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Effect of phosphorus and determination of optimum nitrogen for bread wheat in Kofele District, West Arsi Zone of Oromia, Ethiopia

Tilahun Firomsa¹, Abdurahman Husien^{1*}, Kafyalew Assefa², Tilahun Abera¹, Amante Lemma¹, Chali Hundessa¹

¹Batu Soil Research Center, P.O. Box 59, Batu Oromia, Ethiopia, ²Oromia Agricultural Research Institute, P.O. Box 108, Finfinne Oromia, Ethiopia

ABSTRACT

Optimum nutrients are basic for proper and balanced fertilizer recommendations as paramount importance in order to confirm food security and increase crop productivity in a sustainable way for farmers and other stakeholders. Soil test based crop response phosphorus calibration study for bread wheat at Kofele District in 2016 with objectives to determine the optimum nitrogen of bread wheat to nitrogen-fertilizer applications in soils and to give quantitative guidelines and recommendations of nitrogen-fertilizer for bread wheat on Eutric Vertisols. The study was conducted on farmers' fields across the district. The treatments considered for optimum nitrogen determination were four levels of nitrogen (0, 46, 69 & 92) and phosphorus (0, 23, 46 & 92) fertilizer included in the treatments. The treatments were arranged in a factorial combination of complete block design with two replications. The plot size of 5mx4m with a seed rate of 150kg/ha a variety of Ogolcho which had been recommended for the area was used. The analysis of variance showed that there were significant differences ($p < 0.05$) among treatments application for all locations. The highest grain yield was obtained on the application 69N kg/ha with no application of phosphorus fertilizers on Eutric Vertisols. Minimum grain yield was obtained on the control plots at all sites. Optimum determination with the partial budget analysis made using the annual average bread wheat grains prices showed that 69 kg N ha⁻¹ gave a marginal rate of return of 119.46%, which is above the acceptable minimum rate of return. Therefore, future research should focus on soil test crop response based phosphorus calibration study of on the result optimum nitrogen of the farmland could be a pre request of the technology before to the end user.

KEYWORDS: Optimum nitrogen, soil test, bread wheat.

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***Corresponding Author:**

Abdurahman Husien

Email: abdurahmanh2010@gmail.com

INTRODUCTION

Wheat (*Triticum* spp.) is one of the world's most important staple foods for about one third of the world's population [1]. Among many wheat plants, only three species are commercially important. These are bread wheat (*Triticum aestivum*), durum wheat (*Triticum durum*) and emmer wheat (*Triticum compactum*) [2]. Ethiopia is the second largest producers of wheat in sub-Saharan Africa with an estimated area of 1.6 million ha [3]. However, the Ethiopia government is forced to import wheat ever year because of high demand than supply [4].

Soil fertility decline is one of the principal factors contributing to low productivity of crops and food insecurity in Ethiopia [5]. Nitrogen is one of the most important nutrients limiting yield of bread wheat in Ethiopian highlands. Likewise, application of a

large amount of N fertilizer has been a method of increasing yield in the study area which is costly and can cause environmental pollution [6]. In Ethiopia, the blanket recommendations that are presently in use all over the country were issued several years ago, which may not be suitable for the current production systems [7]. For this reasons, the blanket recommendation will make inefficient use of these expensive nutrients which contribute to the depletion of scarce financial resources, increased production costs and potential environmental risks [8].

N rate significantly influenced grain yield, protein content, and N uptake efficiency, N biomass production efficiency, and N utilization efficiency, N use efficiency for grain and N use efficiency for protein yield. Time of N application had highly significant effect on grain yield, protein content and NUE traits [9]. The results of this experiment indicated increase

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in grain yield and agronomic efficiency with mineral nitrogen fertilization. Considering the output from this investigate, it can be concluded that nitrogen applied at the rate of 46 kg/ha enhanced wheat productivity and produced the maximum grain yield per nitrogen unit increase and showed the greatest agronomic efficiency [5]. The establishment of a reliable soil test is able to assist in the determination of P and N requirements. Likewise, these were followed by a calibration to relate soil test numerical value with field nutrient response in the form of crop yield from the addition of the fertilizer nutrient to the soil [10]. Therefore, the objectives of this study were to determine economically optimum N fertilizer for bread wheat in kofole district and establish agronomic recommendation for optimum P fertilizer rate on bread yield for the study area.

