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Effect of the Time and Rate of N-Fertilizer Application on Growth and Yield of Wheat (Triticum aestivum L.) at Gamo-gofa Zone, Southern Ethiopia

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Abstract
There is little knowledge among farmers on the time and rate of N-fertilizer application at Gamo-gofa. Therefore, there is a need to determine time and rate of N-fertilizer application on growth and yield of wheat. Accordingly, an experiment were conducted to evaluate the effect of the time and rate of N-fertilizer application on yield and yield components of wheat on two locations at Gamo-gofa, Southern Ethiopia in 2014 and 2015 cropping season. A factorial combination of the time (at planting, 15 and 30 days after planting) and rate (0, 23, 46, 69 and 92 k.gha^{-1}) of N-fertilizer application were arranged in split plot. Time and rate of N-fertilizer and their interaction had significantly affected days to heading, plant height, number of tiller, panicle, thousand seed weight, grain, straw and total biomass yields. Also year and location had significantly affected days to maturity and spike length. Whereas location had significantly affected days to heading and spike length; but year had significantly affected plant height, biomass, straw yield, thousand seed weight and grain yield. Meanwhile time and rate of N-fertilizer and there interaction, and location had not significantly affected days to maturity and harvest index; but year had significantly affect. The additive effect of fertilizer applied with the rate of 23, 46, 69 and 92 kg ha^{-1} at thirty days after planting; minimize the date of heading by six days compared with fertilizer applied at the time of planting in the rate of 0, 23, 46 and 69 kg ha^{-1}. Planting at Bonke woreda had hastened the day for heading by one day compared with planted at Chencha woreda. Wheat planted in 2014 was delayed the date of maturity by twenty days compared with planted in 2015. Planting of wheat at Bonke woreda hasted the day for maturity by nineteen days compared with planting at Chencha woreda. The additive effect of 69 kg ha^{-1}N-fertilizer applied at thirty days after planting had contributed for 16.5 cm in increments in height than control. Wheat which, planted in 2014 had 6.8 cm more plant height than planted in 20015. Fertilizer applied at fifteen days after planting with the rate of 46 kg ha^{-1} was decrease spike length by 3.8 cm compared with fertilizer applied at thirty days after planting with the rate of 46 kg ha^{-1}. The additive effect of fertilizer applied thirty days after planting with the rate of 23 kg ha^{-1}had 70.3 % more tillers than control, but 12.4 % less tillers than fertilizer applied thirty days after planting with the rate of 46 kg ha^{-1}. Fertilizer applied 69 kg ha^{-1} at thirty days after planting contributed to 28.6 % increment in biomass than fertilizer applied 92 kg ha^{-1}at thirty days after planting. Fertilizer applied 92 kg ha^{-1} had 57.8 % less straw than fertilizer applied thirty days after planting with the rate of 69 kg ha^{-1}. The combined effect fertilizer applied 69 kg ha^{-1}at thirty days later of planting had 19.2% more thousand seed weight than control. Fertilized applied at fifteen days after planting with rate of 23 kg ha^{-1}had 25.5 % more grain yield than control; but 7.5 % less grain yield than 69 kg ha^{-1} N fertilizer applied at thirty days after planting. Wheat planted in 2015 had 37 % less harvest index than which, planted in 2014. Thus, 23 kg ha^{-1} fertilizer applied at thirty days after planting is economically beneficial compared to the other treatments.
Keywords: Time of fertilizer application; Rate of fertilizer, Fertilizer, Nitrogen

1. INTRODUCTION

Ethiopia is one of the largest producers of wheat in sub-Saharan Africa (Tanner and Mwangi, 1992). Wheat grows mostly in the highlands area of Ethiopian, at altitudes ranging from 1500 to 3000 m (Bekele *et al*., 1994).

Though Ethiopian agro-climatic condition is suitable for white production, productivity is low (1.3 t ha^{-1}). This is because of depleted soil fertility (Asnakew *et al*., 1991; Tanner *et al*., 1993), low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application (Asnakew *et al*., 1991; Amsal *et al*., 1997; CSA, 2000), and the unavailability of other modern crop management inputs (Asnakew *et al*., 1991). Therefore managing of soil fertility is crucial for improving wheat productivity.

Using of fertilizers which, containing N and P are affects wheat yield and quality (Fischer, 1989; Bacon 1995).Especially using of N fertilizer is considered to be a primary means of increasing wheat grain yield in Ethiopia (Tanner *et al*., 1993; Amsal *et al*.,2000).

