

Influence of Phosphorous and Nitrogen Fertilizer Rate on Grain Yield of Rice at Kamashi Zone of Benshal-gul Gumuz Region, Ethiopia

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To cite this article:

Bekele Anbessa Fayisa, Getahun Dereje Welbira. Influence of Phosphorous and Nitrogen Fertilizer Rate on Grain Yield of Rice at Kamashi Zone of Benshal-gul Gumuz Region, Ethiopia. *Journal of World Economic Research*. Vol. 5, No. 2, 2016, pp. 8-14.

doi: 10.11648/j.jwer.20160502.11

Received: May 24, 2016; Accepted: June 13, 2016; Published: June 21, 2016

Abstract: The scientific information available with regards to the response of upland rice to N and P fertilizers for its optimum production on nitosols of Kamashi zone is very limited. Therefore, a field experiment was conducted on nitosols of Kamashi, western Ethiopia to study the yield and yield components response of rice and to establish the optimum N and P fertilizer levels required for improved grain yield of upland rice. Field experiments were conducted at Kamashi locations, for two years at this location, to investigate the response of rice N and P fertilization. Four levels of N (0, 46, 92, 138 kg ha⁻¹) and four levels of P (0, 10, 20 and 30 kg ha⁻¹) were studied in factorial combinations in a randomized complete block design with triplicates. The results revealed substantial responses of rice to the main factors of N and P fertilization on grain yield, No. of panicle/m², No. of tiller/plant, No of tiller/m², and plant height. Rice grain yield, No. of panicle/m², No. of tiller/plant, No of tiller/m², and plant height increased significantly with increasing level of P and N (P < 0.001). The effects of N by P interaction were non-significant (P ≤ 0.05) among the different yield and yield components studied except panicle length (p < 0.05) and straw yield (P < 0.01). Mean grain yield was significantly (P < 0.001) enhanced by 16.2% with the application of 10 kg P ha⁻¹, 23.6% with application 20 kg P ha⁻¹ and 34.6 with the application of 30 kg P ha⁻¹ over zero-P (Table 2). High N at 138 kg ha⁻¹ significantly (P < 0.001) increased the yield of rice by 47.2%, while 92 kg N ha⁻¹ increased it by 36.2%, and 46 kg N ha⁻¹ increased the yield by 32.5% compared to 0 kg N ha⁻¹. There was no significant difference in grain yield between 46, 92 and 138 kg N ha⁻¹. The magnitude of increase in grain yield over the control due to application of 46 N and 10 P kg ha⁻¹ were 32.5% and 16.2% higher over the control respectively. The partial budget analysis also indicated economic benefit for finger millet when it is fertilized with 46 N and 10 P kg ha⁻¹.

Keywords: Rice (*Oryza Sativa* L.), Fertilizers, Grain Yield, Nitrogen, Phosphorous

1. Background

The demand for rice far exceeds the production which in the last 30 years in Sub-Saharan Africa (SSA) has increased by 70% due mainly to land expansion and only 30% due to increase in productivity [10]. This increase in production, not withstanding, rice production has not kept pace with the demand as a result of rapid population growth. Grain yield as in most developing countries is as low as 0.5 mg ha⁻¹ [3]. The low productivity arises from the use of low yielding varieties,

pest and disease problems, inherently low soil fertility, and poor nutrient supply.

The cultivation of rice in Ethiopia is of more recent history than its utilization as a food crop. Some evidences indicate that 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 in to major rice-producing areas in Ethiopia [7]. At the Fogera plain, rice plays an important role in relaxing the problem of food-insecurity of the farming community.

Benishangul-Gumuz Regional State (BGRS) is one of the potential regions in Ethiopia with ample rainfall i.e. for six months and conducive environment which are suitable for rice production. It is estimated to be 4.9 million hectare of land is potential for rain fed rice production [22]. About two million hectare is highly suitable and the rests are suitable and moderately suitable both for upland and low land rice ecosystems.

Rice production in Kemashi zone 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 similar weredas 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). The Agro ecology allows for several crops production and rice can be the main demand driven item for the areas.

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 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 [2]. 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). 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 (fertilizers).

Therefore, the objective of the study was to determine the optimum of rate N and P fertilizer for upland rice (NERICA-4) in the area in terms of yield increase and economic return and for evaluate the effects of applied N and P fertilizer rates on yield and yield components of upland rice (NERICA-4 variety) under Nitosol condition.