MATERIALS AND METHODS

Descriptions of Study Area

The interaction of phosphorus and nitrogen with determination of optimum nitrogen for bread wheat in Kofole District for one year during the main cropping seasons in Kofole District of West Arsi Zone, in the central highlands of Ethiopia (Figure 1). Accordingly, bread wheat is grown mainly by subsistence farmers which is located at 06° 50' to 07° 09' N and 38°38' to 39°04' E at a distance of about 280 km Southeast of Addis Ababa and at an altitude of 2620 m above sea level.

The area is characterized by high altitude in the humid temperate climatic zones. According to National Ethiopia Meteorology agency Station records from the experimental field was under continuous cereal production for long time. The

long-term (1998-2018) mean total annual rainfall is 1036 mm with mean maximum and minimum temperatures of 19.64 and 7.53°C, respectively. The environment is seasonally humid and major soil type of the trial sites is Eutric vertisols. The coldest month is July whereas March is the hottest month (Figure 2). Monthly rainfall during the cropping season, long term average rainfall, maximum and minimum monthly average temperature of Kofole District.

Experimental setup

A composite soil samples were collected from farmer fields before planting i.e. 20-30 sub samples with 0-20cm depth by zigzag method. So that available phosphorus was analyzed using Olsen method. Accordingly, the value of soil test range from very low to very high (very low, low and medium P soils) were selected as test with a minimum of six (6) sites.

The treatments considered for optimum nitrogen determination were four levels of nitrogen (0, 46, 69 & 92) and phosphorus (0, 23, 46 & 92) fertilizer included in the treatments. The treatments were arranged in factorial combination of complete block design with two replications. The plots size were 4mx5m with Ogocho variety at seed rate of 150kg/ha. On other hand practices, hand weeding, herbicide application, and disease/pest protection were controlled according to the recommendations for the locality and/or farmers practice.

Data collection: The agronomic data like grain yield, aboveground total biomass, thousand seed weight, test weight, panicle length and plant height (average of 5 plants). A total biomass and grain yields recorded on plot basis were collected and converted to kg ha⁻¹ for statistical analysis.

