

Influence of N and P Fertilizer Rate on the Yield and Yield Components Bread Wheat in Northwestern Ethiopia

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Abstract
Bread wheat fertilizer response trial was conducted on farmers' fields at major bread wheat growing areas, Womberema and Debre Elias districts, northwestern Ethiopia in 2012 and 2013. The principal objective of the trial was to determine economic optimum rates of N and P fertilizer for these areas. Three N rates (92, 184, 276) kg/ha and three P_2O_5 rates (30, 60, 90) kg/ha were tested including previously recommended rate (138/46 kg/ha N /P_2O_5) as a control. Factorial RCBD with three replications was used. The results indicate an extremely high grain yield response to N and a lesser, but significant, response to P. Both locations responded similarly in both years for N and P levels since the three and three way interaction components (N X P, N x P X location and N x P X year) were confirmed statistically not significant. Almost all yield and yield components were responded positively with the application of N and P. The highest grain yield of 5194.1 kg/ha was recorded at the highest NP level of 276/90 kg/ha N /P_2O_5, representing a yield increase of 1681.1 kg/ ha over the control (i.e., 136/46 kg/ha N /P_2O_5) treatment.
Keywords: economic, interaction, control

1. Introduction

Bread wheat is one of the most important cereals cultivated in Ethiopia. It ranks fourth after teff (*Eragrostis tef*), Maize (*Zea mays*) and Sorghum (*Sorghum bicolor*) in area coverage and third in total production (CSA, 2014). The national average yield of bread wheat in the country is 2.4 tons/ ha (CSA, 2014). The total wheat area and production in the Amhara Region in 2014 were reported as 493,395.00 ha (27% of the country's coverage) and 1,626,604.5 tons, respectively, with the productivity of 2.1 t/ha (CSA, 2014).

The productivity of the crop in the country as well as in Amhara region is generally low compared to the potential of this crop. According to FAO (2002), declining of soil fertility has been identified as one of the most important constraints to limit food production in Ethiopia in particular and Africa in general. This is true in the highlands of Ethiopia specifically due to high human population pressure, intensification in land use, inadequate soil and water conservation measures, expansion of cropping to marginal lands and poor soil management. This low productivity can be enhanced through improved crop management practices including application of fertilizers. In Amhara region, farmers are usually applying urea and DAP based on research recommendations within the range of 100-261 kg/ha and 100 kg/ha respectively despite some resource rich farmers are rarely found to apply above this range (personal communication, 2010). Best experiences in some bread wheat producing areas of Ethiopia like Bale and Arsi zones showed the yield of bread can be maximized beyond 4 tons/ha by using N and P fertilizers as high as 6-8 tons/ha integrated with other better crop management options. Fertilizers play a pivotal role in increasing yield and improving the quality of crops.

High yielding wheat varieties demand adequate nutrient supply to produce maximum grain yield (Ali &Yasin, 1991). Determining the optimum rate of N and P fertilizer is the key to maximize the economic yields. Therefore, this work was mainly incepted to determine economical nitrogen and phosphorus rate for bread wheat in major bread wheat growing areas Northwestern Amahra region at Debre Elias and Wonberema districts. Furthermore it was also designed to know the effect of N and P on the yield of bread wheat compared to previously recommended rates under use.

2. Materials and Methods:

The Study was carried out on farmers fields of Debre Elias and Wonberema districts located in East and West Gojjam zones of Amhara Region, Ethiopia, respectively. Wonberema is located 10.27° N latitude and 37.056° E longitude with an altitude of 2600 meters above sea level (masl) while Debre Elias is located 10.3333° N latitude and 37.7167° E longitude with an altitude of 2425 masl. The minimum and maximum temperature of Wonberema is 17^0c and 25^0c respectively, while, the minimum and the maximum annual rainfall is 1386 mm and 1757 mm respectively. The mean annual rainfall of Debre Elias is 1266 mm. The average annual maximum temperature of Debre Elias is 25^0c and the average minimum temperature is 15^0c.