Though appropriate time and rate of N fertilizer application have a number of merits, there is little knowledge in Ethiopia (Asnakew *et al*., 1991). Particularly farmers of Chencha and Bonke woreda have no idea on appropriate rate and time of N fertilizer application. These resulted for reeducation in both yield and quality of wheat (Tilahun *et al*., 1996b). Therefore, this study was initiated with the following objectives:

- To evaluate the effect of time and rate of N-fertilizer application on growth and yield of wheat.

- To see the interactive effect of time and rate of N-fertilizer application on growth and yield of wheat.
- To identify the optimum time and rate of N-fertilizer application on growth and yield of wheat.

2. MATERIALS AND METHODS

2.1 Site Description

These studies were conducted at Chencha and Bonke woredas, in Southern Ethiopia. The Chencha and Bonke woredas are situated at 9^0 5'N and 39^0.45'E and 50 9'N and $37^0$24'E respectively. Meantime Chencha and Bonke woredas are situated an elevation range of 1700- 3100 masl and 501-3500 masl respectively; which are ideal for the production of wheat. The mean annual rain fall varies from 900-1400 mm in Chencha woreda and 900-1400 mm in Bonke woreda. The dominant crops growing around the experimental area are enset (*Ensete ventricosum*), wheat (*Triticum aestivum* L.) and Potato (*Solanum tuberosum*) (GGZRDO, 2016).

2.2. Experimental Treatments and design

The experiment consisted of two factors, time and rate of N-fertilizer application; were arranged in split plot design and replicated four times. Times of N-fertilizer consist of application (at planting, 15 and 30 days after planting) and Rat of N-fertilizer consists of application (0, 23, 46, 69 and 92k.gha^{-1}).

2.3. Experimental Procedure

Degelo wheat variety was used at 150kg ha^{-1} as a test crop; and the experimental field was prepared by using oxen plow and plowed four times, before planting. Meanwhile DAP fertilizer was used at the rate of 100 kg ha^{-1} as source of N and P; and Urea was applied at the rate of 0 , 23, 46, 69 and 92 k.g ha^{-1} at the time of planting, 15and 30 days after planting.

2.4. Soil Sampling and Analysis

Sixteen random soil samples (0-30 cm depth) from the experimental field were thoroughly mixed to make a composite. The sample was air dried and ground to pass 2 mm sieve and necessary parameters such as soil texture, available P, pH and CEC were determined. For the determination of OC and N 1mm sieve was used. Soil texture was analyzed by Bouyoucos hydrometer method (Day, 1965). Available P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen et al. (1954).The pH of the soil was measured potentiometrically in the 1:2.5 soil: water mixture by using a pH meter and organic carbon was determined following Walkely and Black wet oxidation method (Walkely and Black, 1934).Cation Exchange Capacity (CEC) was determined by Ammonium Acetate method (Jackson, 1973).

2.5. Data Collection

2.5.1. Phenological data

Days to 50% heading: number of days from sowing up to the date when the tips of the panicles first emerged from the main shoot, on 50% of the plant in a plot

Days to 90% maturity: number of days from the date of sowing up to the date when 90% of the crop stands in a plot changed to light yellow color.

2.5.2. Growth data

Plant height (cm): - It was taken at an interval of 20 days; by taking six randomly selected plants and measured from the base of the main stem to the tip of the panicle.

Growth Rate: - It was the ratio of the differences between two consecutive plant heights measured at difference time [GR= $\Delta H \div \Delta T$] (Watson, 1952).

Tillers number (m^{-2})**: -** to determine the capacity of tillering per 1m^2, 10 cm X 20 cm area was demarcated and the number of plants existed in that area was counted. Then recounting was done after at flowering on demarked area; because maximum tillers produced during vegetative phase and senescence occurs at maturity (Lafarge et al., 2004). Finally the difference between the first and second count was converted into 1m^2.

Panicles per plant: - six plants were randomly taken and the average number of panicles per plant was considered.

Panicle length (cm): - length of the panicle was measured by selecting six plants randomly and measuring from the node (the first panicle branch started) to the tip of the panicle.

2.5.3 Yield and yield components

Total above ground biomass (kg):- was measured after sun-drying for two days.

Straw yield (kg): - was measured by subtracting grain yield per plot from the total above ground biomass.

Grain yield (kg ha^{-1}):- yield from every plot

Thousand seed weight (g): - the seeds were taken from each plot and 1000 seeds counted by hand and then weighted.

