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Determination of Seed and Nitrogen fertilizer rate on yield and yield components of upland Rice (*Oryza Sativa* L.) in western Oromia, Ethiopia.

Bodena Guddisa *, Hailu Feyisa, Geleta Gerema and Gudeta Bedada

Abstract: *A field experiment was conducted in the 2019–2020 main cropping season from the end of May to the end of November at western Oromiya on Bako and Chewaka locations to determine the optimum seed and nitrogen rate that maximizes the yield and yield components and to evaluate the economic profitability of seed and N fertilizer rates for rice production. The treatments were arranged in factorial combination with five nitrogen fertilizer rates (35, 46, 58, 69, and 81 kg/ha N) and four seed rates (60, 80, 100, and 120 kg/ha) tested on a rice variety (Chewaka) with a uniform application of 125 kg/ha NPS in a randomized complete block design replicated three times. The pre-soil analysis indicated that the soil of the experimental area was acidic (pH = 5.04 at Bako and 5.02 at Chewaka), with moderate (11 mg/kg) available phosphorus at Bako and low (5.91 mg/kg) at Chewaka. The post-soil analysis depicted a lower percent increment in total nitrogen and organic matter while decreasing phosphorus. The main and interaction effects of Days to heading, Panicle length, number of effective tillers, and Thousand seed weight were not significantly influenced (P > 0.05) by nitrogen (N) and seed rates, but plant height was significantly (P<0.01) different due to the main effect of N both at Bako and Chewaka locations. However, the number of filled grain, number of unfilled grains, Aboveground biomass, Grain yield, and Harvest index were significantly (P<0.01) influenced due to the main and interaction effects of nitrogen (N) and seed rates at both tested sites. Thus, economic analysis showed that 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety gave better grain yield (4318.2 kg/ha) and net benefit (65684.9 birr/ha), and the highest Marginal Rate of Return (MRR) (3605.6%) were economically feasible compared to the other treatments. Therefore, it is recommended to use 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety since it is economically feasible for the farmers.*

Keywords: *Economic analysis, fertilizer rates, seed, yield and soil fertility*

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Introduction

Rice (*Oryza sativa* L.*)* belongs to the grass family. It is a vital food crop because half the world's population feeds rice as a main part of their diets. It provides more calories per hectare in comparison to any other cereal grain. Rice is a valuable crop that is mostly cultivated for its grains in Ethiopia. Rice is 2nd in area basis and total production worldwide after wheat (FAO, 2012). In Ethiopia, rice is cultivated in an area of about 85,288.87 hectares (CSA, 2021). The main factors influencing rice productivity in Ethiopia include low soil fertility caused by continuous cropping, intensive grazing, high soil erosion, and removal of field crop leftovers(Getachew and Birhan, 2015). Rice is the high-yielding and most important food crop in the developing world and the staple food of more than half of the world's population (Seck *et al*., 2012). Although, low yields of these crops were attributes of several biotic and abiotic 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.

In Ethiopia, the productivity is much lower than the attainable yield and does not exceed 3.5 t/ha due to the challenges of biotic and abiotic factors (Gebrekidan and Seyoum, 2006). The average national yield of rice is less than 3.15 t/ha (CSA, 2021). Productivity of grain crops in the country suffers from large yield gaps arising from many factors including low-input, low-output, and rain-dependent (KIT, 2020). Even though it was cultivated in all regions of the country, it is grown in a few locations of the regions. On the other hand, the growth and yield of rice are influenced by different nutrient management and other factors during their production in a field (Seck *et al*., 2012). 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 the availability of water (FAO, 2004). The application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation and the nutrient needs of crops are according to their physiological requirements and expected yields (Teshale and Legesse, 2020). Excessive application of fertilizers or manure can contribute to pollution of streams, groundwater resources and generally reduce profitability (Di and Cameron, 2002). When commercial fertilizers are applied at rates that exceed the plants' ability to remove the nutrients at a given growth stage, fertilizer run-off can occur. When N is supplied from fertilizer or other sources (manure, sewage sludge, etc), it should be applied at a rate that does not greatly exceed the expected crop N requirement. It should be applied as near as possible by the time when the plant needs to reduce the chance for potential losses and to reduce the loss of N to the environment (PSE, 2014). However, the farmers around the rice growing area apply more Nitrogen rate even more than the rate recommended by research centers for the assumption of increasing yield. Besides, different seed rate is utilized across national, regional, and individual farmers of rice growing in the vicinity area, resulting sparse population in some places and denser in other areas. In other cases, producers suggested when there is a sparse population per hectare there is the appearance of termite infestation and normal plant physical structure in relatively densely plant-populated areas. Thus, the research aimed to investigate different seed and Nitrogen rate fertilizers to the rice crop for determining optimum seed and nitrogen rate that maximizes the yield and yield components and to evaluate the economic profitability of seed and N fertilizers rate for rice production.