2. Materials and Methods

2.1. Location and Time of Study

A field experiment was conducted under rain fed conditions during the main rainy season (June to October) of 2014 and 2015 to investigate the effects of N and P fertilizers on grain yield and yield components of upland rice under research fields on nitosols of the Kamashi zone. Kamashi *Wereda* is one of the 5 *Weredas* found in Kamashi Zone with is capital also known as Kamashi town located at 560 km west of Addis Ababa and 246 km to the south east of Assosa. Its altitude ranges from 1000 to 1350 m.a.s.l. with annual rainfall of 900 to 1400mm. The temperature ranges from

20°C to 30°C. The *Wereda* has a total area of 1595 km² of which 71910 ha is cultivable land, 39950ha is forest land, 11186 ha is grazing land, 31960 ha is unusable land and the remaining 4794 ha is under construction for road, house, town etc. Agriculture is the main occupation and livelihood source of the area. Crop production is characterized by hoe based shifting cultivation with little oxen plow. The major crops grown are sorghum and maize mainly for home consumption while sesame and ground nut are grown for cash. Small ruminants, donkey, poultry and honey bee are the most important livestock species raised. There is huge coverage of forest resources which is composed of various tree species dominated by bamboo.

2.2. Experimental Treatments, Design, and Procedures

The fertilizer treatments considered in the study consisted of four levels of N (0, 46, 92, and 138 kg N ha⁻¹) and four levels of P (0, 10, 20 and 30 kg Pha⁻¹) and their complete factorial combinations. The experiment was then conducted using a factorial experiment laid out in a randomized complete block design with three replications consisting of a total of 16 treatments and 48 total plot per three replication or 16 plots per one replication. A 3m × 4m (12m²) plot size was used as an experimental unit. A composite soil sample (0-30cm) was collected from the site for laboratory analysis before land preparation. The blocks were separated by a 1.5 m wide open space where as the plots within a block were separated by a 0.75 m wide space. Soil bunds were constructed around each plot and around the entire experimental field to minimize nutrient and water movement from plot to plot. Planting was made on 20 June 2014 to 2015 by hand drilling the seeds at a rate of 65kg ha⁻¹ in rows spaced 30 cm apart. Nitrogen was applied in two equal splits, where in 50% of the N rate was applied basal at planting and the remaining half was top dressed at the maximum tillering stage which occurred 35-45 days after germination, as urea (46% N). Unlike N, the total dose of P was applied basal as triple super phosphate (20% P) during sowing. Weed control was manual mainly by hand picking. Crop growth was then monitored until harvest. Due to the frequent prevalence of vigorous growth and high infestation of weeds, the field was hand weeded four times at 20, 35, 50, 65 and 90 days after sowing.

2.3. Yield and Agronomic 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, and yield per plot and kilogram per hectare were recorded. Number of tillers was counted after maximum tiller formation stage and mean number of tillers determined while plant height was measured at harvest. At maturity, an area of 1m² excluding border rows was measured out in each plot, number of panicles counted and harvested. Grain and Stover yield were measured and yield per hectare estimated. Panicles were also

collected from non-border rows and mean individual weight per panicle determined. The whole trials have been harvested manually by collaboration of researchers, technical assistance and daily laborers and finally the seeds was properly cleaned and weighed and the data collected from the treatments were analyzed by STATISTIX 8.

2.4. Economic Data Collection and Analysis

Economic analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). A partial budget, dominance and marginal analysis were used. The average yield was adjusted downwards to reflect the difference between the experimental plot yield. The average open market price (Birr kg⁻¹) for rice and the official prices of N and P fertilizers were used for analysis

