Effect of NPS rate on yield and yield components of Upland rice (*Oryza Sativa* L.) in western region of Ethiopia.

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ABSTRACT

The key elements that contributed to low rice productivity is such biotic, abiotic factors and inappropriate crop management practices. Moreover, application of balanced fertilizers is the basis to produce more crop yield from existing land under cultivation and nutrient needs of crops is according to their physiological requirements and expected yields. Thus, a field experiment was conducted in 2016-2018 main cropping season from the end of may to end November at western oromiya on Bako and Chewaka locations to improve soil fertility and increase yield of Rice in East Wollega and West showa and to determine optimum level of NPS fertilizer for growth, economically feasible rates that maximize the yield of Rice in the area. The treatments were factorial combination of seven rates of fertilizer (0, 25, 50, 75, 100, 125 kg/ha NPS) and one previous recommendation (100 kg/ha DAP) with two Rice varieties (chewaka and Nerika-4) and with uniform application 23 N kg/ha in randomized complete block design and replicated three times. The pre soil analysis indicates that the soil of experimental area is acidic (pH = 5.4) and medium in available Phosphorus (13 ppm). The main effect of Plant height, Panicle length and number of effective tiller were not influenced by NPS rate but significantly (P<0.01) different due to variety both at Bako and Chewaka locations. But the main effect of Above ground biomass and Grain yield were significantly different at chewaka site. Though the other parameters were non-significantly affected, Grain yield of chewaka variety was significantly influenced due to the interaction effect of NPS rates and varieties at Bako. Thus, economic analysis revealed that 125 kg/ha NPS (47.5 P_2O_5, 23.75 N and 8.75 kg/ha S) rate on chewaka variety gave grain yield (6454.8kg/ha) with the net benefit (61160.5 birr/ha) and the highest marginal rate of return (787.69%) are economically feasible alternative to the other treatments. Therefore it is advisable to use 125kg/ha NPS rate on chewaka variety since economically feasible to the farmers.

Keywords: Economic analysis, NPS rates, biotic and abiotic, yield and yield components

Introduction

In Ethiopia field crops cover the largest cultivated land area from which cereals covered nearly 80.7% and rice covered 0.51% from cereal land coverage and accounting 2844kg/ha grain yield (CSA, 2018). A latest report of Central Statistical Authority (CSA) indicates that area covered by major cereals namely, Tef, Maize, Sorghum and Wheat were 23%, 17%, 16% and 13% respectively, in main crop season of 2010. During the same season, national yield averages obtained from the same cereals were 1.26, 2.25, 2.00 and 1.86 t/ha, respectively. Rice is also a part of cereal crops which is cultivated in all regions of the country even if specific to a few locations of the regions. It is said a new comer crop of the country. This crop also a full of challenges like other cereal crops in the country (Heluf and Mulugeta, 2006). Despite, the fact that numbers of farmers' as well as area coverage are increasing from time to time, crop yields are generally found in declining trends (CSA, 2009).

Although, low yields of these crops were attributes of several biotic and a biotic factors, inappropriate crop management practices that mainly include; sowing periods, seeding methods, weeding practice, and lack of farmers awareness on uses of cropping systems and different soil fertilization methods are found the key elements that contributed to low crop productivity in the country. Rice is the high yielding crop in the cultivating countries of the world and stable food in some countries (Riaz *et al*., 2007). In Ethiopia the productivity is very low then the attainable yield and not Exide 35 kuntal per hectare due to the challenges mentioned above. Improvement of its production has not been possible due to low soil fertility and inadequate nutrient management among other factors (Heluf and Mulugeta, 2006).

Therefore, to alleviate the aforementioned persistent problems of crop production, there has been a growing interest to increase the productivity through improved agronomic practices. Consequently, some crop management research activities with objectives to identify agronomical optimum and economical maximum crop management practices are proposed to conduct on various crops in different agro-ecologies of the country.

But the growth and yield of rice is influenced by different nutrients management and other factors during their production in a field (Riaz *et al.*, 2007). Despite its importance and increased production, crop productivity, in many parts of the world, is low due to genetic and environmental factors affecting its yield and yield related traits (Nonnecke, 1989). In many crop producing areas lack of available nutrients is frequently the limiting factor next to the soil water as their uptake and liberation of N, P and S from soil organic matter depends upon availability of water (FAO, 2003). Research work has been done on the base of NP in different soil types and in various climatic conditions, but very limited work has been reported on various sources of fertilizers for a certain nutrient. Application of only N and P containing fertilizers causes reduction of the quantity of K and S in most of the soils as there is also evidence of fixation of potassium and leaching of sulphur in different types of soils in addition to mining by different crops as result of continues cultivation of land (Murashkina *et al*., 2006). Under P deficient conditions, rice does not respond to application of N, K, and other nutrients (Bijay and Singh, 2017). Therefore the application of K and S and other micronutrients to soils having even fair amounts of K and S contents may still show its effect on plants. In rice, number of panicles and panicle length may be adversely affected by S deficiency (Fageria *et.al.* 2003). Phosphorus management must focus on the buildup and maintenance of adequate available P levels in the soil to ensure that P supply does not limit crop growth and N-use efficiency (Fairhurst *et.al.*, 2007). The recently cultivated crop(upland rice) in the country also full of these challenges such as, soil fertility problem, pests(weed, disease, insects) & a biotic factors .Therefore, improving the productivity of the crop, soil fertility improvement will be the mandatory & this can be improved by different mechanisms. Thus the research aimed to investigate different optimum and economically feasible rate of fertilizers to the rice crop.