Materials and Methods

Description of Study Area

The experiment was conducted at Bako Agricultural Research Center's sub-sites of Bako and Chewaka locations. The center is located 258 km west of the capital, Addis Ababa, 8 km away from the nearest town, Bako, and 4 km from the highway to Nekemte town, western Ethiopia. The study site at Bako is located in Bako Tibe districts of West Shewa, Oromiya regional state of Ethiopia, and is geographically located at a latitude of 9^{0} 6' N and a longitude of 37° 9' E with an altitude of 1650 m above sea level (Fig. 1). It receives an annual rainfall of 1,600 mm, with mean maximum and minimum temperatures of 29 ºC and 13 ºC, respectively (Tesfaye et al., 2023). Chewaka is the second study area found 552 km Southwest of Addis Ababa in the Buno Bedelle zone, Oromia Region of Ethiopia, and lies between 8^{0} 43' 30'' N and 9^{0} 5' 30'' N latitude and longitude of 35° 58′ 0″ E to 36° 14′ 30″ E, having an average rainfall varies between 800 and 1200 mm (Abera et al., 2020). The mean annual temperatures of the district range from 19.8 to 28.5 °C with the altitude ranging between 1130 and 2053 meters above sea level.

Treatments, design and experimental procedures

The trial was conducted at Bako Agricultural Research Center at Bako on station and sub-station of Chewaka site during the 2019-2020 main cropping seasons. The treatments consisted of different seed and Nitrogen fertilizer rates. Four seed rates (60, 80, 100 and 120 Kg/ha) and five rates of Nitrogen (35, 46, 58, 69 and 81 Kg N/ha) were combined factorially, with two times Nitrogen application 1/2 at plating and the remaining half at tillering was done. One hundred twenty-five (125kg/ha) NPS was used uniformly on the experimental plot. Three replications under a completely randomized block design were used in the field trial. The land preparation was started at the beginning of the rainy season and the soil was loosened before planting. Seed of Rice (Chewaka) variety was sown in six rows with 20cm between rows. The experimental area consisted of twenty (20) treatments with the spacing between the block and plots 1.5 and 1m, respectively. The gross area (6m^{2}) of the plots with 1.2m width and 5m length was accommodated. A composite soil sample was taken before the onset of rainfall from the selected area of the intended site and analyzed for the Physicochemical properties of the soil and available nutrients. After the harvest of the crop, twenty composite samples per treatment base were collected for nutrient analysis such as phosphorus, Total nitrogen, organic matter, sulfur and exchangeable cations of the soil.

Data Collection and Measurements

Growth, Yield and Yield Component

Plant height was measured at physiological maturity from the ground level to the tip of the panicle from five randomly selected plants in each plot and the average was taken.