3. Results

3.1. Soil Physico-chemical Properties Before Sowing

Nitrosol is the major soil types found in all Weredas of Kamashi zone. This soil type occurs in high rainfall areas on flat to slopping terrains. It is dark reddish brown to dark red in color with deeply developed clay alleviation horizon of high structural stability. Nitrosols are well drained, porous with high water holding capacity. The texture of these soils is clay-to-clay loam with moderate organic matter content and relatively easily weathering minerals. The soil used for this study ranges from very moderate acidic (pH 5.46) to the slightly acidic (pH 5.71) 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 0.46 cmol (+) kg⁻¹ to 0.51 cmol (+) kg⁻¹. All experimental soils had adequate K content. According to Landon (1991), available (Bray II extractable) 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, both trial year had low to medium (bray II extractable) P (Table 1). 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 (1991), the experimental soils qualify for low total N. Similarly, the organic carbon (OC) content of the soil was also very low to low in accordance with Landon (1991), who categorized OC content as very low (< 2%), low (2-4%), medium (4-10%), high (10-20%). The very low OC and low N content in the study area indicate low fertility status of the soil. This could be due to continuous cultivation and lack of incorporation of organic materials. (Table 1)

Table 1. Chemical analysis of some parameters of soil prior to cropping.

Year	depth	PH	%OC	%N	ppmP	Meq. K/100g	Meq. CEC/100g
2014	0-30cm	5.71	1.476	0.11	10.8	0.51	22.6
2015	0-30cm	5.46	1.870	0.17	9.8	0.46	23.2

3.2. Influence of Year, Phosphorus and Nitrogen on Yield and Yield Components of Upland of Rice

Year had highly significant ($P < 0.01$) influence on all grain yield and yield components measured. The main effects of phosphorus was also highly significant ($P < 0.01$) on yield and yield components measured, except number of panicle per m², number of tiller per plant and panicle length. Nitrogen had highly significant ($P < 0.01$) effects on all parameters measured, except panicle length (Table 1). Year had a significant influence on nitrogen as there was a significant year \times nitrogen interaction on grain yield ($P < 0.05$), number of tiller per plant ($P < 0.05$), number of tiller per m² ($p < 0.01$) and straw yield ($P < 0.001$) (Table 1 & 3). The mean squares due to N \times P interactions were significant only for panicle length ($p < 0.05$) and straw yield ($p < 0.01$).

Table 2. Analysis of variance for yield and yield components of rice on nitrosol of Kamashi at Benshal-gul Gumuz Regional State.

Source of variation	Mean squares	Df	Grain yield	No. of panicle/m ²	No. of tiller/plant	No. of tiller/m ²	Plant height	Panicle length	Straw yield
N	1.479 ***	3	12785**	5.0228**	5833**	466.05 ***	0.914 NS	61.088***	
P	8946895***	3	1748 ^{NS}	1.080 ^{NS}	1579 ^{NS}	87.86**	3.12 ^{NS}	28.595***	
Year	1.224 **	1	475314***	13.60***	405601***	3542.94***	242.88***	660.76***	
N*P	2129549 ^{NS}	9	1084 ^{NS}	0.550 ^{NS}	1829 ^{NS}	10.76 ^{NS}	2.708*	9.500 **	
N*Year	1453087*	3	2412 ^{NS}	1.7828*	4257**	270.31 ***	0.775 *	29.487***	
P*Year	1453087 ^{NS}	3	112 ^{NS}	0.423 ^{NS}	607 ^{NS}	9.45 ^{NS}	0.628 ^{NS}	2.648 ^{NS}	
N*P*year	782659 ^{NS}	6	466 ^{NS}	1.857 ^{NS}	1257 ^{NS}	13.45 ^{NS}	1.854 NS	6.458 ^{NS}	
Errors	1449946	62	1141	1.4029	1612	22.45	1.532	3.832	

ns-non significant. *, **, *** indicate significant difference at probability levels of 5%, 1% and 0.1% respectively.

3.2.1. Influence of Year, Phosphorus and Nitrogen on Yield of Upland Rice

Analysis of variance for two factors randomized complete block design (Table 2) revealed highly significant difference ($P < 0.001$) due to the main effects of the levels of N and P application for the means of yield. However the mean squares due to N \times P interactions were non-significant

difference for the yield of upland rice. Mean grain yield was significantly ($P < 0.001$) enhanced by 16.2% with the application of 10 kg P ha⁻¹, 23.6% with application 20 kg P ha⁻¹ and 34.6 with the application of 30 kg P ha⁻¹ over zero-P (Table 2). There was no significant difference observed between 20 and 30 kg P ha⁻¹ (Table 2). Thus, the results of this investigation finding was disagreement with the works of

[9] who reported that at higher levels of applied P, grain yield increased marginally or decreased due to the reduction in the number of filled spikelet and 1000 grain weight, particularly in soils with high soil test values of available P. Application of P slightly increased grain yield (Table 2). The highest grain yield of 5660 kg ha⁻¹ was recorded at the highest P rate of 30 Kg ha⁻¹ and it was at par with P rate of 20 Kg ha⁻¹. The lowest grain yield of 4205 kg ha⁻¹ was recorded in P rate of 0 Kg ha⁻¹. [6] reported that phosphorus deficiency in small grains is usually expressed as stunted growth.