It was conducted in 2012 and 2013 cropping seasons. The design was randomized completed block design (RCBD) factorially arranged and replicated three times. Three N levels (92,184,276 kg/ha) and three levels of P_2O_5 (30, 60,90 kg/ha) was tested including previously recommended rate for the area (138/46 kg/ha N/P_2O_5) as a control. Nitrogen and phosphorus were applied in the form of urea and diammonium phosphate (DAP),

respectively. Whole of P and half of N was applied at sowing time and remaining nitrogen was top-dressed at tillering of the crop. A gross and net plot sizes of 5 m x 4 m and 4 m x 3 m, respectively were used. The improved bread wheat variety Tay (which originate from parents ET12D4 and HAR604) was used. All other agronomic practices were kept normal for all the treatments. Data collected on different growth, yield and quality parameters were analyzed statistically using SAS software by Fisher's analysis of variance technique and Duncan's multiple range test (DMRT) test at 1% and 5% probability level was employed to test the significance of treatment.
The mean grain yield data over sites for each location was adjusted down by 10% and economic analysis was performed following the CIMMYT partial budget (CIMMYT, 1988). Total costs that varied (fertilizer cost) for each treatments was calculated and treatments were ranked in order of ascending total variable cost (TVC) and dominance analysis was undertaken to eliminate those treatments costing more but producing a lower net benefit than the next lowest cost treatment. The marginal rate of return (MRR) was calculated for each non-dominated treatment and a minimum acceptable MRR of 100% was assumed. Sensitivity analysis was made through the assumption that costs of fertilizer increased by 10% while the price of grain decreased by 10%.

3. Results and Discussions

The response of grain yield for Nitrogen (N) was highly significant ($P \leq 0.01$) for both locations. But it was only at Debre Elias that grain yield was significantly affected by Phosphorus (P) (Table 1). The combined analysis over locations and years showed that grain yield was highly influenced both N and P (Table 1 and Table 4). Increased grain yield with higher NP levels was also reported by Maqsood *et al*. (1999) and Ali *et al*. (2000). The N by P interaction was not significant to affect grain yield in both locations and their combination (Table 1). In contrast, Minale Liben *et al*. (1998) stated that N, P and site by N interactions significantly affected all of the crop parameters except the number of spikes m^{-2}.
An increasing trend of grain yield with an application of increased N and P amount was observed despite the effect of P was in favor of N (Figure 1). The top N amount (276 N kg/ha) gave the highest yield at the top P_2O_5 level of 90 kg/ha; otherwise the biggest N rate might give even lower yield than 184 N kg/ha when combined with lower P levels (30 and 60 kg/ha P_2O_5). Grain yield was significantly varied for N and P combinations in similar fashion in all years and locations tested (Table 1-4). Generally, grain yield was ranged from 2620 kg/ha to 5194.16 kg/ha where the lowest was recorded form application of 92 kg/ha N and 30 kg/ha P_2O_5; while the highest was from application of 276 kg/ha N and 90 kg/ha P_2O_5 (Table 4). Despite the slight difference in soil properties of the two locations (Wonberema and D/Elias), the response of grain yield was similar in both locations evident form two and three way interactions (location by nitrogen, location by phosphorus, location by nitrogen by phosphorus) were not confirmed statistically significant ($P \leq 0.01$) (Table 1).
Plant height increased with N and P rates application with variation on plant height within the range of 89.4 cm-100 cm. Similar results were reported by Kausar *et al*. (1993), Ayoub *et al*. (1994) and Maqsood *et al*. (1999). Seeds per panicle and thousand seed weight were not significantly ($P \leq 0.01$) altered by both N and P. Panicle length was highly affected by the application of nitrogen. The shortest and longest panicle length of 8.4 cm and 9.1 cm were recorded respectively from the highest N rate (276 kg/ha) and the lowest N rate (92 kg/ha) tested (Table 4).
Thousand seed weight responded only for the application of nitrogen but not for the interaction of N and P. The highest N rate gave the highest thousand seed weight. Significant effects of NPK fertilizers level on 1000-grain weight were also reported by Malik *et al*. (1990), Khaliq *et al*. (1999), Maqsood *et al*. (1999) and Ali *et al*.(2000).
The economical analysis indicate that application of higher N and P amount gave a better net benefit over the lower N and P applications (Table 5). Among the different N and P amounts combined, 138 kg/ha N and 46 kg/ha P_2O_5; and 276 N kg/ha and 30 kg/ha P_2O_5 have been economically dominated since their NB became lower when their TVC increased relatively from the value before them (Table 6). Only two treatments had MRR (%) less than 100% among the none dominated ones. Therefore, for those farmers with better financial capacity and access to credit to buy fertilizer the combined application of 276 kg/ha N and 90 P_2O_5 kg/ha is recommended; however, resource poor farmers can alternatively use 184 kg/ha of N and 90 kg/ha P_2O_5 followed by 184 kg/ha N and 60 kg/ha P_2O_5 in both locations (Table7). The study also reveals that application of more N will be profitable only with higher levels of P. The control treatment (138/46 N/ P_2O_5 kg/ha) which was the previously recommended, was proven to be economically inappropriate and gave inferior yield (Table 7). This control yield (i.e., mean of 981 kg/ha) is similar to the national mean yield attained by peasant wheat farmers in Ethiopia who characteristically use little purchased crop inputs (Hailu *et al.,* 1991).

