Canadian Journal of Agriculture and Crops
Vol. 1, No. 2, 60-69, 2016

Effect of the Time of N-Fertilizer Application on Growth and Yield of Wheat (*TriticumAestivum* L.) At Gamo-Gofa Zone, Southern Ethiopia

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Significance and Impact of the Study: To identify the right time of N-fertilizer application for better yield of wheat

ABSTRACT

There is little knowledge among farmers on the time of N-fertilizer application at Gamo-gofa. Therefore, there is a need to determine time of N-fertilizer application on growth and yield of wheat. Accordingly, an experiment were conducted to evaluate the effect of the time 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. The experiment consisted of single factor, which is the time of N-fertilizer application (at planting, 15, 30 days after planting and Control (no application)); was arranged in split plot design and replicated four times. Time of N-fertilizer application, year and location had significantly affected spike length and number of tillers. Also year and location had significantly affected maturity; whereas time of N fertilizer application and year of planting had significant effect on thousand seed weight. Time of N-fertilizer application, significantly affected days to heading, plant height and grain yield; whereas year was significantly affected harvest index, biomass and straw yield. Controls (no application) minimize the date of heading by ten days compared with fertilizer applied thirty days after planting. Wheat planted in 2014 was delayed the date of maturity by twenty days compared with planted in 2015. Planting of wheat at Bonkeworeda hasten the day for maturity by twenty days compared with planting at Chenchaworeda. Treatment which applied thirty days after planting had minimized plant height by 10.5 cm compared with control. Fertilizer applied thirty days after planting was contributed 2.8 cm increment in spike length than control, fertilizer applied at the time of planting and fifteen days after planting. Fertilizer applied thirty days after planting had 44.3 % more tillers than control. Wheat which planted in 2014 had maximized spike length by 44.4 % compared with planted in 2015. Wheat which planted in 2014 had increased biomass yield by 44.4 % compared with planted in 2015. Wheat which planted in 2014 had maximized straw yield by 44.4 % compared with planted in 2015. Fertilizer applied thirty days after planting had 16 % more thousand seed weight than control. Fertilized applied at thirty days after planting had 27.9 % more grain yield than no application. Harvest index is describes plant capacity to allocate biomass (assimilates) into the formed reproductive parts. Thus, it is possible to recommend that; N application thirty days after planting is effective in attaining higher grain yield and economic benefit of wheat in the trail area.

Keywords: Wheat, Time of fertilizer application, Fertilizer, Nitrogen.

DOI: 10.20448/803.1.2.60.69

Citation | Bekalu Abebe; Arega Abebe (2016). Effect of the Time of N-Fertilizer Application on Growth and Yield of Wheat (TriticumAestivum L.) At Gamo-Gofa Zone, Southern Ethiopia. Canadian Journal of Agriculture and Crops, 1(2): 60-69.

Funding : This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

History : **Received:** 16 July 2016/ **Revised:** 26 August 2016/ **Accepted:** 30 August 2016/ **Published:** 3 September 2016

Publisher: Online Science Publishing

1. INTRODUCTION

Ethiopia is one of the largest producers of wheat in sub-Saharan Africa [1]. Wheat grows mostly in the highlands area of Ethiopian, at altitudes ranging from 1500 to 3000 m [2].

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 [3, 4] low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application [3, 5, 6] and the unavailability of other modern crop management inputs [3]. 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 [5]. Especially using of N fertilizer is considered to be a primary means ofincreasing wheat grain yield in Ethiopia [4, 7].

Though appropriate time and rate of N fertilizer application have a number of merits, there is little knowledge in Ethiopia [3]. Particularly farmers of Chencha and Bonkeworeda have no idea on appropriate time of N fertilizer application. These resulted for reeducation in both yield and quality of wheat [7]. Therefore, this study was initiated with the following objectives:

- To evaluate the effect of time of N-fertilizer application on growth and yield of wheat.
- To identify the right time 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 Bonkeworedas, in Southern Ethiopia. The Chencha and Bonkeworedas 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 Bonkeworedas 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 Chenchaworeda and 900-1400 mm in Bonkeworeda. The dominant crops growing around the experimental area are enset (*Enseteventricosum*), wheat (*Triticumaestivum*L.) and Potato (*Solanumtuberosum*) [8].