Also, the yield of rice was significantly ($P < 0.001$) influenced by N rates. High N at 138 kg ha⁻¹ significantly ($P < 0.001$) increased the yield of rice by 47.2%, while 92 kg N ha⁻¹ increased it by 36.2%, and 46 kg N ha⁻¹ increased the yield by 32.5% compared to 0 kg N ha⁻¹ (Table 2). There was no significant difference in grain yield between 46, 92 and 138 kg N ha⁻¹.

The same is true for nitrogen treatment application at kamashi zone of Benshal-gul gumuz. Application of N slightly increased grain yield (Table 2). The highest grain yield of 5692 kg ha⁻¹ was recorded at the highest nitrogen

rate of 138 Kg ha⁻¹ and it was at par with nitrogen rate of 46 Kg ha⁻¹. The lowest grain yield of 3867 kg ha⁻¹ was recorded in nitrogen rate of 0 Kg ha⁻¹.

In line with applied N, application of P increased rice grain yield through its effects on major yield attributes such as number of panicles per m² and spikelets per panicle. [12] 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 [4]. Phosphorus application has also improved number of panicles per m², panicle length and plant height thereby indirectly contributing to increment in grain yield.

Year had a significant influence on nitrogen as there was a significant ($p < 0.05$) year × nitrogen interaction on grain yield of rice (Table 1 & 3). The significant ($P < 0.05$) year × nitrogen rate interaction on grain yield showed that rice had higher grain yield in 2014 (6934.7 kg ha⁻¹) than in 2015 (4450.9 kg ha⁻¹) (Table 3). However, year × phosphorous interaction on grain yield showed that non-significant ($P > 0.05$) difference by application of the treatments (Table 1).

Table 3. Yield and yield components of rice as influenced by year, phosphorus and nitrogen rates during 2014 and 2015.

Source of variation	Grain yield kg/ha	No. of panicle/m ²	No. of tiller/plant	No. of tiller/m ²	Plant height	Panicle length	Straw Yield (t/ha)
Year							
2014	6117.0A	282.03A	5.31A	298.92A	92.90A	22.62A	10.21A
2015	3858.1B	141.31B	4.42B	168.92B	80.75B	19.44B	4.97B
LSD	491.33	13.78	0.48	16.38	1.93	0.50	0.79
Phosphorous (P)							
0	4205.9C	200.17B	4.59	222.14A	84.90B	20.74B	6.28C
10	4886.4BC	211.4AB	4.82	235.08A	86.12B	20.83AB	7.17BC
20	5197.5AB	214.6AB	5.06	239.92A	86.8AB	20.98AB	8.15 AB
30	5660.6 A	220.46A	5.00	238.53A	89.43A	21.55A	8.76A
LSD	694.85***	19.48	0.68	23.17	2.73	0.71	1.12
Nitrogen (N)							
0	3867.0B	192.64B	4.57B	211.68B	81.38C	20.76	5.88C
46	5124.9 A	214.13A	4.78 B	238.79A	85.77B	21.13	6.95BC
92	5265.7A	216.28 A	4.58 B	237.11A	88.27B	21.01	7.89B
138	5692.8 A	223.64 A	5.54 A	248.08A	91.86A	21.20	9.65A
LSD	694.85***	19.48	0.68	23.17	2.73	0.71	1.12
CV%	24.14	15.96	24.32	17.17	5.46	5.88	25.77