4. CONCLUSION AND RECOMMENDATION

The current study revealed that nitrogen and phosphorus fertilizers play an important role for maximizing yield of bread wheat. The synergic effect of N and P was also apparent than their indivuial effect. Application of more doses of N and P than previously recommended rate (136/46 N/ P_2O_5 kg/ha) were found to be more economical for bread wheat production at Wonberema and Debre Elias districts. According to the results, for both areas 276 kg/ha N and 90 kg/ha P_2O_5) is recommended to get maximum yield and economic advantage of bread wheat production in Wonberma and Debre elias woredas. Resource poor farmers who are not capable of buying higher amounts of Urea and DAP fertilizers at the time of planting can use 184/90 N/ P_2O_5 kg/ha and 184/60 N/ P_2O_5 kg/ha as secondary and tertiary choices, respectively. Since the increment trend of grain yield with N and P was not ceased to their maximum tested rates, more rates should be experimented in the future to investigate the declining point of the economical yield for these locations.

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Table 1 over all ANOVA for major sources of variations at Wonberema and D/Elias combined in 2012/2013 and 2013/14

Source of variation	Wonberema				D/Elias				Combined over locations						
	PH	TN/hill	BY	GY	PH	TN/hill	BY	GY	PH	TN/hill	BY	GY	SL	SPS	TSW
Nitrogen(N)	**	Ns	**	**	**	**	**	**	**	ns	**	**	**	ns	*
Phosphorus(P)	*	ns	ns	ns	**	**	**	**	**	ns	**	**	ns	ns	ns
Year(Y)	**	**	*	**	**	*	**	**	**	**	*	**	ns	**	ns
Location(L)	-	-	-	-	-	-	-	-	**	**	**	ns	**	**	ns
N x P	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
N x P x L	-	-	-	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns
N X P X L X Y									ns	ns	ns	ns	ns	ns	ns

PL=plant height, ST=stand count, TN= tiller number/hill, SL=spike length, SPS=seeds per spike, GY=grain yield, BY=biomass yield, TSW =1000 seed weight,

Table 2 Response of bread wheat yield and yield components to N and P at Womberema - combined over years