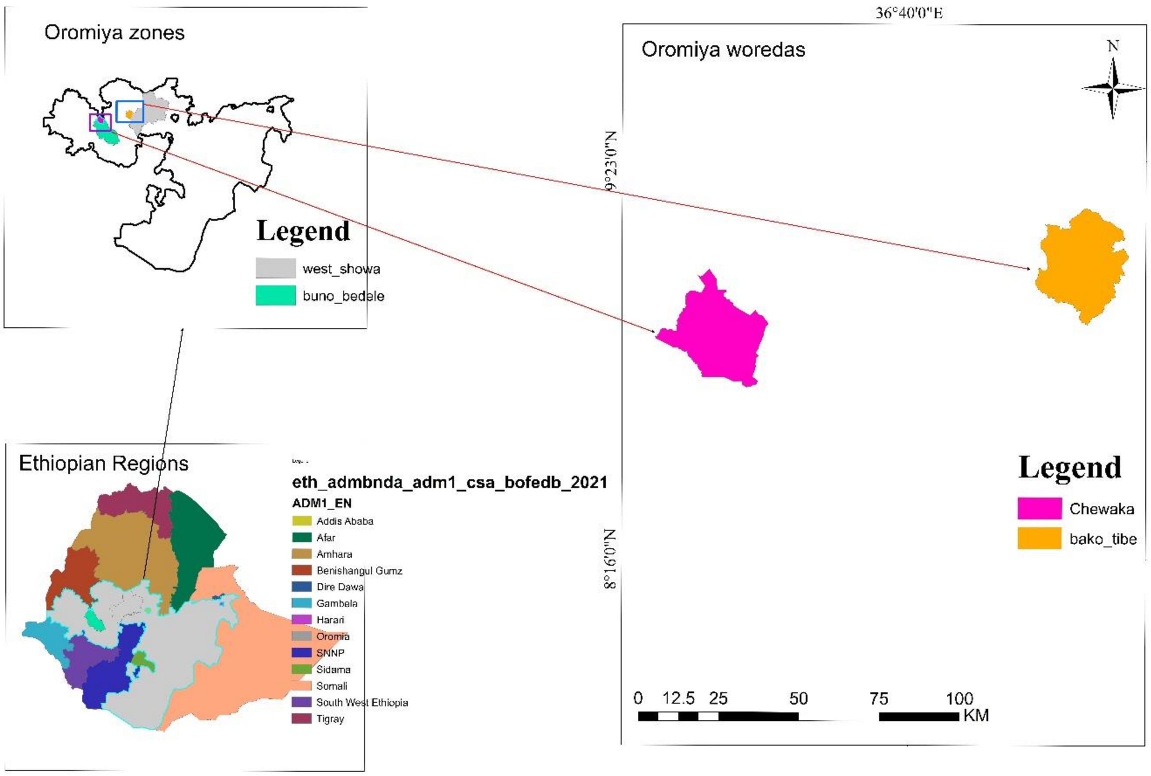

Figure 1. Indicating the study area of two locations: Bako at Bako Tibe and Chewaka at Chewaka districts.

Panicle length was measured from the node where the first panicle branches emerged to the tip of the panicle from five selected plants per plot and the average was calculated. The average number of effective tillers per plant was determined by counting the number of tillers from five plants of harvestable rows at maturity.

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 the weight of biomass was taken after sun drying for a week when the weight got constant. 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 of the proportion of 38% sand, 54% clay and 8% silt indicating clay at Bako and Clay loam (48% sand, 20% silt and 32% clay) at Chewaka which is ideal for rice production. pH of the soil was 5.04 and 5.02 at Bako and Chewaka respectively, categorized as acidic which is in line with the rating of (Landon, 1991), soils with pH of 5.1-5.5 are acidic. The organic matter of the soil showed medium (3.43 and 4.97%) at Chewaka and Bako, respectively which agreed with Debele (1980) rating, soil organic matter in the range of 2.6-5.2 was categorized as medium. The Total N of the soil was medium (0.17 and 0.21%) at Chewaka and Bako which coincided with a rating of ((EthioSIS, 2014). Available phosphorus indicated there was medium (11 mg/kg) phosphorus content of the soil at Bako and low (5.91 mg/kg) at Chewaka which was in line with Landon (1991) rated soil phosphorus content below 10 mg/kg is low, 11-20 mg/kg moderate and > 20 mg/kg as high (Table 1). After crop harvest even though some soil nutrients like organic matter, total nitrogen showed small increment trends at both locations of Bako and Chewaka, available phosphorus indicated decreasing at both locations which might be associated with high nutrient consumption of the rice crops. Similarly, the lower increment of the organic matter probably had direct implications for the removal of crop residues (biomass) during harvesting of the crop. The result agreed with Mekonne (2015) and (Melese *et al*., 2015) who reported that available soil phosphorus (P) was found to be deficient in most soils of cultivated lands.