3.2.2. Influence of Year and Nitrogen Interaction on Yield and Yield Components of Upland Rice

There was a significant interaction of year × N rates on grain yield ($p < 0.05$), number of tiller per plant ($p < 0.05$), number of tiller/m² ($p < 0.01$), plant height ($p < 0.001$) and straw yield ($p < 0.05$). The significant year × nitrogen rate interaction showed that the nitrogen produced higher grain yield at all nitrogen rates in 2014 than 2015. Grain yield was the lowest in 2015 when N fertilizer was not applied (Table 3). The highest grain yield (6934.7kg ha⁻¹) was obtained from plot that received maximum nitrogen 138 kg ha⁻¹ during 2014 growing season, however statically analysis indicate that there were non-significant from plot that received 46 & 92 kg nitrogen ha⁻¹ of during 2014 growing season. Year x nitrogen was significant ($p < 0.05$) difference to number of tiller per

plant. The significant year × nitrogen rate interaction showed that the nitrogen produced higher grain yield at all nitrogen rates in 2014 than 2015. The highest number of tiller per plant (6.31) was obtained from plot that fertilized maximum nitrogen (138 kg ha⁻¹) during 2014 growing season. Also, the significant ($P < 0.01$) influence of year × nitrogen interaction on number of tiller/m² showed that highest number of tiller/m² were observed in 2014, the highest number of tiller/m² was obtained from 138 kg N ha⁻¹ (302.7), however ANOVAs table indicated that non-significant difference from 46 & 92 kg N ha⁻¹ (Table 3). The same is true for plant height and straw yield of upland rice. The longest plant height (101.6 cm) and the highest straw yield (13.73 t/ha) was obtained from plot that fertilized with maximum nitrogen during 2014 than 2015.

Table 4. Year \times nitrogen fertilizers interaction on yield and yield components of rice, 2014 and 2015.

Nitrogen	Grain yield kg/ha	No. of panicle/m ²	No. of tiller/plant	No. of tiller/m ²	Plant height (cm)	Panicle length (cm)	Straw Yield
2014							
0	4634.8B	248.7	4.68BC	257.6B	83.4D	22.5A	7.42D
46	6319.2A	288.8	5.25B	312.4A	90.5C	22.7A	9.03C
92	6579.4A	287.7	5.01BC	302.8A	95.9B	22.5A	10.67B
138	6934.7A	302.7	6.31A	312.4A	101.6A	22.5A	13.75A
2015							
0	3099.2C	136.5	4.46BC	165.7C	79.3E	18.9B	4.35E
46	3930.5C	139.3	4.31BC	165.1C	80.9DE	19.4B	4.87E
92	3951.9BC	144.8	4.15C	171.3C	80.5DE	19.4B	5.13E
138	4450.9 B	144.5	4.76BC	173.4C	82.1DE	19.8B	5.54E
LSD	982.6	-	0.96	32.7	3.8	1	1.59
CV%	24.14	15.96	24.32	17.17	5.46	5.88	25.77

3.2.3. Influence of Phosphorus and Nitrogen on Yield Components of Upland of Rice

I. Panicles per square meter

Nitrogen application rates also significantly ($P < 0.01$) enhanced the number of panicles per square meter by 11.5% to 16.1% over zero-N, but there was no significant ($P < 0.01$) difference in panicle production observed among 46, 69 and 138 kg N ha⁻¹ (Table 2). Application of N up to 138 kg ha⁻¹ increased the number of panicles per m² significantly ($P < 0.01$) apparently by increasing the number of productive tillers (Table 2). This finding was in agreement with the results reported by [8]. The main effect of phosphorous fertilizers and the interaction effect of applied N and P levels on panicles per m² (Table 1) was non-significant difference, however number of panicles per m² increased with increasing the level of phosphorous fertilizers. The highest mean number of panicles per m² (223.6 m⁻²) was obtained with the applications of 138 kg N (Table 2), representing an increase of 16.1% (31 panicles per m²) over the control treatment. In conformity with the findings of the present study, [2] noted that panicle number is the most important factor that causes variation in the grain yield of rice.

II. Panicle length

The main effect of N and P had no significant ($p > 0.05$) influence on panicle length (Table 2). The significant ($P < 0.05$) year \times nitrogen rate interaction on panicle length showed that rice had longer panicle length in 2014 than in 2015. The highest panicle length was obtained from 46 N kg ha⁻¹ (22.7 cm), (Table 3). The effect of the interaction of nitrogen \times phosphorus rates on the panicle length of rice showed that mean yield increased with increments in N and P rates. With regards to the interaction between N and P fertilizers, the highest panicle length (22.65 cm) was obtained from the combination of 46 kg N and 30 kg P ha⁻¹ (Table 4). Since one of the most important functions of N is promotion of rapid growth, application of N fertilizer increased panicle length of rice crop more than P fertilizer. In accordance to the findings reported by [20], panicle length has contributed to increment of rice grain yield indirectly by increasing the number of panicles per m² and number of spikelets per panicle.