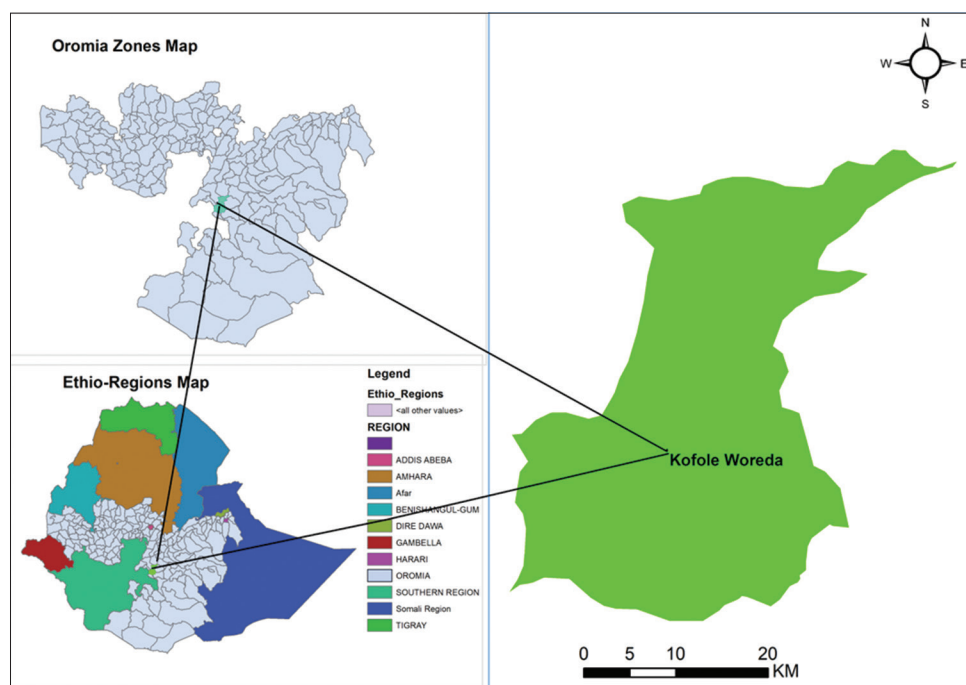


Figure 1. Maps of the study area

Economic analysis: To identify the Economic significance of the treatments, Partial budget analysis was employed and calculates the marginal rate of return (MRR) [11] (CIMMYT, 1988), the treatments were significance, and economic analysis was done for optimum nitrogen fertilizer determination. The grain yield was adjusted by 10% to reduce the exaggeration of small plot management.

Data Management and Analysis: All agronomic and soil data which were collected across locations was properly managed using the EXCEL computer software. The collected data were subjected to the analysis of variance using the SAS computer package version 9.0 [12] (SAS Institute, 2002) statistical software.

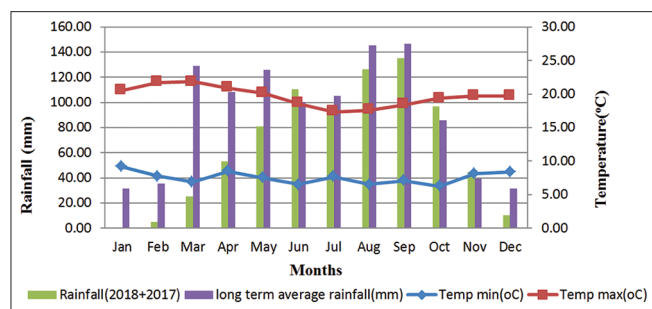


Figure 2. Monthly rainfall 2017 & 2018, long term average rainfall, maximum and minimum monthly average temperature of Kofole District

Table 1: Mean grain yield of bread wheat as influenced by different rate of nitrogen fertilizer at Kofole District

Treatments	GYLD (Kg ha ⁻¹)			
	Nitrogen	Phosphorus		
		0	23	46
0	2309.4 ^d	2896.9 ^{dc}	3715.6 ^{bac}	3562.5 ^{bac}
46	3187.5 ^{bcd}	3531.3 ^{bac}	4140.6 ^{ba}	4250 ^{ba}
69	3928.1 ^{bac}	3581.3 ^{bac}	3715.6 ^{bac}	4281.3 ^a
92	3193.8 ^{bdc}	3546.9 ^{bac}	3625 ^{bac}	3875 ^{bac}
CV(%)	30.18			
LSD (<0.05)	1072.3			

Means followed by the same letter with in the same column of the respective treatment are not significantly different (P ≤ 0.05), CV = Coefficient of variation, LSD = Least Significant differences, NS = not significant

Table 2: Partial budget analysis on optimum nitrogen determination for bread wheat at Kofole District

Urea N(kg/ha)	DAP P(kg/ha)	AGY (kg/ha)	GFB (EB/ha)	TVC (EB/ha)	NB (EB/ha)	MRR (%)
0	0	2078.46	11431.53	1039.23	10392.30	0.00
0	50	2607.21	14339.66	2084.61	12255.05	178.19
100	0	2868.75	15778.13	2731.38	13046.75	122.41
0	100	3344.04	18392.22	3234.02	15158.20	420.07
150	0	3535.20	19443.60	3713.10	15730.50	119.46
150	50	3222.90	17725.95	4337.95	13388.00	525.40
100	100	3726.00	20493.00	4722.00	15771.00	620.49
150	100	3343.50	18389.25	5179.25	13210.00	301.13
100	200	3825.00	21037.50	6333.50	14704.00	129.43