Harvest index: - the ratio of grain yield to the above ground (shoot) biomass. [HI= Grain yield/Total biomass].

2.6. Economic Analysis

For economic analysis, a simple partial budget analysis was employed using CIMMYT approach (CIMMT, 1988). For partial budget analysis, the factors with significant effect were considered. The yield was adjusted by subtracting 10 % from average gain yield. Than after, gross yield benefit was obtained by multiplying the adjusted yield by the price of grain (13 birr kg^{-1}). Net benefit was calculated, by subtracting labor cost from gross yield. Finally marginal rate of return (MRR) was obtained, by dividing marginal net benefit to the marginal cost and expressed as percentage (CIMMT, 1988). The mean market price of wheat was obtained by assessing the market at harvest (2014 cropping season).

2.7. Data Analysis

The various agronomic data were analyzed using the general linear model (GLM) procedures of the SAS statistical software (SAS Institute, 2000) to evaluate the effect of sowing method and time of fertilizer application and their interaction. Least Significant Difference (LSD) test at $P \leq 0.05$ was used to separate means whenever there were significant differences.

3. RESULTS AND DISCUSSION

3.1. Physicochemical Properties of the Experimental Soil.

The analytic results indicated that the experimental soil of Chencha and Bonke woredas were textured loam and clay loam respectively. Meantime both woredas having organic carbon content (OC) of 0.95 and 0.78% respectively (Table 1). Accordance with Sahlemedhin (1999), the soil in both locations had high OC, who rated OC between 1.74-2.90% as high. The CEC of the soil were 22.4 cmol kg^{-1} and 24.6 cmol kg^{-1} at Chencha and Bonke woredas respectively which, could be considered as medium. Because if CEC value ranges between 25 and 40 cmol kg-1 satisfactory response for applied fertilizer (Sahlemedhin, 1999). According to Olsen *et al*(1954) P rating (mg kg^{-1}), P content of < 3 is very low, 4 to 7 is low, 8 to 11 is medium, and > 11 is high. Thus experimental sites, available P content were medium in both locations. The pH of the soil were 5.23 and 5.88 on Chencha and Bonke woredas respectively, which is within the range of 4 to 8 suitable for wheat production (FAO, 2000).Total N of the soil on both locations (0.098 % and 0.070%), are low; as rated by Havlin et al., (1999) who rated total N less than 0.15 % as low.

Table 1: - Physio-chemical properties of the experimental soil.

Location	Depth (cm)	pH (H_2o)	CEC (cmol kg^{-1})	OC (%)	Total N (%)	Av.P (mg kg^{-1})	Particle size distribution (%)			Textural
							sand	clay	silt	Class
Chencha	0-30	5.23	22.4	0.78	0.070	7.8	26	26	48	Loam Clay loam
Bonke	0-30	5.88	24.6	0.95	0.098	8.4	36	28	36	

CEC= Cation Exchange Capacity, OC= Organic Carbon, Av.P= Available phosphorous.

3.2. Crop Phenology

3.2.1. Days to heading

The time and rate of N-fertilizer application had a significant ($P \leq 0.001$); effect on days to heading; whereas there interaction and location had a significant ($P \leq 0.1$); effect on days to heading. But the year had non-significantly affected days to heading.

The additive effect of fertilizer applied with the rate of 23, 46, 69 and 92 kg ha^{-1} at thirty days after planting; minimize the date of heading by six days compared with fertilizer applied at the time of planting in the rate of 0, 23, 46 and 69 kg ha^{-1} (Table 2). The result in line with the finding of Cock and Ellis (1992) indicated that sufficient nitrogen at right time results in rapid growth and heading.

However too little N fertilizes application and excessive N applied at any time resulted in delayed heading, because excessive N kept vegetative growth active and finally resulted in delayed heading and flowering (Osman and Mohamed, 1981).

Planting at Bonke woreda had hastened the day for heading by one day compared with planted at Chencha woreda (Table 2). This is due to relatively better amount of available N and P at Bonke woreda compared with Chencha woreda (Table 1). Because increasing in elevation results for fast root and shoot growth; as well as facilitate rapid maturity of wheat (Amanuel *et al*., 2002).