Table 5. Panicle length of rice as affected by N \times P interaction during the 2014/2015 main cropping season.

Nitrogen (N)	P			
	0	10	20	30
0	21.16BCD	20.70BCD	20.98BCD	20.20D
46	20.78BCD	20.25CD	20.85BCD	22.65A
92	20.70BCD	20.73BCD	20.98BCD	21.65ABC
138	20.33BCD	21.66ABC	21.13BCD	21.700AB

N*P Interaction

Means followed by the same letter within a column or row are not significantly different at 5% level of significance; LSD (5%) = 1.42 to compare N \times P interaction; * indicates significant difference at 5% level of significance; and CV (%) = 5.88

III. Plant Height

Plant height was significantly affected by application of N ($p < 0.001$) and P ($p < 0.01$) main effects application (Table 2). As the level of nitrogen and phosphorous was increased the plant height was also increased. Nitrogen is a major contributor to crop growth, size and total dry matter production. The increase in height with increasing levels of N could not be explained better. While [19] in a similar study in Bida, Nigeria observed that there were significant increases in plant height with increasing levels of N when compared with the control. Increasing the levels of N up to 138 kg ha⁻¹ increased rice plant height significantly ($P < 0.001$) from 81.36cm cm in the control treatment to 91.86 cm with the application of 138 kg N ha⁻¹ (Table 2). The same as, plant height increased significantly ($P < 0.01$) with increasing applied P levels up to 30 kg P ha⁻¹ (Table 2). Increasing the levels of P up to 30 kg ha⁻¹ increased rice plant height significantly ($P < 0.01$) from 84.90 cm in the control treatment to 89.43 cm with the application of 138 kg N ha⁻¹ (Table 2).

IV. Straw yield

The straw yield increased with increasing levels of N (Table 2). Straw yield increased from 5.88t ha⁻¹ at 0 kg N ha⁻¹ to a maximum of 9.65 t ha⁻¹ at 138 kg N ha⁻¹. At N rates of 46, 92 and 138 kg N ha⁻¹, straw yield were significantly higher than 0 kg N ha⁻¹. At higher N rates of 138 kg N ha⁻¹ significantly

higher straw yields were produced. Straw yield increased by 1.07, 2.01 and 3.77 t ha⁻¹ over the control for 46, 92 and 138 kg N ha⁻¹ respectively. The data in (Table 3) indicate that increasing the levels of applied N increased straw yield of rice significantly ($P < 0.001$) up to 138 kg N ha⁻¹. The results of the present study are in agreement with the findings of [2] who observed increasing dry matter accumulations due to increasing rates of applied mineral N fertilizer. This is attributed to enhanced plant N uptake [18] there by promoting vigorous vegetative growth of the rice crop plants.

Generally, straw yield increased from 5.88 t ha⁻¹ in the control (no N) treatment to 9.65 t ha⁻¹ with application of 138 kg N ha⁻¹ (Table 2). The same as straw yield increased with increasing levels of P (Table 2). Straw yield increased from 6.28 t ha⁻¹ at 0 kg P ha⁻¹ to a maximum of 8.76 t ha⁻¹ at 30 kg P ha⁻¹. At P rates of 10, 20 and 30 kg P ha⁻¹, straw yields were significantly higher than 0 kg P ha⁻¹. At higher P rates of 30 kg P ha⁻¹ significantly higher straw yields were produced. Likewise, [12] also reported that increasing rates of P increased dry matter accumulation as a result of increased vegetative growth favored by enhanced nutrient uptake by rice plants. The data in Table 2 indicate that increasing the levels of applied P increased straw yield of rice significantly ($P < 0.001$) up to 30 kg P ha⁻¹.

Table 6. Straw Yield of rice as affected by N x P interaction during the 2014/2015 main cropping season.

