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Determination of Economically Optimum Nitrogen Fertilizer for Bread Wheat in Shashemene District, West Arsi Zone of Oromia, Ethiopia

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Abstract
The objective of this study was to determine the bread wheat's ideal level for nitrogen fertilizer applications on Eutric andosol. The treatments included phosphorus (0, 10, 20, 30, 40kg/ha) and nitrogen (0, 46, 69, & 92kg/ha) at four levels each in a factorial combined effect of complete block design with three replications. a 3m x 3m plot with a 150kg/ha seed rate was used. Wheat variety called "Ogolcho" was applied to evaluate the treatments. The results from the analysis of variance demonstrated that there were significant differences (p 0.05) between all of the applied treatments. The application of 46kg/ha N and 92kg/ha P2O5 together resulted in the highest grain yield (5358kg/ha), while the lowest grain yield was obtained. at the control treatment.. However, there are no significant differences ($p<0.05$) between the combined effects of Nitrogen and phosphorous fertilizers levels above 46kg/ha on grain yield response. This implies that the application of N and P2O5 greater than 46kg/ha may not be economically important. Therefore, 69 N kg ha-1 N fertilizers was determined as economically feasible optimum N rates at 2655%, MRR on Eutric andosol in Shashemene district for Bread wheat.
Key Words/phrases: Economically, Optimum Nitrogen Fertilizer, Bread Wheat
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Introduction
With an estimated 1.6 million acres, Ethiopia is the second-largest producer of wheat in sub-Saharan Africa (CSA, 2015). Yet, due to declining soil fertility, wheat output is quite poor (Wogene, 2017). Ethiopia is one of the sub-Saharan African nations where agricultural crop production and economic growth are severely constrained (Scoones and Toulmin, 2004). The inefficient use of limited financial resources increased production costs, and significant environmental problems result from the blanket application of fertilizer that fails to take into account the soil fertility status and crop nutrient requirements (Tarekegne, 2001). Soil test-based fertilizer recommendations are crucial for ensuring agricultural production gets economical and balanced nutrients.

Objectives:
- To determine the economically optimum level of nitrogen fertilizer for wheat production in the study area

Material and Methods
Site description
The activity took place in Ethiopia's West Arsi Zone's Shashemene regions. The Shashemene districts are situated in 38° 56' N, 7° 23' E, and have an average elevation of 2002 meters above sea level. The district's rainfall distribution is bimodal, with the main rainy seasons Meher and the small rainy season Belg (March to June) (July-November). The mean annual average temperature is 19.7, and there is 1520 mm of total yearly rainfall.

In terms of soil type, andosol is the most prevalent soil unit in the Shashemene district. Sandy loam is the texture type assigned to the local soils. The main crops grown in this area are wheat, barley, potatoes, maize, and teff.

Site selection
The district's office of agriculture and natural resources assisted in the selection of potential wheat-growing regions in the area. To measure the overall soil pH, nitrogen content, and phosphorous content, composite soil samples were taken from the chosen location

Treatments and Experimental design
In three locations or PAs that had the capacity to produce wheat, the study was carried out. To ascertain the district's optimal level of nitrogen from an economic perspective, tests were done at six farmer's fields. Hence, four levels of N (0, 46, 69, and 92 kg ha1) and four levels of P (0, 10, 20, 30, and 40 Kg ha1) were combined in a factorial design with three replications set up using a randomized complete block design (RCBD). Before planting, representative composite soil samples from 0 to 20 cm depth were taken from each farmer's field. The test was conducted using the recently released enhanced wheat variety called Ogolcho.

Table 1: Treatment Combinations for determination of optimum Nitrogen

Treatments (N,P) levels				
(0,0)	(0,10)	(0,20)	(0,30)	(0,40)
(46,0)	(46,10)	(46,20)	(46,30)	(46,40)
(69,0)	(69,10)	(69,20)	(69,30)	(69,40)
(92,0)	(92,10)	(92,20)	(92,30)	(92,40)

Data collection

Physiochemical properties, such as pH, available phosphorous, EC, Total nitrogen, and soil texture were analyzed. In addition, yield data was collected and recorded.

Data management and Analysis

All will be collected across locations and will be properly managed using the EXCEL computer software. The collected data were subjected to the analysis of variance using the SAS/STAT computer package version 9.0 (SAS Institute, 2001). Statistical (Minitab-19) was used to develop graphs and correlation analysis

Economic Analysis

Economic analysis was performed to investigate the economic feasibility of the treatments. Partial budget and MRR (%) analyses were used to determine the economic analysis (CIMMT, 1988). The average open market price (Birr kg^{-1}) for different crops and the official prices of N, P, and K fertilizers were used for analysis.

The marginal rate of return **(MRR) was calculated** using the formula given below.

$$\mathbf{MRR} = \frac{\textbf{Net Income From Fertilized Field} - \textbf{Net Income From Unfertilized Field}}{\textbf{Total Variable Cost From Fertilizer Application}}$$

Total variable cost is a cost incurred due to the application of P fertilizer (both but in separate of Soil test based P calibration result and farmers' fertilizer rate) with the assumption that the rest of the costs incurred are the same for all treatments.

Gross income is obtained by multiplying the mean grain yield (kg/ha) of each treatment by the price of one kg of the grain. ***Net income*** is calculated by subtracting the total variable cost from the gross income.

Result and Discussion

Soil physicochemical characteristics of the study sites

Composite soil samples were collected from each experimental site to characterize the physicochemical properties. The following (table1) showed the soil laboratory analysis to determine the physical and chemical properties of the sites before planting.