Growth, Yield and Yield Components

From the analysis of variance Days to maturity, Panicle length, Number of effective tillers, and Thousand seed Weights were not influenced due to the main and interaction effect of Nitrogen and Seed rate (p>0.05) at Bako and Chewaka locations. However, Plant height had a significant difference due to the main effect of nitrogen only when Days to heading responded positively for both the main effect of Nitrogen and Seed rates ($p<0.05$) but was not significantly influenced due to their interaction effects ($p>0.05$) (Table 2). Increasing Nitrogen rates from the lowest to the highest rates increased plant height, which might be connected with the optimum nitrogen demand being met for their growth. On the other hand, Grain yield and Above ground biomass were highly significantly different due to both the main and interaction effects of Nitrogen and seed rates($p<0.01$) and the interaction effects of the Number of filled and unfilled grain as well as Harvest index of rice (Chewaka) variety at both locations (Appendix Table 2).

The Number of filled grains showed a significant difference due to the main ($p<0.05$) and the interaction ($p<0.01$) effects of Nitrogen and seed rates at both Bako and Chewaka locations. The highest number of filled grain (104.97) was observed at the combination of 58 kg/ha N and 100 kg/ha seed rates even if statistically par with 58 kg/ha N and 60kg/ha seed rates and 69 kg/ha N and 80 kg/ha seed rates (Table 3). Conversely, the lowest number of filled grain was obtained from the combination of 46 kg/ha N and 100 kg/ha seed rates though similar with 69 kg/ha N and 120 kg/ha seed rates. The highest number of filled grain at the combination of 58 kg/ha N and 100 kg/ha seed rates was probably due to an adequate supply of nitrogen for sufficient spikelet growth thereby contributing to optimum grain filling of the variety (Chewaka). This result agreed with Noor (2017) who reported source maximum proportion of N source is used to produce maximum spikelet per panicle and grain filling and when more the number of spikelet is produced, less number of filled grains occurred at any rate of nitrogen application. Similarly reported that Woldesenbet and Haileyesus (2016) maximum N fertilization level (92 Kg N/ha) increased growth and yield components of maize plants.

Table 1. Percent change of soil pH, Organic matter content (%), Total nitrogen (%) and available phosphorus (P) after harvest of the crop in response to 58 kg Nitrogen and 81 kg seed rate application.

Soil analysis	Location					
	Bako			Chewaka		
	Before planting	After harvest	% change	Before planting	After harvest	% change
pH	5.04	5.4	7.14	5.02	5.3	5.58
Organic matter (%)	4.97	5.04	0.25	3.43	4.24	0.81
Total Nitrogen (%)	0.21	0.25	0.04	0.17	0.21	0.04
Avail. P (mg kg^{-1})	11	7.22	-34.36	5.91	5.39	-8.80

Table 2. The main effect of Nitrogen and seed rates on Plant height, Panicle length, Number of effective tillers, Days to maturity, Days to heading and thousand seed weight at Bako and Chewaka locations

N rates (kg/ha)	DH	DM	PH	PL	NET	TSW
35	86.54 a	122.15	106.3 c	20.36	5.34	27.09
46	85.98 a	121.72	106.6 c	20.64	5.32	27.38
58	85.85 ab	121.81	108.7 bc	20.46	5.61	27.49
69	85.83 ab	122.14	110.9 ab	20.77	5.38	27.40
81	85.17 b	122.10	112.5 a	20.71	5.37	27.15
LSD (0.05)	0.76	Ns	3.250	ns	ns	ns
Seed rates (kg/ha)						
60	86.62 a	122.30	107.93	20.71	5.517	27.28
80	85.75 b	121.82	109.23	20.66	5.380	27.54
100	85.60 b	122.03	110.64	20.49	5.330	27.14
120	85.53 b	121.80	108.24	20.48	5.387	27.25
LSD (0.05)	0.69	Ns	Ns	ns	ns	ns
Cv	2.2	1.2	7.4	5.6	21.7	7.2

LSD (0.05) = Least significance difference at 5% probably level, CV = Coefficient of variation, NS = non-significant at 5% probability level. DM= days to maturity, DH= Heading, PH=Plant height, PL=Panicle length, NEF= number of effective tillers and TSW=thousand seed weight.