Nitrogen (N)	P			
	0	10	20	30
0	6.04DEF	5.06F	6.48CDEF	5.95DEF
46	5.54EF	6.86BCDEF	6.59BCDEF	8.80B
92	6.78BCDEF	8.57BC	7.61BCDE	8.63BC
138	6.78BCDEF	8.20BCD	11.91A	11.68A

N*P Interaction

Means followed by the same letter within a column or row are not significantly different at 5% level of significance; LSD (5%) = 2.25 to compare N x P interaction; * indicates significant difference at 1% level of significance; and CV (%) = 25.77

Generally, straw yield increased from 6.28 t ha⁻¹ in the control (no P) treatment to 8.76 t ha⁻¹ with application of 30 kg P ha⁻¹ (Table 2). The significant ($P < 0.05$) year x nitrogen rate interaction on total straw yield showed that rice had higher straw yield in 2014 than in 2015, the higher straw yield was obtained in 2014 (10.21 t ha⁻¹), (Table 2). The effect of the interaction of nitrogen x phosphorus rates on the straw yield of rice showed that mean yield increased with increments in N and P rates. With regards to the interaction between N and P fertilizers, the highest straw yield (11.61 t ha⁻¹) was obtained from the combination of 138 kg N and 20 kg P ha⁻¹, however statically analysis indicate that non-significant difference with the combination of 138 kg N and 30 kg p ha⁻¹ (Table 5).

3.3. Economic Analysis

Economic analysis revealed that the gross return and net return were maximum with application of 46 N and 23 P₂O₅ kg ha⁻¹ followed by application of 138 N and 69 P₂O₅ kg ha⁻¹. Application of 46 N and 23 P₂O₅ kg ha⁻¹ was well above the 100% minimum (CIMMYT, 1988). But investing on additional fertilizer rate gave less MRR. According to CIMMYT (1988) experience and empirical evidence, for the majority of situations indicated that the minimum rate of return acceptable to farmers would be between 50-100%. Therefore, the treatments that have highest Marginal rate of return (MRR%), w/c is application of 46 N and 23 P₂O₅ kg ha⁻¹NP for Rice production in Kamashi zone is recommended.

Table 7. Partial Budget Analysis of NP fertilizer application rates on Upland rice at Kamashi Zone.

Treatments	Total cost of Production (ETB/ha)	Yield (kg ha ⁻¹)		Gross Return (ETB/ha) from			Net return	Marginal rate of return
		Straw	Grain	Grain yield	Straw yield	Total		
P kg ha ⁻¹								
0	3375.0	6080	3785.3	47316.4	608	47924.4	44549.4	
10	4312.5	7060	4397.8	54972.0	706	55678.0	51365.5	727
20	5250.0	8020	4677.8	58471.9	802	59273.9	54023.9	284
30	6187.5	9205	5094.5	63681.8	920.5	64602.3	58414.8	468
N kg ha ⁻¹								
0	3375.0	5885	3480.3	43503.8	588.5	44092.3	40717.3	
46	4760.0	6950	4612.4	57655.1	695	58350.1	53590.1	929
92	6145.0	7900	4739.1	59239.1	790	60029.1	53884.1	21
138	7530.0	9645	5123.5	64044.0	964.5	65008.5	57478.5	259

N. B: Prices - Urea= 9.85 birr/kg, DAP=13.85 birr/kg, TSP=18.75 birr/kg, Price of Paddy Rice=12.50 birr/kg, Price of straw= 0.10 birr/kg, Seed=10 birr/kg & Labor cost =30 birr/ person/day for 8 hours, TC=Total cost, Gross return (Return from Grain &straw yield) =price /kg* yield in kg and Net return = gross return - Total cost

4. Recommendations and Conclusions

The study was designed to determine the effects of Nitrogen and P fertilizer applications on grain yield and yield components of rice on Nitisols of Kamashi Zone District. The results obtained from this study showed that, grain yield

and plant parameters were significantly ($P \leq 0.001$) influenced by the applied rates of nitrogen and/or phosphorous fertilizer. In this study, number of panicles per m² and number of filled spikelet's per panicle as well as panicle length were the most important yield forming attributes causing significant variation in grain yield of rice.

Panicle length contributed to grain yield increment indirectly by increasing the number of spikelets per panicle.

From this result, it can be concluded that farmers of Kamashi area need to apply a combination of 46 kg N and 10 P ha⁻¹ in order to improve the grain yield and yield components of rice on nitosols under rain fed conditions. Thus, in the light of the significant response of rice to both N and P fertilizers, further studies aimed at promoting integrated soil fertility management and formulation of fertilizer recommendation on soil test basis over locations are desirable.

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