Table1: Soil physiochemical properties of experimental sites before application

Sites	Soil properties				
	Soil pH	Initial Ava. P in ppm	SOC (%)	Total N (%)	C: N
1.	6.50	7.72	3.66	0.14	26.14
2.	5.98	10.00	2.83	0.17	16.65
3.	6.50	7.40	2.66	0.15	17.73
4.	7.20	31.00	2.37	0.14	16.93
5.	6.75	13.18	2.82	0.17	16.59
6.	7.35	18.82	2.96	0.18	16.44
7.	7.12	20.76	2.83	0.15	18.87
8.	6.50	11.20	2.66	0.22	12.09
9.	6.50	15.04	2.83	0.14	20.21
10.	5.98	14.12	2.98	0.17	17.53
11.	6.50	19.96	2.68	0.15	17.87
12.	7.20	12.28	2.37	0.14	16.93
13.	6.75	13.32	2.82	0.17	16.59
14.	7.35	18.88	2.96	0.18	16.44
15.	7.12	20.24	2.83	0.15	18.87
16.	6.50	17.84	3.16	0.22	14.36

17.	6.78	14.22	3.71	0.25	14.84
18.	6.40	10.56	3.66	0.22	16.64
19.	6.90	15.04	2.99	0.18	16.61
20.	6.50	7.72	2.79	0.14	19.93
Mean	**6.71**	**14.96**	**2.92**	**0.17**	**17.41**

Soil pH: soil pH is an indicator of soil acidity or alkalinity level. Accordingly, the average pH levels of the study sites were 6.71 which is in the acceptable range for optimum crop production (table1). The level of pH usually affects the availability of major crop nutrients. The desirable soil pH range for optimum plant growth varies among crops. Generally, a soil pH of 6.0-7.5 is recommended for most plants as most nutrients become available in this pH range (US Environmental Protection Agency, 2004).

Soil Organic Carbon: Soil organic carbon is a measurable component of soil organic matter. It is an indicator of the potential of soil nutrient retention and turnover, soil structure, moisture retention, and carbon sequestration. As it is indicated in table 1, the average SOC of the study site was 2.92%. The study by Emanuel et, al, 2018 also showed that soil organic carbon on agricultural land varies from 1.34-to 9.75% depending on its degree of degradation and land management.

Total Nitrogen: Total Nitrogen (Tot N) exists in organic forms and inorganic (or mineral) forms such as plant available ammonium (NH_4^+) and nitrate (NO_3^-). It was identified that the soil total nitrogen content of the study area was 0.17% which is found to be classified as low (table1). The majority of Tot N is bound in soil organic matter. Soil microorganisms decompose organic matter to liberate energy stored in chemical bonds to fuel their activity and to harvest carbon and nitrogen to build their biomass. Soil biota requires nitrogen for the synthesis of their proteins and other nitrogen-containing organic molecules. As dynamic microbial populations grow, if there is insufficient nitrogen in the organic matter they are decomposing they can out-compete crop plants for inorganic nitrogen. This is called immobilization. Conversely, if the organic matter contains sufficient nitrogen to satisfy microbial demands, excess inorganic N is released to crop plants (Harold van, et.al, 2020)

The economically optimum level of Nitrogen fertilizer

The maximum grain yield (5358kg/ha) was obtained at the combined application of 46kg/ha N and 92kg/ha P_2O_5 while the lowest grain yield (1873kg/ha) was obtained at the control treatment. A similar study by Shaver (2014) indicated that optimum yield can be gained in the presence of all available essential nutrients at a balanced and optimum level where phosphorus and nitrogen are the most deficient essential nutrient in the country. The main effect of nitrogen fertilizer significantly ($p<0.05$) affects the grain yield. It was significantly varied from 2428kg/ha to 4587kg/ha in applying 46kg N and 92kgN respectively (table). However, there are no significant differences ($p<0.05$) between the combined effects of Nitrogen and phosphorous fertilizers levels above 46kg/ha on grain yield response. This implies that the application of N and P_2O_5 greater than 46kg/ha may not be economically important. On the other hand, a partial economic analysis was conducted to determine the economically optimum level of nitrogen fertilizer. Accordingly, a maximum net benefit of 114425.00 birrs was obtained where 69kg/ha N was applied. For a treatment to be considered as worthwhile to farmers, 100% marginal rate of return (MRR) was the minimum acceptable rate of return Dejene et al, 2020. Therefore, 46 N kg ha-1 N fertilizers was determined as economically feasible optimum N rates at 2655%, MRR on Eutric andosol in Shashemene district for Bread wheat.

Table2: Partial budget analysis

No.	N-levels	UREA in kg	Unit price	TVC	Grain YLD	Unit price	Gross Benefit	Net Benefit	MRR (%)
1	0	0	15	0	2297.00	25	57425	57425	0
2	46	100	15	1500	3950.00	25	98750	97250	2655
3	69	150	15	2250	4667.00	25	116675	114425	2200
4	92	200	15	3000	4509.00	25	112725	109725	2076

Table 3: Response of wheat grain yield to NP fertilizers application

Level of N in kg/ha	**Level of phosphorous(P2O5) in kg/ha**			
	0	23	46	92
0	1873g	2154fg	2308fg	2853defg
46	2428efg	3516cdef	4498abc	5358a
69	3886bcde	4093abcd	4600abc	4891abc
92	4587abc	5106ab	5319a	4626abc
LSD (5%)	1466			
CV	12.47			

Conclusion and Recommendations

An experiment to determine the economically optimal nitrogen fertilizer was conducted on one year of the growing season (2018) for bread wheat in the Shashemene area. Nitrogen fertilization at 46 kg/ha N was determined to be the economic maximum that farmers and other users should use in connection with wheat production in this area. Therefore, a 46 N kg ha-1 N fertilizer was recommended as the optimal economically viable N rate on Eutric andosol. Further validation of results in farmland could be a preliminary study before pushing the technology to users.

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