2.2. Experimental Treatments and Design

The experiment consisted of single factor, which is the time of N-fertilizer application (at planting, 15, 30 days after planting and Control (no application)); was arranged in split plot design and replicated four times.

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 time of planting, 15and 30 days after planting with the rate of 100kg ha^{-1}, but one treatment was used as control (no application).

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 [9]. Available P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen, et al. [9]. 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 [10]. Cation Exchange Capacity (CEC) was determined by Ammonium Acetate method [11].

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= $\Delta H \div \Delta T$] [12].

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 [13]. 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. Data Analysis

The various agronomic data were analyzed using the general linear model (GLM) procedures of the SAS statistical software [14] to evaluate the effect of sowing method and time of fertilizer application and their interaction. Least Significant Difference (LSD) test at $P \le 0.05$ 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 Bonkeworedas 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 [15] 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 Bonkeworedasrespectively which, could be considered as medium. Because if CEC value ranges between 25 and 40 cmol kg-1 satisfactory response for applied fertilizer [15]. According to Olsen, et al. [16] 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 Bonkeworedasrespectively, which is within the range of 4 to 8 suitable for wheat production [17]. Total N of the soil on both locations (0.098 % and 0.070%), are low; as rated by Havlin, et al. [18] 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 Class
							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 of N-fertilizer application had a significant (P≤0.001) effect on date of heading; whereas year and location had no significant effect.

Controls (no application) minimize the date of heading by ten days compared with fertilizer applied thirty days after planting(Table 2). The result in line with the finding of Cock and Ellis [19] indicated that sufficient nitrogen at right time results in rapid growth and heading.

Table-2. Effect of the time of N-fertilizer application on 50% heading of wheat

Treatments	50% Heading	90 % Maturity
Time of N-fertilizer		
Control (no application)	56.50a	158.75
at planting	52.87ab	157.00
15 DAP	49.75bc	152.37
30 DAP	47.00c	154.75
LSD (5%)	3.71	15.93
CV (%)	5.23	7.44
Year		
2007	52.25	166.00a
2008	50.81	145.44b
LSD (5%)	1.96	8.43
CV (%)	5.23	7.44
Location		
Chencha	52.31	165.68a
Bonke	50.75	145.75b
LSD (5%)	1.96	8.43
CV (%)	5.23	7.44

TF= Time of Fertilizer, 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

The time of N fertilizer application had no significant effect on days to 90% maturity; whereas year and location had significant (P≤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 2). This is due to limited amount of rain in 2015 retarded the growth rate and facilitates the day for maturity. Because the growth and maturity of wheat directly influenced by availability of essential nutrients [20].

Planting of wheat at Bonkeworeda hasten the day for maturity by twenty days compared with planting at Chenchaworeda (Table-3). This is due to relatively high elevation in Chenchaworeda, results for maximum freezing effect. Because temperature has great influence on crop metabolism which, is directly affect growth and maturity of the crop [21].

3.3. Growth Data

3.3.1. Plant Height

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

Treatment which applied thirty days after planting had minimized plant height by 10.5 cm compared with control (Table 3). This result is major indicator for the height of wheat mainly affected by the time of fertilizer application [22].

Table-3. Effect of the rate of N-fertilizer application on growth and yield of wheat

Treatments	**PH (CM)**	**SL (CM)**
Time of N-fertilizer		
Control (no application)	77.52b	5.07b
at planting	80.12ab	5.42b
15 DAP	90.20a	6.17b
30 DAP	89.97a	8.37a
LSD (5%)	10.38	1.98
CV (%)	8.94	22.97
Year		
2007	86.37	4.81b
2008	82.54	7.71a
LSD (5%)	5.49	1.047
CV (%)	8.94	22.97
Location		
Chencha	86.30	6.78a
Bonke	82.61	5.74b
LSD (5%)	5.49	1.05
CV (%)	8.94	22.97

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

3.3.2. Spike Length

The time of N-fertilizer application, year and location had significant at ($P \leq 0.001$), ($P \leq 0.001$) and ($P \leq 0.05$) respectively.

