopian Agricultural Research Organization 14: 1-2.
3. CIMMYT (1988) Farm Agronomic to farmers recommendation. An Economic Training Manual. Completely revised edition, DF Mexico, p: 51.
4. Halima RM, Jerome PM, Balthazar MM (2017) Response of Rice to Nitrogen and Phosphorus Applied on Typical Soils of Dakawa Irrigation Scheme, Morogoro, Tanzania.
5. Bahmanyar MA, Mashaee SS (2010) Influences of nitrogen and potassium top dressing on yield and yield components as well as their accumulation in rice (Oryza sativa). African Jornal of Biotechnology 9: 2648-2653.
6. Zaman SK, Razzque MA, Karim SMR, Bhuiyan NI (1995) Rice response to phosphorus in wetland soil. Pakistan J Sci 38: 11-12.
7. Hasanuzzaman M, Nahar K, Alam MM, Hossain MZ, Islam MR (2009) Response of transplanted rice to different application methods of urea fertilizer. International Journal of Sustainable Agriculture 1: 1-5.
8. Uddin S, Sarkar MAR, Rahma MM (2013) Effect of nitrogen and potassium on yield of dry direct seeded rice cv. NERICA-1 in aus season. International Journal of Agrononomy Plant Production 4: 69-75.
9. Behera AK (1998) Response of scented rice (Oryza sativa) to nitrogen under transplanted condition. Indian J Agron 43: 64-67.
10. Sewenet A (2005) Effects of nitrogen and seed rates on grain yield and yield components and nitrogen uptake of rainfed rice (Oryza sativa L) in Fogera, South Gonder. M Sc Thesis, Alemaya University, Ethiopia.
11. Bekele AF, Getahun DW (2016) Influence of Phosphorous and Nitrogen Fertilizer Rate on Grain Yield of Rice at Kamashi Zone of Benishangul Gumuz Region, Ethiopia. Journal of World Economic Research. 5: 8-14.
12. Tanaka K (1995) Physiology of Ripening: The Science of the Rice Plant. Food and Agriculture Policy Center. Tokyo 2: 97-118.
13. Kisetu E, Kasian J, Mtakimwa ZS (2013) Determination of urea-N levels application to Nerica-4 cultivar of rice (Oryza sativa L.) grown on soils of Dakawa Morogoro, Tanzania, Access International Journal of Agricultural Sciences, pp: 73-80.