Treatment	Plant height(cm)	Tiller number/m2	Fresh biomass kg/ha	Grain yield (kg/ha)
		Nitrogen(N)		
92	95.4B	5.0	5925.9B	3162.57 B
184	101.3A	5.3	8761.1A	4566.82 A
276	101.9A	5.1	9713.0A	4979.06 A
$P_{0.05\&0.01}$	<.0001	0.61	<.0001	<.0001
		Phosphorus (P)		
30	97.4B	5.0	7564.8	3877.57
60	100.5A	5.3	8296.3	4399.30
90	100.8A	5.1	8538.9	4431.58
$P_{0.05\&0.01}$	0.0349	0.7630	0.2133	0.2496
		N XP interaction		
92/30	91.7C	4.7	4777.8C	2666.71
92/60	96.5BC	5.3	6305.6BC	3343.03
92/90	98.1AB	4.9	6694.4BC	3478.26
184/30	99.7AB	5.2	8361.1AB	4212.59
184/60	103.0A	5.5	9027.8A	4773.01
184/90	101.3AB	5.3	8894.4A	4714.99
276/30	100.7AB	5.1	9555.6A	4753.67
276/60	102.1AB	5.1	9555.6A	5082.16
276/90	103.0A	5.0	10027.8A	5101.50
C- 138/46	96.6	4.7	7167	4000.00
CV	5.3	28.2	25.7	32.0

PL=plant height, ST=stand count, TN= tiller number, GY=grain yield, BY=biomass yield, HLW=hectoliter weight, TSW =1000 seed weight P=probability, CV= coefficient of variation, C=control

Table 2.1.3: Response of N and P on the yield and yield c 3 Response of N and P on the yield and yield components of bread wheat at Debre Elias -

Table 3 Response of bread wheat yield and yield components to N and P at Debre Elias - combined over years

Treatment	Plant height(cm)	Tiller number/m2	Fresh biomass kg/ha	Grain yield (kg/ha)
		Nitrogen (kg/ha)		
92	88.9B	3.4A	5138.9B	3014.54 B
184	93.1A	2.5B	6805.6B	4077.36 A
276	93.9A	2.5B	7625.0A	4405.84 A
$P_{0.01\&0.05}$	<.0001	0.0023	<.0001	0.0002
		Phosphorus (P_2O_5kg/ha)		
30	89.2C	3.3A	5472.2B	3188.45B
60	92.1B	2.6B	6416.7B	3787.41B
90	94.6A	2.4B	7680.6A	4521.74A
$P_{0.01\&0.05}$	<.0001	0.0050	0.0002	0.0005
		N x P interaction		
92/30	86.0D	4.0A	3958.3D	2550.68
92/60	88.1D	2.9BC	5333.3DC	2956.52
92/90	92.7AB	3.2AB	6125.0BC	3536.28
184/30	90.1BC	3.0BC	5791.7C	3536.28
184/60	93.4AB	2.7BC	6833.3BC	4000.00
184/90	95.7A	2.0C	7791.7BC	4695.65
276/30	91.6ABC	3.0BC	6666.7BC	3478.26
276/60	94.8A	2.4BC	7083.3BC	4405.84
276/90	95.5A	2.1C	9125.0A	5333.29
Control- 138/46	89.8	3.6	4125	2782.61
CV	3.5	27.3	22.3	24.5

PL=plant height, ST=stand count, TN= tiller number, GY=grain yield, BY=biomass yield, HLW=hectoliter weight, TSW =1000 seed weight, P=probability, CV= coefficient of variation

Table 4 Response of bread wheat grain yield and yield components to N and P combined over years and locations