Table2:- Interactive effect of the time and rate of N-fertilizer application on 50% heading of wheat

Treatments		50% Heading
TF	**FR**	
Control	0 kg ha^{-1}	56.50a
at planting	23 kg ha^{-1}	54.12ab
at planting	46 kg ha^{-1}	52.87abc
at planting	69 kg ha^{-1}	52.37abc
at planting	92 kg ha^{-1}	50.37bcde
15 DAP	23 kg ha^{-1}	48.12de
15 DAP	46 kg ha^{-1}	48.75cde
15 DAP	69 kg ha^{-1}	49.87cde
15 DAP	92 kg ha^{-1}	50.87bcd
30 DAP	23 kg ha^{-1}	47.62de
30 DAP	46 kg ha^{-1}	47.00de
30 DAP	69 kg ha^{-1}	46.37e
30 DAP	92 kg ha^{-1}	49.75cde
LSD (5%)		4.23
CV (%)		4.94
Year		
2007		50.38
2008		50.33
LSD (5%)		0.97
CV (%)		4.94
Location		
Chencha		50.88a
Bonke		49.83b
LSD (5%)		0.97
CV (%)		4.94

TF= Time of Fertilizer FR= Fertilizer Rate, DAP=Days After Planting, the same letter in a column of each factor shows a non-significant difference at 5% probability level.

3.2.2. Days to maturity

Main effect of the rate and time of N fertilizer application and their interaction were no significant effect on days to 90% maturity; whereas year and location had significant ($P \leq 0.001$); effect on days to 90% maturity.

Wheat planted in 2014 was delayed the date of maturity by twenty days compared with planted in 2015 (Table 3). This is due to limited amount of rain in 2015retured the growth rate and facilitates the day for maturity. Because the growth and maturity of wheat directly influenced by availability of essential nutrients (Hailu Geberemariam, 2003).

Planting of wheat at Bonke woreda hasted the day for maturity by nineteen days compared with planting at Chencha woreda (Table-3). This is due to relatively high elevation in Chencha woreda, results for maximum freezing effect. Because temperature has great influence on crop metabolism which, is directly affect growth and maturity of the crop (Amanuel *et al*., 2002).

Table 3:- Effect of the time and rate of N-fertilizer application on wheat 90 % maturity

Treatments	90 % Maturity
Time of N-fertilizer	
at planting	156.17
15 DAP	152.34
30 DAP	153.68
LSD (5%)	6.26
CV (%)	7.05
Rate of N-fertilizer	
0 kg ha	158.75
23 kg ha	154.71
46 kg ha	154.54
69 kg ha	153.21
92 kg ha	152.96
LSD (5%)	10.34
CV (%)	7.05
Year	
2007	164.06a
2008	144.40b
LSD (5%)	4.23
CV (%)	7.05
Location	
Chencha	163.86a
Bonke	144.61b
LSD (5%)	4.24
CV (%)	7.05

TF= Time of Fertilizer FR= Fertilizer Rate, DAP=Days After Planting, the same letter in a column of each factor shows a non-significant difference at 5% probability level.

3.3. Growth data

3.3.1. Plant height

The interaction of rate and time of fertilizer application, time of fertilizer application and year had significant ($P \leq 0.001$) effect on plant height; while the rate of fertilizer application had significant ($P \leq 0.001$) effect on plant height. But location had non-significant ($P \leq 0.001$) effect on plant height.

The additive effect of 69 kg ha^{-1}N-fertilizer applied at thirty days after planting had contributed for 16.5 cm in increments in height than control (Table 4). This result is major indicator for the height of wheat mainly affected by the time of fertilizer application. Meanwhile the combined effect of optimum fertilizer application at right time had significant effect on height of wheat (Lemma *et al.*'1992). But too early and let application of N, resulted in significantly reduced heights (Mekonnen, 1985; Zewdu *et al.*, 1992; Tilahun *et al.*, 1996a).

Wheat which, planted in 20014 had 6.8 cm more plant height than planted in 2015 (Table 4). This is because of adequate rain in 2014 contributed for increment in plant height. The result is in line with the finding of (Kumara *et al.*, 2006), the amount of water supplied for plants has direct effect on growth of height of plant. Meantime growth rate and height of wheat varies based on the season which planted (FAO, 2003).