Objectives

- To illustrate improving fertility thereby increasing rice production and productivity in order to sustain food security in East Wollega Zone Oromia
- To determine optimum level of NPS fertilizer for growth, economically feasible and high productivity of upland rice in the research area.

Materials and Methods

The trial was conducted at Bako Agricultural research center at Bako on station and sub- station of chewaka site during 2016-2018 main cropping seasons. The treatments were consisted of different level of NPS compound fertilizer and control treatment without fertilizer application. The recommended fertilizer rate 46 P_2O_5 (100kg kg/ha DAP) was used as check in comparison with different levels of fertilizers. Uniform application of 23 kg/ha Nitrogen (50kg/ha Urea) was used in split at sowing and tillering. The constituent of Nitrogen, phosphorus and sulfur in 100 Kg/ha NPS is 38 kg P_2O_5, 19 kg N and 7 kg S respectively. Two upland rice varieties (Chewaka and Nerica-4) were used as tested crop in the trial during conducting the experiment. Thus, fourteen treatment combinations consisting seven rates (0, 25, 50, 75, 100 & 125 kg/ha NPS with one recommended rate of 46 kg/ha P_2O_5) fertilizer and two rice varieties (Chewaka and Nerica-4) combined factorially were arranged in a randomized complete block design in three replications.

Data Collection and Measurements

Growth, Yield and Yield Component

Plant height was measured at physiological maturity from the ground level to the tip of panicle from five randomly selected plants in each plot and the average was taken. Panicle length was measured from the node where the first panicle branches emerged to the tip of the panicle from an average of five selected plants per plot. Number of effective tillers was determined by counting the number of tillers from five plants from the harvestable rows and the average was considered. Biomass yield was harvested at maturity at ground level from the whole plant parts, including leaves, stems, and seed from the net plot area and weight of biomass was taken after sun drying for a week. Finally the total Grain yield was measured by harvesting the crop from the net middle plot area of 5m x 0.8 m (4 m^2).

Results and Discussions

Soil Physico-Chemical Properties of Experimental Site

The soil textural classes consisted proportion of 38% sand, 54% clay and 8% silt indicating clay at Bako. According to Tekalign (1991) rating, the organic carbon of the soil showed medium at Bako (2.88%) while the available phosphorus indicated that there was medium (13 mg/kg) phosphorus content of the soil at bako site which was in line with (Jones, 2003).

Growth, Yield and Yield Components

From the analysis of variance Plant height, Panicle length, Number of effective tiller , number of filled grain, Above ground biomass and Harvest Index were not influenced by main effect of NPS rate ($p>0.05$) but highly influenced ($p<0.01$) due to variety at Bako locations and Chewaka except non-significance difference on number of filled grain and harvest index at chewaka. However, none of their interaction effects were significantly different at both locations during the main growing season of 2016-2018 cropping calendar (appendix Table 1). In all parameters the highest values were recorded at chewaka variety than Nerika-4 (Table 1). The lower values of Nerika-4 when compared with Chewaka variety were probably associated with the severity of head blast at Nerika-4 especially at Bako location.

Table 1. The main effect of rates of NPS on Plant height, Panicle length, Number effective tiller, Number of filled grain, Above ground biomass and Harvest Index of rice at Bako

NPS rates (kg/ha)	PH	PL	NET	NFG	AGBM	HI
0	100.51	20.78	12.83	85.1	12838	34.58
25	104.58	21.13	13.72	93.7	13927	30.5
50	101.36	20.73	13.14	83.3	13154	31.02
75	103.67	21.03	12.54	82.8	13065	31.71
100	103.39	20.82	12.4	84.7	12672	31.69
125	103.43	21.43	12.22	84.7	13867	33.43
100 DAP	101.69	20.94	12.48	81.1	12536	30.37
LSD	NS	NS	NS	NS	NS	NS
Variety						
chewaka	118.1	21.37	14.13	90.4	16030	38.36
Nerika-4	87.22	20.59	11.39	79.7	10273	25.44
LSD	3.81	0.42	0.9	6.84	1030.4	2.37
Cv	10.5	5.7	19.8	22.7	22.1	21.0

LSD (0.05) = Least significance difference at 5% probably level, CV = Coefficient of variation, NS = non-significant at 5% probability level. PH=Plant height, PL=Panicle length, NET= Number effective tiller, NFG=Number of filled grain AGBM=Above ground biomass and HI=Harvest Index.