Table 3. The interaction effect of Nitrogen and seed rates on the number of filled grains of rice (Chewaka variety) at Bako and Chewaka locations

Seed rates (kg/ha)	Nitrogen rates (kg/ha)				
	35	46	58	69	81
60	97.03 b-e	97.22 b-e	100.18 ab	96.88 b-e	98.85 bc
80	98.67 b-d	97.63 b-e	98.52 b-d	100.12 ab	93.25 d-f
100	92.38 ef	90.28 f	104.97 a	92.73 ef	93.87 c-f
120	98.28 b-d	94.80 b-f	94.40 c-f	91.82 f	99.83 ab
LSD (0.05)	5.42				
CV	7.0				

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

Table 4. The interaction effect of rates of Nitrogen and seed on the number of unfilled grains of rice (Chewaka variety) at Bako and Chewaka locations

Seed rates (kg/ha)	Nitrogen rates (kg/ha)				
	35	46	58	69	81
60	13.25 c-f	13.10 d-f	12.97 d-f	14.00 b-f	16.07 ab
80	12.20 f	14.65 b-e	13.58 c-f	12.70 ef	17.23 a
100	13.15 d-f	14.43 b-f	14.92 b-e	15.48 a-c	14.47 b-e
120	13.50 c-f	14.87 b-e	12.80 ef	15.18 a-d	14.15 b-f
LSD (0.05)	0.80				
CV	19.6				

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

The number of unfilled grains showed significant differences due to the main effect of nitrogen ($p<0.01$) and their interaction ($p<0.05$) effects of Nitrogen and seed rates at both tested sites. The highest number of unfilled grains (17.23) resulted from the combination of 81 kg/ha N and 80 kg/ha seed rates even if statistically similar with 81 kg/ha N and 60kg/ha seed rates and 69 kg/ha N and 100 kg/ha seed rates (Table 4). Unlikely the lowest number of unfilled grains was observed at the lower Nitrogen and seed rates. This might be connected with when increasing seed and nitrogen rates, more unfilled grain resulted at the highest rate because of a greater number of tillers flushed and probably competition for growth resources. The result agreed with Gewaily *et al.* (2018) who depicted that with an increased rate of nitrogen application, a significant increase in the number of filled grains per panicle for all rice genotypes was observed. Similarly, Noor (2017) indicated that the more the number of spikelet produced, the less will be the number of filled grains at any rate of nitrogen application.

Analysis of variance despite some traits showing non-significant differences, Grain yield was highly significantly affected due to the main and interaction($p<0.01$) effects of Nitrogen and seed rates of rice at the test site of bako and Chewaka locations (Appendix Table 2). The highest grain yield (4880 kg/ha) was recorded from the combination of 69 kg/ha N and 120 kg/ha seed rates on rice variety (Chewaka), even if statistically par with 69 kg/ha N and 100kg/ha seed rates, 81 kg/ha N and 120 kg/ha seed rates and 58 kg/ha N and 81 kg/ha seed rates (Table 5). However, the lowest grain yield was observed when the lowest Nitrogen (35 kg/ha N) rate was combined with the highest seed (120 kg/ha and 100 kg/ha) rates.

Table 5. The interaction effect of Nitrogen and seed rates on Grain yield of rice (Chewaka variety) at Bako and Chewaka locations

Seed rates (kg/ha)	Nitrogen rates (kg/ha)				
	35	46	58	69	81
60	3937 g	3851g	4279 d-f	4647a-d	4517 b-d
80	4034 fg	4179 e-g	4798 a-c	4556 b-e	4663 a-c
100	3872g	4432 c-e	4699 a-c	4671 ab	4626 a-c
120	3872 g	4004 fg	3974 fg	4880 a	4840 ab
LSD (0.05)	289.46				
CV	8.2				

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

Table 6. The interaction effect of Nitrogen and seed rates on Above ground Biomass of rice (Chewaka variety) at Bako and Chewaka locations

Seed rates (kg/ha)	Nitrogen rates (kg/ha)				
	35	46	58	69	81
60	10195 hi	9371 i	11467 f-h	13365 a-d	13644 ab
80	11450 f-h	11478 f-h	13325 a-d	12327 c-f	14350 a
100	10747 gh	12763 b-e	12157 d-f	12221 d-f	13796 ab
120	11056 f-h	12177 d-f	11495 e-g	13546 a-c	13069a-d
LSD (0.05)	1284.22				
CV	13.1				

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

Table 7. The interaction effect of rates of Nitrogen and seed on Harvest index of rice (Chewaka variety) at Bako and Chewaka locations

Seed rates (kg/ha)	Nitrogen rates (kg/ha)				
	35	46	58	69	81
60	38.87 a-c	41.13 a	38.14 a-d	35.54 c-f	34.08 f
80	34.42 ef	37.64 b-e	35.85 b-f	37.61 b-e	33.69 f
100	35.96 b-f	34.45 ef	39.09 ab	38.10 a-d	34.41 ef
120	34.80 d-f	33.49 f	34.91 d-f	35.84 b-f	36.75 b-f
LSD (0.05)	3.36				
CV	11.5				

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

Table 8. Results of partial budget analysis for Nitrogen fertilizer and seed rates on Rice varieties (chewaka).