Table 4:- Interactive effect of the time and rate of N-fertilizer application on growth and yield of wheat

Treatments		PH (CM)	SL (CM)
TF	**FR**		
Control	0 kg ha^{-1}	77.52d	5.07f
at planting	23 kg ha^{-1}	79.40bcd	5.287f
at planting	46 kg ha^{-1}	80.12 bcd	5.42f
at planting	69 kg ha^{-1}	79.02cd	5.10f
at planting	92 kg ha^{-1}	88.10abcd	6.64f
15 DAP	23 kg ha^{-1}	83.35 abcd	5.85f
15 DAP	46 kg ha^{-1}	90.20ab	25.90b
15 DAP	69 kg ha^{-1}	88.75abc	13.737d
15 DAP	92 kg ha^{-1}	80.47bcd	5.287f
30 DAP	23 kg ha^{-1}	89.32abc	6.77f
30 DAP	46 kg ha^{-1}	89.97abc	29.70a
30 DAP	69 kg ha^{-1}	94.02a	17.27c
30 DAP	92 kg ha^{-1}	80.75bcd	10.10e
LSD (5%)		11.04	2.64
CV (%)		7.66	14.18
Year			
	2007	88.11a	11.83a
	2008	81.27b	10.03b
LSD (5%)		2.53	0.60
CV (%)		7.66	14.18
Location			
	Chencha	85.70	11.32a
	Bonke	83.68	10.55b
LSD (5%)		2.53	0.60
CV (%)		7.66	14.18

PH=Plant Height, SL= Spike Length, TF= Time of Fertilizer FR= Fertilizer Rate, DAP=Days After Planting, the same letter in a column of each factor shows a non-significant difference at 5% probability level.

3.3.2. Spike length

Main and interactive effect of the time and rate of N-fertilizer application, and year significantly ($P \leq 0.001$) affected spike length; also location had significant ($P \leq 0.01$) effect.

Fertilizer applied at fifteen days after planting with the rate of 46 kg ha^{-1} was contributed 20.8 cm increment in spike length than control. Whereas fertilizer applied at fifteen days after planting with the rate of 46 kg ha^{-1} was decrease spike length by 3.8 cm compared with fertilizer applied at thirty days after planting with the rate of 46 kg ha^{-1} (Table 4). These findings are strongly justifies, N fertilizer application by itself do not have significant effect on panicle length of wheat. But the combined effect optimum amount of fertilizer at right time has significant effect on growth of spike length. Similar results have also been reported by (Alcoz *et al*., 1993), higher spike length of wheat achieved by fertilizer applied 69 kg ha^{-1}at one month later of planting (Table 4). Meanwhile excessive application of N fertilizer has toxic effect on wheat growth and results for stunted growth and reduced spike length (Smith and Hamel (1999).

Wheat which planted in 2014 had maximized spike length by 1.8 cm capered with planted in 2015 (Table 4). Inadequate and less uniform rain in 2015 resulted for reduction in spike length. Because spike length of wheat, directly affected by amount of available nutrients and water (Genene, 2003).

3.4. Yield and yield components

3.4. 1. Tillers

Time of fertilizer, fertilizer rate and their interaction effect significantly ($P<0.001$) affected the number of tillers. But the year of planting and location were not significantly affected the number of tillers.

The additive effect of fertilizer applied thirty days after planting with the rate of 23 kg ha^{-1}had 70.3 % more tillers than control, but 12.4 % less tillers than fertilizer applied thirty days after planting with the rate of 46 kg ha^{-1}. Whereas fertilizer applied thirty days after planting with the rate of 69 kg ha^{-1} had 61.3 % less tillers than fertilizer applied thirty days after planting with the rate of 46 kg ha^{-1}, but 32.7 % more tillers than fertilizer applied at the time of planting with the rate of 23 kg ha^{-1} (Table 5).These variations on tiller number due to, the time fertilizer application had significant effect on the number of tiller (Bekalu.A and Tenaw.W, 2015).

The above result indicated that enhancement in tiller number when N fertilizer applied at right time with optimum amount. Meanwhile the result is agreement with that of Genene (2003) who reported higher tillering and maximum survival percentage of tillers with optimum time and rate of N fertilizer application in bread wheat. Agree with the results of this study, Botella *et al*. (1993) reported that stimulation of tillering with optimal application of nitrogen might be due to its positive effect on cytokinin synthesis. Generally maximum number of tiller achieved through 69 kg ha^{-1} of N fertilizer applied thirty days later of planting (Haftom *et al*, 2009).