Treatment	Plant height(cm)	Tiller number/m2	Fresh biomass kg/ha	Grain yield (kg/ha)	SL(cm)	SPS	TSW(g)
			Nitrogen (kg/ha)				
92	92.8B	4.3	5611.1C	3103.44 B	8.4B	42	44.8B
184	98.0A	4.2	7978.9B	4371.06 A	8.9A	45	46.4A
276	98.7B	4.0	8877.8A	4749.77 A	9.1A	45	46.0AB
$P_{0.01\&0.05}$	<.0001	0.3685	<.0001	<.0001	<.0001	0.0670	0.0198
			Phosphorus (P_2O_5kg/ha)				
30	94.1B	4.3	6727.8B	3601.95 B	8.8	44	45.6
60	97.2A	4.2	7544.4A	4154.57 A	8.9	45	45.8
90	98.3A	4.0	8195.6A	4467.62 A	8.7	44	46.1
$P_{0.01\&0.05}$	<.0001	0.3380	0.0007	0.0019	0.7162	0.7449	0.3038
			Nitrogen x Phosphorus				
92/30	89.4C	4.4	4450.0D	2620.24	8.4	41	44
92/60	93.1BC	4.4	5916.7DC	3188.45	8.4	42	44
92/90	95.9AB	4.2	6466.7C	3501.50	8.5	43	46
184/30	95.9AB	4.3	7333.3BC	3941.98	8.9	45	46
184/60	99.2A	4.4	8150.0BA	4463.72	8.9	45	46
184/90	99.1A	4.0	8453.3BA	4707.20	9.0	44	46
276/30	97.0AB	4.3	8400.0BA	4243.48 BAC	9.2	44	45
276/60	99.2A	4.0	8566.7BA	4811.55	8.9	45	46
276/90	100.0A	3.8	9666.7A	5194.16	9.1	46	47
Control-138/46	93.8	4.3	5950.0	3513.04	8.5	42	45
CV	4.7	29.3	25.0	29.8	12.26	15.72	10.06

PL=plant height, ST=stand count, TN= tiller number, SL=spike length, SPS=seeds per spike, GY=grain yield, BY=biomass yield, HLW=hectoliter weight, TSW =1000 seed weight P=probability, CV= coefficient of variation

Table 5 Amount of input, total variable cost, gross and net benefit analysis for the bread wheat N and P fertilizer experiment

Trt#	N	P_2O_5	GY(kg/ha)	Adjusted GY(kg/ha)	DAP (Kg/ha)	Urea (kg/ha)	TVC	Gross Benefit (Birr/ha)	Net Benefit (Birr/ha)
1	92	30	2620.24	2358.216	65.2	174.5	3534.2	16507.5	12973.3
2	92	60	3188.45	2869.605	130.4	149.0	4056.4	20087.2	16030.8
3	92	90	3501.5	3151.35	195.7	123.4	4578.6	22059.5	17480.9
4	184	30	3941.98	3547.782	65.2	374.5	6546.2	24834.5	18288.3
5	184	60	4463.72	4017.348	130.4	349.0	7068.4	28121.4	21053.1
6	184	90	4707.2	4236.48	195.7	323.4	7590.6	29655.4	22064.8
7	276	30	4243.48	3819.132	65.2	574.5	9558.2	26733.9	17175.7
8	276	60	4811.55	4330.395	130.4	549.0	10080.4	30312.8	20232.4
9	276	90	5194.16	4674.744	195.7	523.4	10602.6	32723.2	22120.6
control	138	46	3513.04	3161.736	100.0	260.9	5318.7	22132.2	16813.5

Key: SR=seed rate kg/ha, N=nitrogen kg/ha, P=phosphorus, TVC=total variable cost
Cost of Urea =15.06 birr/kg
DAP=13.90 birr/kg
Cost of wheat grain= 7 birr/kg

Table 6 Dominance Analysis

N level (kg/ha)	P2O5(kg/ha)	TVC (birr/ha)	Net Benefit (Birr/ha)	Dominated (D)
92	30	3534.2	12973.3	
92	60	4056.4	16030.8	
92	90	4578.6	17480.9	
138	46	5318.7	16813.5	dominated
184	30	6546.2	18288.3	
184	60	7068.4	21053.1	
184	90	7590.6	22064.8	
276	30	9558.2	17175.7	dominated
276	60	10080.4	20232.4	
276	90	10602.6	22120.6	

Table 7 Analysis of marginal rate of return (MRR %)