Fertilizer applied thirty days after planting was contributed 2.8 cm increment in spike length than control, fertilizer applied at the time of planting and fifteen days after planting (Table 3). These findings are strongly justifies, right time of N fertilizer application is significant effect on panicle length of wheat [23]. Also right time of N fertilizer has harmless effect on wheat growth Smith and Hamel [24].

Wheat which planted in 2014 had maximized spike length by 2.9 cm compared with planted in 2015 (Table 3). 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 [25].

Wheat planted at Chenchaworeda had 1.04 cm more spike length than which planted at Bonkeworeda; because spike length of wheat is affected by place which it planted [21].

3.4. Yield and Yield Components

3.4.1. Tillers

The time of fertilizer application, year of planting and location were significantly ($P<0.001$) affected the number of tillers.

Fertilizer applied thirty days after planting had 44.3 % more tillers than control (Table 4). These variations on tiller number due to, right time of fertilizer application had significant effect on the number of tiller of wheat [26].

Wheat which planted in 2014 had maximized spike length by 44.4 % compared with planted in 2015 (Table 4). Inadequate and less uniform rain in 2015 resulted for reduction in spike length. Because number of tiller of wheat, directly affected by amount of available nutrients and water [25].

Wheat planted at Chenchaworeda had 26.5 % more number of tiller than which planted at Bonkeworeda; because number of tiller of wheat is affected by place which it planted [21].

Table-4. Effect of the time and rate of N-fertilizer application on growth and yield of wheat

Treatments	NT	TBM (kg ha^{-1})	SY (kg ha^{-1})	TSW (g ha^{-1})	GY (Qha^{-1})	HI
Time of N-fertilizer						
Control	3.77b	11189	8966	46.62c	20.75b	0.24
at planting	4.02b	12308	9956	49.00bc	23.31ab	0.21
15 DAP	5.02ab	13559	10775	52.25ab	27.84a	0.22
30 DAP	6.77a	12832	9976	55.50a	28.76a	0.23
LSD (5%)	1.89	3055.8	3051.9	5.18	5.92	0.06
CV (%)	28.12	17.81	22.37	7.41	17.11	20.00
Year						
2007	3.50b	10641.1b	8028.6b	53.06a	25.38	0.27a
2008	6.30a	14302.9a	11808.1a	48.62b	24.94	0.18b
LSD (5%)	1.00	1617.9	1615.8	2.74	3.14	0.03
CV (%)	28.12	17.81	22.37	7.41	17.11	20.00
Location						
Chencha	4.15b	12119.8	9503.7	50.53	25.79	0.23
Bonke	5.65a	12824.2	10333.0	51.16	24.54	0.22
LSD (5%)	1.00	1617.9	1615.8	50.53	3.14	0.03
CV (%)	28.12		22.37	7.41	17.11	20.00

TF= Time of Fertilizer, 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

The time of N fertilizer application and location were not significantly affected biomass yield of wheat, whereas year was significantly ($p\leq0.001$) affected biomass yield of wheat.

Wheat which planted in 2014 had increased biomass yield by 44.4 % compared with planted in 2015 (Table 4). Inadequate and less uniform rain in 2015 resulted for reduction in spike length. Because biomass yield of wheat, directly affected by amount of available nutrients and water [25].

3.4.3. Straw Yield

The year of planting was significantly ($p \leq 0.001$) affected straw yield of wheat, whereas time of N fertilizer application and location were not significant affect.

Wheat which planted in 2014 had maximized straw yield by 44.4 % compared with planted in 2015 (Table 4). Adequate and uniform rains in 2014 facilitate vegetative growth which, contributes straw yield of wheat [23].