Table 5:- Interactive effect of the time and rate of N-fertilizer application on growth and yield of wheat

Treatments						
TF	**FR**	**NT**	**TBM (kg ha^{-1})**	**SY (kg ha^{-1})**	**TSW (g ha^{-1})**	**GY (Qha^{-1})**
Control	0 kg ha^{-1}	2.02g	11189b	8966b	46.62b	20.75d
at planting	23 kg ha^{-1}	2.20g	10500b	8345b	47.50b	21.54cd
at planting	46 kg ha^{-1}	2.32fg	12308ab	9976ab	49.00ab	23.31abcd
at planting	69 kg ha^{-1}	2.86de	12771ab	9926ab	51.50ab	22.82bcd
at planting	92 kg ha^{-1}	2.74ef	12119b	9567ab	53.12ab	25.51abcd
15 DAP	23 kg ha^{-1}	3.21d	11903b	9404ab	49.37ab	24.98abcd
15 DAP	46 kg ha^{-1}	3.95c	13559ab	10775ab	52.25ab	27.84abc
15 DAP	69 kg ha^{-1}	3.11de	10969b	8377b	46.62b	25.91abcd
15 DAP	92 kg ha^{-1}	2.81de	11415b	9682ab	51.62ab	23.53abcd
30 DAP	23 kg ha^{-1}	6.80b	12031b	9387 b	55.50ab	26.44abcd
30 DAP	46 kg ha^{-1}	7.76a	12832ab	9068b	55.50ab	28.77ab
30 DAP	69 kg ha^{-1}	3.00de	16512a	13503a	58.50a	30.10a
30 DAP	92 kg ha^{-1}	2.92de	11784b	9161b	47.62b	22.54bcd
LSD (5%)		0.46	4209.1	4167.2	10.41	7.02
CV (%)		7.76	20.09	25.22	11.96	16.55
Year						
	2007	3.52	14336.8a	11969.3a	53.44a	26.18a
	2008	3.51	10261.8b	7436.4b	48.83b	23.67b
LSD (5%)		0.10	963.4	953.8	2.38	1.61
CV (%)		7.76	20.09	25.22	11.96	16.55
Location						
	Chencha	3.52	12475.6	9961.9	51.68	25.50
	Bonke	3.51	12123.0	9443.8	50.58	24.35
LSD (5%)		0.11	963.4	953.8	2.38	1.61
CV (%)		7.76	20.09	25.22	11.96	16.55

TF= Time of Fertilizer FR= Fertilizer Rate, DAP=Days After Planting, NT= Number of Tillers**,** TBM = Total Bio Mass, SY = Straw Yield, GY = Grain Yield, the same letter in a column of each factor shows a non-significant difference at 5% probability level.

3.4.2. Total biomass

Main and interactive effect of the time and rate of N fertilizer application were significantly ($p \leq 0.01$) affected biomass yield of wheat, whereas year was significantly ($p \leq 0.001$) affected biomass yield of wheat. But location was no significant effect on biomass yield of wheat.

Fertilizer applied 69 kg ha^{-1} at thirty days after planting contributed to 28.6 % increment in biomass than fertilizer applied 92 kg ha^{-1}at thirty days after planting (Table 5). N fertilizer application at optimum amount and right time significantly enhanced biomass yield of wheat (Amanuel *et al*.; 1991). But application of highest level of N resulted in less biomass yield. This might be due to the effect of lodging resulted from too high amount of N fertilizer that encourage vegetative growth and height leading to lodging before the translocation of dry matter to economic yield since biomass includes the economic yield (Albert *et al.;*2005).

Adequate amount of rain in 2014 contributed for 28.4 % increment in biomass yield compared with panted in 2015 (Table 5). This result in line with the finding of (Kumara *et al.;* 2006), biomass yield of onion depends on seasonal rainfall availability. Meantime biomass yield of the crop linearly correlated with the amount of essential nutrient (Genene, 2003.).

3.4.3. Straw yield

The interaction of time and rate of fertilizer application and the year of planting were significantly ($p \leq 0.01$) and

($p \leq 0.001$) respectively affected straw yield of wheat. But time and rate of fertilizer application and planting location were non-significant effect on straw yield of wheat.

Fertilizer applied 92 kg ha^{-1} had 57.8 % less straw than fertilizer applied thirty days after planting with the rate of 69 kg ha^{-1}, but no significant variation in straw yield compared with all other treatments (Table 5). These might be due to right time and rate of N fertilizer application on treatment of 69 kg ha^{-1}fertilizer applied at thirty days after planting, resulted for maximum vegetative growth (Alcoz *et al*.;1993). But excessive N fertilizer application had toxic effect on crop and resulted for less vegetative growth and straw than control. Similarly, Abdo (2009) reported highest straw yield of durum wheat in response to applying nitrogen at the rate of 69 kg ha^{-1}.