N rate (kg/ha)	seed rates (kg/ha)	TVC	FGy(kg/ha)	adj Gy (10%) down	GB	NB	Dominance	MC	MB	MRR (%)
35	60	2258.80	3937	3543.3	56692.8	54434		0	0.00	
35	80	2718.80	4034	3630.6	58089.6	55470.8		460.00	1036.80	225.39
46	60	2755.00	3851	3465.9	55454.4	52799.4	D			
35	100	2978.80	3872	3484.8	55756.8	52778	D			
46	80	3015.00	4179	3761.1	60177.6	57162.6		296.20	1691.80	571.18
58	60	3146.30	4279	3851.1	61617.6	58571.3		131.30	1408.70	1072.85
35	120	3338.80	3872	3484.8	55756.8	52418	D			
46	100	3375.00	4432	3988.8	63820.8	60445.8		228.70	1874.50	819.65
58	80	3520.30	4798	4318.2	69091.2	65684.9		145.30	5239.10	3605.60
69	100	4200.00	4671	4203.9	67262.4	63062.4	D			
81	80	4268.80	4663	4196.7	67147.2	62878.4	D			
69	120	4560.00	4880	4392	70272	65712		1039.70	27.10	2.61
81	100	4628.80	4626	4163.4	66614.4	61985.6	D			
81	120	4988.80	4840	4356	69696	64707.2	D			

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

The highest grain yield from the highest Nitrogen and seed rates is probably due to the application of sufficient nutrients met the plant demand and the increasing population of rice may lead to the provision of the highest yield of rice. Contrary to this, the application of less nitrogen with the highest seed rates might increase competition among the rice population and result in low grain yield. Khan *et al*. (2002) and Hameed *et al.* (2003) reported that grain yield increased as seed rate increased and the highest grain yield was noted in plots seeded at the rate of 120 kg ha^{-1} on wheat. Similar results were obtained by Pandey *et al*. (2001), who reported that increasing nitrogen rates increased grain yield. Gewaily *et al*. (2018) also reported increasing nitrogen rates from controlled to maximum level (220 kg N ha^{-1}) significantly enhanced the grain yield of rice. Similarly, Bokado *et al.* (2020) stated that increasing nitrogen levels increased the grain yield of rice due to the improvement of yield contributing characters.

Above-ground biomass significantly responded to Nitrogen and seed rates due to the main and their interaction effects of the rice (Chewaka) variety at both test sites. The highest above ground biomass yield (14350 kg/ha) was recorded from the combination of 81 kg/ha N and 80 kg/ha seed rates on rice variety (Chewaka) even if statistically similar with 69 kg/ha N and 120 kg/ha seed rates as well as when interacting 81 kg/ha N and with all seed rates (Table 6). On the other hand, the lowest (9371 kg/ha) above ground biomass was obtained from the combination of 46 kg/ha N and 60 kg/ha seed rates. The highest above ground biomass from the highest Nitrogen and seed rates might be because of optimum supply of nutrients for growth led to the flush of more tiller growth. On the other side, lowering both nitrogen and seed rates reduced tiller emergency from individual plants thereby decreasing above ground biomass. The result is in line with Iqbal *et al*. (2012) who reported increased in biomass production might be attributed to the increased plant population due to a higher seeding rate with better nitrogen application. In similar ways, Otteson *et al.* (2007) found that increasing nitrogen to optimal levels increased biological yield. Similarly, Jahan *et al.* (2020) reported that Nitrogen fertilization improved rice vegetative growth in terms of plant height and tiller number leading to increased straw yield though its effect varied with varietal response.