On the other hand, even if the other traits except panicle length and Number of effective tiller showed non-significant difference due to the main effect of NPS, Plant height, Grain yield and Above ground biomass were highly (P>0.01) influenced due to the main effect of NPS rates and rice varieties but all of the parameters were not significantly affected (P>0.05) due to their interactions at chewaka location (Appendix Table 2). This result was in line with Increase in the magnitude of yield attributes is associated with better root growth and increased uptake of nutrients favoring better growth of the crop (Heluf and Mulugeta, 2006). Except number of filled grain and Harvest index all parameters were significantly different due to the main effect of Variety at chewaka location and the highest values were also observed at chewaka variety when treated with Nerika-4 on the site (Table 2).

Table 2. The main effect of rates of NPS on Plant height, Panicle length, Number effective tiller, Number of filled grain, Grain yield, Above ground biomass and Harvest Index of rice at Chewaka

NPS rates (Kg/ha)	Traits						
	GY(Kg/ha)	AGBM(Kg/ha)	HI	NET	NFG	PH (cm)	PL (cm)
0	2517c	5645c	45.492	6.056	54.95	91.17b	20.422
25	3243ab	7988a	43.528	6.489	57.68	95.28b	20.267
50	2939b	6784bc	46.368	6.233	54.53	92.72b	20.922
75	3291a	7096ab	49.291	6.422	61.8	95.56ab	20.889
100	3263ab	7373ab	46.263	6.467	56.02	96.5ab	20.789
125	3318a	7677ab	44.77	6.322	56.89	96.5a	21.58
100 DAP	3108ab	7276ab	45.787	5.9	58.89	95.78ab	21.544
LSD(0.05)	344.16	1194.9	NS	NS	NS	5.66	NS
Varieties							
Chewaka	4032a	9528a	46.87	6.91a	58.49	109.6a	21.61a
Nerika -4	2199b	4712b	44.98	5.63b	56.01	81.25b	20.22b
LSD	183.96	638.69	NS	0.51	NS	3.03	0.56
CV	16.7	25.3	12.8	22.8	18.0	8.9	7.5

LSD (0.05) = Least significance difference at 5% probably level, CV = Coefficient of variation, NS = non-significant at 5% probability level. PH=Plant height, PL=Panicle length, NET= Number effective tiller, NFG=Number of filled grain AGBM=Above ground biomass GY= grain yield and HI=Harvest Index.

From analysis variance despite of other trait showed non-significant difference, Grain yield was significantly affected due the main effect of NPS rate and Variety as well as their interactions at bako location (Appendix Table 1). The highest grain yield (7172 kg/ha) was recorded from 125 kg/ha NPS (47.5 P_2O_5, 23.75 N and 8.75 kg/ha S) on chewaka variety at Bako location (Table 3). This was in line with Fageria *et.al.* (2003) suggesting the above-ground P uptake by high-yielding rice varieties commonly ranges from 25 to 50 kg P/ ha with 60–75% of the total plant P contained in the panicles at maturity. Comparative result was also stated as application of phosphorus fertilizer had significantly increased the grain yield of rice up to the applied level of 46 kg P_2O_5 /ha on baby trail (Getahun *et.al.*, 2017). Generally the grain yield obtained from Nerika-4 variety was by far smaller than chewaka variety on bako station as well as Chewaka location over years due to increased number of unfilled grains that had positive correlation for lower total grain yield in Nerika-4 which might be connected with rice head blast.

Table 3. Interaction effects of rates of NPS and Variety on Grain yield (Kg/ha) of rice varieties (Chewaka and Nerika-4) at Bako

NPS (kg/ha)	Chewaka	Nerika-4
0	6048bc	2929d
25	6202bc	2635de
50	6314bc	2211ef
75	6523b	2307ef
100	6192bc	2393def
125	7172a	2606de
100 DAP	5742c	1896f
LCD	611.8	
CV	14.9	

LSD (0.05) = Least significance difference at 5% probably level, CV = Coefficient of variation, NS = non-significant at 5% probability level.