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 [27]. The analysis of variance showed that the time of N fertilizer application and year of planting had significant ($p \leq 0.01$) effect on thousand seed weigh. But location of planting had no significant effect on thousand seed weight.

Fertilizer applied thirty days after planting had16 % more thousand seed weight than control (Table 4). This result is agree with that of Channabasavanna and Setty [28] who reported thousand seed weight of rice affected by the time of N application. However, in contrast to the finding of this study, Melesse [29] Melesse [1] reported no significant effect by the time of N application on thousand seed weight of bread wheat. But the optimum amount of N fertilizer within right time gave better grain weight [30].

Wheat planted in 2014 had 8.4 % 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 [27].

3.4.5. Grain Yield

Grain yield of wheat was significantly ($P \leq 0.01$) influenced by the time of N fertilizer application. But year and location were not significantly affected grain yield of wheat.

Fertilized applied at thirty days after planting had 27.9 % more grain yield than no application (Table 4). In line with the result of this study, Temesgen [31] reported that, N fertilizer palliation application atdifferent times significantly affected grain yield of tef on farmer's field. This is because of right time of N fertilizer, results in higher net assimilation rate and increased grain yield [32]. According to this study to maximizing the grain yield wheat, applying thirty day after planting isappropriate, because right time of N fertilizer application are critical for meeting crop needs. Also it has considerable opportunities for improving grain yields [33]. Consistent with this study, also Ashraf and Azam [34] reported that, growth stage of plants at which fertilizer is applied determines the final yield of the crop.

3.4.6. Harvest Index

The year of planting had significant ($P \leq 0.001$) effect on harvest index of wheat. But the rate of N fertilizer application had no significant effect on harvest index of wheat.

Harvest index is describes plant capacity to allocate biomass (assimilates) into the formed reproductive parts [35]. Since the year of planting affects harvest index of the most cereals [36]. So wheat planted in 2014 had 33.3 % less harvest index than which, planted in 2015 (Table 4). The result is in line with finding of Reynolds, et al. [37] the year of planting is significantly affect harvest index.

3.5. Correlationof 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 5).

Grain yield was positively and significant ($P < 0.001$) associated with date of plant height and spike length r= 0. 87 and 0.58 respectively, whereas tillers significantly ($P < 0.05$) associated r=0.37. Similar correlations were reported in barley by Mekonnen [37]. On the other hand, grain yield was associated negatively with day to maturity, r=¯0.57*****; which was in line with the report of Getachew [38] on bread wheat. But date of heading, total biomass, thousand seed weight and harvest index were not significantly correlated with grain yield.

Table-5. Correlation between yield and yield components of wheat

X	DH	DM	PH	TN	SL	TBM	SY	GY	TSW	HI
DH	1.0	0.42**	-0.50***	-0.65***	-0.47***	-0.37 *	-0.22 ns	-0.57***	-0.47***	0.14 ns
DM		1.0	0.24ns	-0.78***	-0.19 ns	-0.47**	-0.47***	0.04 ns	0.05 ns	0.51***
PH			1.0	0.17ns	0.44**	0.18 ns	-0.03 ns	0.87***	0.66 ns	0.29**
TN				1.0	0.59***	0.66***	0.53***	0.37*	0.24 ns	-0.44*
SL					1.0	0.53***	0.35*	.58***	0.17 ns	-0.27 ns
TBM						1.0	0.99 ***	0.21 ns	-0.08 ns	-0.73***
SY							1.0	-0.03 ns	-0.21 ns	-0.78***
GY								1.0	0.59***	0.26 ns
TSW									1.0	0.30 ns
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. Conclusion

In this study it was found that, N-fertilizer applied thirty day after planting had significant effect on growth and yield of wheat. Especially maximum grain yield () achieve on N-fertilizer applied thirty day after planting. Thus, it is possible to recommend that; N application thirty days after planting 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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