The Harvest index was significantly influenced due to the main ($P<0.05$) effect of Seed rates and the interaction ($P<0.01$) effects of Nitrogen and seed rates (Appendix Table 2). The highest harvest index (41.13 %) was obtained when 46 kg/ha N and 60 kg/ha seed rates even though statistically par with when 58 kg/ha N combined with 60 and 100 kg/ha seed rates. On the other hand, the lowest Harvest index resulted from the highest (81 kg/ha N) Nitrogen and 80 kg/ha seed rates even if statistically similar with when combined with the highest (120 kg/ha seed rates (Table 7). The lowest harvest index at the highest Nitrogen and seed rates was probably because of more growth of tillers at the highest nitrogen rates and the expected population competition at the highest seed rates resulted in low economic yield. Saha *et al.* (2017) also reported that the harvest index varies from cultivar to cultivar and with different levels of nitrogen.

Economic Analysis

Different nitrogen (N) levels and seed rates were combined factorially in a two-factor experiment while maintaining a uniform application of 125 kg/ha NPS rates. Thus, the partial budget analysis was done based on total variable cost considering the costs of different Nitrogen levels, seed rates and transport as well as application costs. The economic analysis was done based on adjusting 10% yield downward for the fact it is closest to the farmer yield. The result of the partial budget analysis showed that seven Nitrogen and seed rates were non-dominated with an associated MRR greater than 100% (Table 8). An additional income of 36.05 Ethiopian Birr per unit Birr invested was obtained from the combination of 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety compared to the other treatments. This analysis revealed that the interaction of 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety gave grain yield (4318.2 kg/ha) with the net benefit (65684.9 birr/ha) and the highest marginal rate of return (3605.60%) is an economically feasible compared to the other treatments (Table 8). Therefore, it is advisable to use 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety since economically feasible for the farmers.

Conclusion

The medium nitrogen and low phosphorus content of the soil reflects the demand for both Nitrogen and Phosphorus application of the soil for Bako and Chewaka sites. Even though farmers believe increasing Nitrogen and seed rates increase rice yield, the optimum yield was obtained at a certain level of the rates at the tested site. Increasing Nitrogen and seed rates to optimum levels resulted in better Grain yield of rice variety (Chewaka). From different Nitrogen and seed rates tested at Bako and Chewaka locations during the two cropping seasons, the combination of 58 kg/ha N and 80 kg/ha seed rates as well as 69 kg/ha N and 120 kg/ha seed rates gave the highest grain yield compared to the other treatments. Economic analysis revealed that from the tested treatments, 58 kg/ha N and 80 kg/ha seed rates which gave better yield, net benefit and highest marginal rate of return are economically alternative to the other treatments. Therefore, it is advisable to use the combination of 58 kg/ha N and 80 kg/ha seed rates on the Chewaka variety since economically feasible for the farmers.

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Appendices

Appendix Table 1. Mean squares of ANOVA for Days to heading, Days to maturity, Plant height, Number of effective tillers, and Thousand Seed weight of Rice in response to Nitrogen and Seed rate at Bako and Chewaka.

sources of variation		Mean squres				
		DH	DM	PH	NET	TSW
Rep	2	19.51**	2.15ns	177.09ns	2.82ns	1.45ns
Nitrogen(N)	4	11.51*	1.93ns	347.43**	0.69ns	1.47ns
Seed rate(SR)	3	10560.27**	3.28ns	89.52ns	0.38ns	1.78ns
N*SR	12	4.45ns	2.34ns	61.24ns	0.95ns	2.58*
MSE	158	3.698	2.11	64.97	1.38	3.85
CV (%)		2.2	1.2	7.4	21.7	7.2

Appendix Table 2. Mean squares of ANOVA for Panicle length, Number of filled grains, Number of unfilled Grains, Grain yield, Above-ground biomass and Harvest index of Rice (Chewaka) in response to Nitrogen and Seed rate at Bako and Chewaka.

sources of variation	Df	PL	NFG	NUFG	GY	AGBM	HI
Rep	2	6.99**	59.96ns	2.79ns	8994.ns	2934771 ns	35.74ns
Nitrogen (N)	6	1.439ns	150.42**	39.64**	5397527**	61207140 **	40.48ns
Seed Rate (SR)	1	0.82 ns	61088.50**	4.40ns	644877**	10450805 *	61.54*
N*SR	6	1.38 ns	161.85**	16.05*	590823**	9324419**	54.60**
MSE	84	1.31	45.16	7.69	128866	3618020	17.33
CV (%)		5.6	7.0	19.6	8.2	13.1	11.5