Economic Analysis

The experiment was conducted with two factor experiments including different NPS rate and two Variety combined factorally by keeping uniform application of 23 kg/ha Nitrogen rates. Thus, the partial budget analysis was done on the basis of total variable cost considering the costs of different NPS rates, variety, and transport as well as application costs. The economic analysis was done on the basis of adjusting 10% yield downward for that fact it closest to the farmer yield. The result of partial budget analysis showed that five NPS rates were non-dominated with an associated MRR greater than 100% (Table 4). An additional income of 7.87 Ethiopian Birr per unit Birr invested was obtained from 125 kg/ha NPS rate on chewaka variety compared to the other treatments. This analysis revealed that 125 kg/ha NPS rate on chewaka variety gave

(6454.8kg/ha) with the net benefit (61160.5 birr/ha) and the highest marginal rate of return (787.69%) are economically feasible alternative to the other treatments (Table 4).

Therefore it is advisable to use 125kg/ha NPS rate on chewaka variety since economically feasible to the farmers.

Table 4. Results of partial budget analysis for NPS fertilizer rates and Rice varieties (chewka and Nerika-4).

NPS (kg/ha)	Variety	Gross yield	Adjested yield (10%)	Gross benefit	TVC	NB	Dominance	MC	MB	MRR (%)
0	Nerika-4	5229	4706.1	53061	1667.5	52400.5		0	0	
0	Chewaka	6048	5443.2	54432	1767.5	52664.5		100	264	264.00
25	Nerika-4	2635	2371.5	23715	1986.5	21728.5	D			
25	Chewaka	6202	5581.8	55818	2086.5	53731.5		319	1067	334.48
50	Nerika-4	2211	1989.9	19899	2310.5	17588.5	D			
50	Chewaka	6314	5682.6	56826	2410.5	54415.5		324	684	211.11
75	Nerika-4	2307	2076.3	20763	2629.5	18133.5	D			
75	Chewaka	6523	5870.7	58707	2729.5	55977.5		319	1562	489.66
100DAP	Nerika-4	1896	1706.4	17064	2868.5	14195.5	D			
100	Nerika-4	2393	2153.7	21537	2968.5	18568.5	D			
100DAP	Chewaka	5742	5167.8	51678	2968.5	48709.5	D			
100	Chewaka	6192	5572.8	55728	3068.5	52659.5	D			
125	Nerika-4	2606	2345.4	23454	3287.5	20166.5	D			
125	Chewaka	7172	6454.8	64548	3387.5	61160.5		658	5183	787.69

GB= gross benefit, TVC= total variable cost, NB= net benefit, D=dominance, MC= marginal cost, MB= marginal benefit and MRR= marginal rate of return

Conclusion

The major factors affecting rice productivity include biotic, abiotic factors and inappropriate crop management practices. To tackle the nutrient management challenges with application of balanced fertilizers according to the nutrient demand of crops is the basis to produce more crop output from existing land under cultivation. From different NPS rate and rice varieties tested, economic analysis showed 125 kg/ha NPS rate on chewaka variety gave grain yield (6454.8kg/ha) with the net benefit (61160.5 birr/ha) with the highest marginal rate of return (787.69%) are economically feasible alternative to the other treatments. Therefore it is advisable to use 125kg/ha NPS rate on chewaka variety since economically feasible to the farmers.

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Appendices

Appendix Table 1. Mean squares of ANOVA for Plant height, Panicle length, Number of effective tiller, Number of filled grain, Grain yield, Above ground biomass and Harvest index of Rice in response to the rates of NPS at bako.

sources of variation	Mean squres							
	Df	PH	PL	NFG	NET	GY	AGBM	HI
Rep	2	493.74**	20.01**	1056ns	14.88ns	3096494**	193872307**	87.72ns
NPS	6	39.2ns	1.07ns	295.1ns	4.87ns	1825822**	5478485ns	44.08ns
Var.	1	30054.9**	19.05**	3581.9**	236.4**	476254615**	1044072423**	5260.09**
NPS*Var	6	78.5ns	0.71ns	242.6ns	6.4ns	989295*	3188373ns	33.01ns
MSE	84	115.5	1.41	372.8	6.41	425605	8E+06	44.74
CV(%)		10.5	5.7	22.7	19.8	14.9	22.1	21

Appendix Table 2. Mean squares of ANOVA for Plant height, Panicle length, Number of effective tiller, Number of filled grain, Grain yield, Above ground biomass and Harvest index of Rice in response to the rates of NPS at chewaka.

sources of variation	Mean squres							
	Df	PH	PL	NFG	NET	GY	AGBM	HI
Rep	2	649.02**	9.44*	4646.1**	3.44ns	336452ns	38592341**	200.95**
NPS	6	173.51*	4.54ns	217.1ns	0.89ns	1634115**	10323536**	56.79ns
Var.	1	25315.84**	61.18**	6.0ns	51.3**	105738571**	730566732**	112.42ns
NPS*Var	6	66.36ns	1.13ns	183.1ns	2.73ns	390204ns	2674621.4ns	30.19ns
MSE	84	72.92	2.46	242	2.04	269366	3E+06	34.77
CV(%)		8.9	7.5	27.4	22.8	16.7	25.3	12.8