TC = total cost, NB = net benefit, MC = marginal cost, MB = marginal benefit and MRR = marginal rate of return

RESULTS AND DISCUSSION

Phosphorus and determination of optimum nitrogen for bread wheat in kofele district on Eutric Vertisols. Accordingly, a field experiment was designed and studied to identify bread wheat response to the applied N and P from 2016 on six (6) farm lands. Likewise, two sites were fall under very low available phosphorus while the other three and one sites were categorized under low and medium available phosphorus respectively

Yield of Bread Wheat for Optimum Nitrogen Response

The analysis of variance showed that interaction mean revealed that the effects of phosphorus and nitrogen were significant (P < 0.05) for all location (Table 1). The highest grain yield was obtained from the application N and P with interaction of 69 N kg ha⁻¹ with no application of P on Eutric Vertisols. Likewise, minimum grain yield was obtained on the control plots interaction at all sites. This study in line with [13]. optimum yield can be gained in the presence of all available essential nutrients at balanced and optimum level where phosphorus and nitrogen are the most deficient essential nutrient in the country. Therefore, determination of optimum nitrogen fertilization level during P fertilizer calibration is the most important procedure. Hence, determination of optimum nitrogen fertilization level was done by partial economic analysis procedure, which is 46 kg N/ha for teff on Eutric vertisols soil for Lume area. They reported that increasing nitrogen rates increase in grain yield according to [11]. found that application of 150 kg ha⁻¹ gave the highest grain yield.

Economic analysis: To identify treatments with the optimum return to the farmer's investment, marginal analysis was performed on non-dominated treatments. For a treatment to be considered as worthwhile to farmers, 100% marginal rate of return (MRR) was the minimum acceptable rate of return [15]. Therefore, 69 N kg ha⁻¹ N fertilizers was determined as economically feasible optimum N rates at 119.46%, MRR on Eutric Vertisols in Kofele district for Bread wheat. In addition, during optimum determination the partial budget analysis made using the annual adjusted average bread wheat grains prices showed 69 kg N ha⁻¹ gave a marginal rate of return of 119.46%, which is above acceptable minimum rate of return (Table 2). In

this study, the highest net benefit was obtained from application of 69 kg N ha⁻¹. This study in line with [13]. The partial budget analysis indicated that the least total variable cost (TVC) was recorded by control treatment, while the highest net income was obtained from N level 200 kg ha⁻¹. The Marginal rate of return were found to be range from 466.77% in N level 300 kg ha⁻¹ to 712.51% in N level 200 kg ha⁻¹ (92 kg N ha⁻¹ and 92 kg P ha⁻¹).

CONCLUSION AND RECOMMENDATIONS

Optimum nitrogen determination experiment had been conducted on bread wheat for one year (2016) of growing season in kofole district. Accordingly as the results of field work clearly revealed that the highest grain yield was obtained from the application N and P with interaction of 69 N kg ha⁻¹ with no application of P on Eutric Vertisols. Likewise, minimum grain yield was obtained on the control plots interaction at all sites. Therefore, 69 N kg ha⁻¹ N fertilizers were determined as economically feasible optimum N rates on Eutric Vertisols for Bread wheat. In addition, during optimum determination the partial budget analysis made using the annual adjusted average bread wheat grains prices showed 69 kg N ha⁻¹ gave a marginal rate of return of 119.46%, which is above acceptable minimum rate of return. Furthermore, a successful fertilizer recommendation program depending on the results of soil test crop response based calibration study which is conditional on rainfall and soil moisture status which influences the response of crops and yield to a greater extent than fertilizer applications. Farther verification of the result on farm land could be a pre request before disseminating the technology to the user.

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