N level (kg/ha)	P2O5 (kg/ha)	TVC	Net Benefit (Birr/ha)	MRR	MRR %	Rank
92	30	3534.2	12973.3			
92	60	4056.4	16030.8	5.855	585.517	
92	90	4578.6	17480.9	2.777	277.679	
184	30	6546.2	18288.3	0.410	41.035	
184	60	7068.4	21053.1	5.295	529.454	3rd
184	90	7590.6	22064.8	1.937	193.747	2nd
276	60	10080.39	20232.3794	-0.736	-73.596	
276	90	10602.58	22120.6296	3.616	361.600	1st

The letter D indicates the treatment is dominated to be removed from the competition

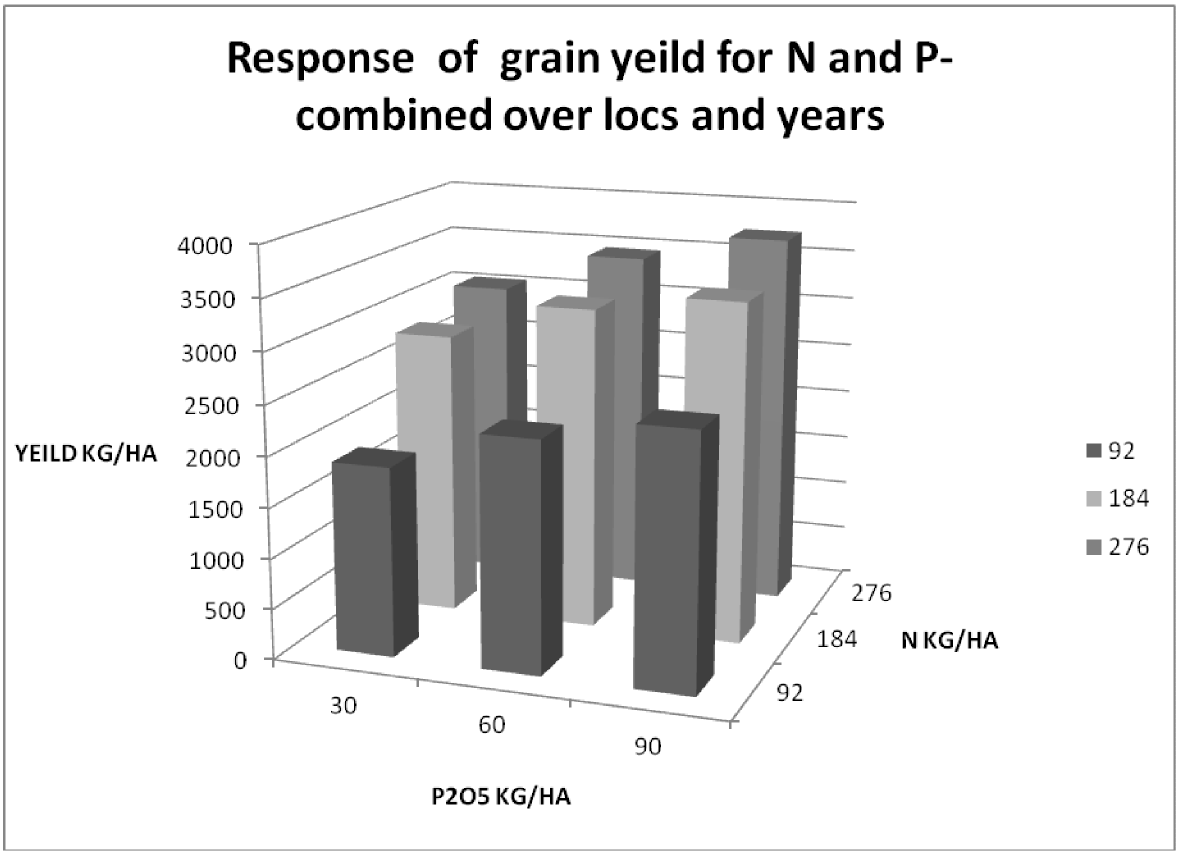

Figure 1 The response of grain yield for N and P application

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