3.4.4. Thousand Seed weight

Thousand seed weight is an important yield determining component and reported to be a genetic character that is influenced least by environmental factors (Ashraf *et al*, 1999). The analysis of variance showed that the main effects of rate and timing of N fertilizer application, and timing of N fertilizer had significant ($p \leq 0.01$) effect on thousand seed weight, meanwhile year of planting had significantly effect at ($p \leq 0.001$). But the rate of N fertilizer application and location had no significant effect on thousand seed weight.

The combined effect fertilizer applied 69 kg ha^{-1}at thirty days later of planting had 19.2% more thousand seed weight than control, fertilizer applied 23 kg ha^{-1} at planting and 69 kg ha^{-1} at thirty days after planting (Table 5). Generally maximum thousand seed weight obtained exceeded the minimum by about 20.3 %. This result is agree with that of Channabasavanna and Setty (1994) who reported positive response of rice grain weight to N application. However, in contrast to the finding of this study, Melesse (2007) reported no significant effect of application of different rates of N fertilizer on thousand seed weight of bread wheat. But the optimum amount of N fertilizer within right time gave better grain weight (El-Kramany, 2001).

Wheat planted in 2014 had 8.6 % more thousand seed weight than which planted in 2015 (Table 5). This is due to sufficient amount of rain in2014 contributed for increment in thousand seed weight, since of thousand seed weight strongly influenced by nutrient availability and environmental like rainfall (Ashraf *et al*, 1999).

3.4.5. Grain yield

Grain yield of wheat was highly significantly ($P \leq 0.05$) influenced by the interaction of time and rate of N fertilizer application, and rate of N fertilizer application. Meanwhile the time of N fertilizer application and year of planting were significant at ($P \leq 0.001$) and ($P \leq 0.01$) respectively. But location of planting had non-significant effect on grain yield.

Fertilized applied at fifteen days after planting with rate of 23 kg ha^{-1}had 25.5 % more grain yield than control; but 7.5 % less grain yield than 69 kg ha^{-1} N fertilizer applied at thirty days after planting (Table 5). In line with the result of this study, Temesgen (2001) reported that application of different levels of N significantly affected grain yield of tef on farmer's field. This is because of well-balanced supply of N at right time, results in higher net assimilation rate and increased grain yield (Sage and Pearcy, 1987). According to this study to maximizing the grain yield wheat, applying of 69 kg ha^{-1} N at thirty days after planting appropriate, because proper rate and time of application are critical for meeting crop needs. Also it has considerable opportunities for improving grain yields (Blankenau *et al*.; 2002). Consistent with this study, also Ashraf and Azam (1998) reported that growth stage of plants at which fertilizer is applied determines the final yield of the crop. In agreement with the results of this study, Michael *et al*. (2000) and Anthony *et al*. (2003) indicated that split N application 69 kg ha^{-1} at thirty days after planting is effective in attaining higher grain yield of wheat.

Greater grain yield of wheat was achieved in 2015 than in 2014. In 2015, 9.6 % reduction in grain yield occurred due to uneven and little amount of rainfall at planted area; because the amount of moisture availability directly influence the growth and grain yield (Samson, 2007).

3.4.6. Harvest index

The year of planting had significant ($P \leq 0.001$) effect on harvest index of wheat. But main effect of rate and time of N fertilizer application, their interaction and location had no significant effect on harvest index of wheat.

Harvest index is describes plant capacity to allocate biomass (assimilates) into the formed reproductive parts (Mazid et al., 2013). Since the year of planting affects harvest index of the most cereals (Wnuk, 2013). So wheat planted in 2015 had 37 % less harvest index than which, planted in 2015 (Table 6). The result is in line with finding of Reynolds et al (2013), the year of planting has direct effect on harvest index of wheat.

Table 6:- Effect of the time and rate of N-fertilizer application on harvest index of wheat.

Treatments	HI
Time of N-fertilizer	
at planting	0.22
15 DAP	0.23
30 DAP	0.23
LSD (5%)	0.02
CV (%)	17.00
Rate of N-fertilizer	
0 kg ha	0.24
23 kg ha	0.22
46 kg ha	0.22
69 kg ha	0.23
92 kg ha	0.22
LSD (5%)	0.04
CV (%)	17.00
Year	
2007	0.27a
2008	0.17b
LSD (5%)	0.01
CV (%)	17.00
Location	
Chencha	0.23
Bonke	0.23
LSD (5%)	0.01
CV (%)	17.00

TF= Time of Fertilizer, FR= Fertilizer Rate, DAP=Days After Planting, HI= Harvest Index, the same letter in a column of each factor shows a non-significant difference at 5% probability level.

3.5. Correlation of grain yield with yield and yield components

Grain yield considered as dependant, whereas plant height, growth rate, tillers, spike length, thousand seed weight, straw yield, total biomass and harvest index were taken as explanatory variables (Table 7).

Grain yield was positively and significant ($P < 0.001$) associated with date of plant height, tillers, spike length, total biomass, thousand seed weight, r= 0.98, 0.87, 0.88 and 0.50, respectively; but significant ($P < 0.05$) and ($P < 0.01$) associated with straw yield and harvest index, r= 0.32 and 0.36 respectively. Similar correlations were reported in barley by Mekonnen (2005) and Alam *et al.* (2005). On the other hand, grain yield was associated negatively with day to heading and maturity, r=-0.89*** and -0.78*** respectively; which was in line with the report of Getachew (2004) on bread wheat.

Table-7:- Correlation between yield and yield components of wheat

X	DH	DM	PH	TN	SL	TBM	SY	GY	TSW	HI
DHD	1.0	0.96***	-0.85***	-0.64***	-0.66***	-0.27*	-0.09 ns	-0.89***	-0.8***	-0.36***
DM		1.0	-0.79***	-0.53***	-0.55***	-0.18 ns	-0.02 ns	-0.78***	-0.65***	-0.33***
PH			1.0	0.86***	0.90***	0.47***	0.29*	0.98***	0.94***	0.34***
TN				1.0	0.96***	0.71***	0.58***	0.87***	0.91***	0.25*
SL					1.0	0.65***	0.52***	0.88***	0.93***	0.27*
TBM						1.0	0.94***	0.50***	0.54***	0.15 ns
SY							1.0	0.32*	0.36***	0.01 ns
GY								1.0	0.97***	0.36**
TSW									1.0	0.35**
HI										1.0

ns = not significant, * ** &*** significant at 0.05, 0.01and 0.001 respectively, DHD= Date of Heading, DM= Date of Maturity, TN= Tillers Number, SL = Spike Length TBM = Total biomass, GY = Grain Yield, SY = straw yield, TSW = Thousand Seed Weight and HI= Harvest Index.

3.6. Partial Budget Analysis

The net benefit obtained in response to N fertilizer applied 0, 23, 46, 69 and 92 kg ha^{-1} thirty days after planting were 24,271, 29,427, 30,367, 32,217 and 21,877 birr respectively. The higher marginal rate of return with least cost was obtained from 23 kg ha^{-1}. Because the marginal rate of return was above the minimum level (100%). According to CIMMYT (1988) the recommendation is not necessarily based on the treatment with the highest marginal rate of return compared to that of neither next lowest cost, the treatment with the highest net benefit, and nor the treatment with the highest yield. The identification of a recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return. Thus, 23 kg ha^{-1} fertilizer applied at thirty days after planting is economically beneficial compared to the other treatments.

Table-8:- Partial budget analysis of wheat as influenced by the rate of N-fertilizer application

Treatment	Av.Y (q ha^{-1})	ADTY (q ha^{-1})	GFB (birr ha^{-1})	Total variable cost (Birr ha-1)	Net benefit (Birr ha-1)	MRR (%)
0	20.75	18.67	24,271	0	24,271	
23, T_3	26.44	23.79	30,927	1,500	29,427	343.73
46, T_3	28.77	25.89	32,617	2,250	30,367	125.33
69, T_3	30.10	27.09	35,217	3,000	32,217	246.67
92, T_3	22.54	20.29	26,377	4,500	21,877	-

Av.Y= Average Yield, ADTY=adjusted yield, GFB= Gross Field Benefit and MRR=Marginal Rate of Return.

3.7 Conclusion

In this study it was found that, the rate of N-fertilizer application had significant effect on growth and yield of wheat. Especially 69 kg ha-1 N applied thirty days after planting, gave maximum biological yield, but 23 kg ha^{-1} fertilizer applied at thirty days after planting is economically beneficial compared to the other treatments. Meantime fertilizer applied 23 kg ha-^{1} had acceptable MRR (343.73 %); and net benefit 29,427 birr ha-^{1} from grain yield. Thus, it is possible to recommend that; N application 23 kg ha-^{1} is effective in attaining higher grain yield and economic benefit of wheat in the trail area. However, it is advisable to undertake further research across soil type, years and locations to draw sound recommendation on a wider scale.

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