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Yield Response of Bread Wheat to Timing of Urea Fertilizer Application in Eastern Amhara Region

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Abstract
Bread wheat is one of the most staple food crops in the world and is one of the most important cereals cultivated in Ethiopia. Timing of urea fertilizer experiment was conducted in major bread wheat growing areas of Eastern Amhara: Kone and Geregera for one year (2013). The principal objective of the experiment was to identify the response of timing of urea fertilizer application on grain yield of bread wheat in Eastern Amhara Region. The experiment was designed in randomized complete block consisting of four urea fertilizer (111 kg/ha) application times: (1) 100% at tillering, (2) 50% at planting and 50% at tillering, (3) 1/3 at planting, 1/3 at tillering and 1/3 before heading and (4) 50% at tillering and 50% before heading replicated three times were used in the study. Basal applications of 100 kg DAP/ha fertilizer was made at sowing for each plot. The result revealed that the highest grain yield (3992 kg/ha) at Kone and (2685 kg/ha) at Geregera was obtained with the application time of urea fertilizer 50% at planting and 50% at tillering stage of bread wheat. Mean combined over locations of the highest grain yield (3248 kg/ha) of bread wheat was recorded with timing of urea fertilizer application of 50% at planting and 50% at tillering stage of bread wheat. The highest grain yield was obtained with the application of 50% at planting and 50% at tillering stages of bread wheat is the best economical recommended timing of urea fertilizer levels for bread wheat production in all locations.
Key words: application time, stages of bread wheat, urea fertilizer

1. Introduction

Bread wheat is one of the most staple food crops in the world and is one of the most important cereals cultivated in Ethiopia. Ethiopia is the largest wheat producer in Sub-Saharan Africa with the cultivated land of 1.6 million ha (CSA, 2013). It is also one of the most important crops in Amhara region. It is used in different forms such as bread, porridge, soup and roasted grain. In addition to the grain, the straw of bread wheat is an important feed for livestock, thatching roofs and bedding. In spite of the crop's tremendous importance, wheat production faced immense production constraints affecting both yield potential and industrial quality.

The average yield of wheat in Ethiopia is very low; it is about 24.4 quintals/ha (CSA, 2013) as compared to the world's average of about 29 q/ha and Germany's national average yield of 100q/ha (FAO, 2006). This low productivity is mainly due to diseases and pests, frost, poor soil fertility, poor agronomic practices (timing of urea fertilizer application), moisture stress (water logging and moisture deficit) and low yielding varieties. Split application of urea fertilizer has been reported to be one of the methods to improve nitrogen nutrient use by the crop while reducing the nutrient loss through leaching and volatilization (Ermias *et al*., 2007).

Many management practices have also been developed (Mohammad *et al*., 2011). But, the influence of timing of urea fertilizer application on the productivity of wheat has not yet been well investigated in Eastern Amhara Region. However, as there are huge yield gaps in different agro-ecologies, developing better agronomic practices is still a priority research area. Increased productivity of wheat can be achieved by adopting improved agronomic practices and varieties (Sadat *et al*., 2008). Presently, a blanket urea fertilizer split application recommendation of 1/2 of the total at planting while the remaining 1/2 at tillering stage of the crop is being confused in most of Eastern Ethiopia. Split-application of N resulted in superior quality attributes than when the entire N was applied at once (Ooro *et al*., 2011). However, some farmers in the region have observed good responses of the crop by reducing the amount of nitrogen at planting and applying more at latter growth stages of the crop (personal communication). Therefore, this research was initiated to identify the response of timing of urea fertilizer application on grain yield of bread wheat in Eastern Amhara Region.

2. Materials and Methods

2.1 Study Area

The experiment was carried out on lithosols in two locations: Geregera and Kone districts of Eastern Amhara Region, Ethiopia during the main cropping season (June–September). The altitudes of the experimental areas are 2900 and 2850m a.s.l. for Geregera and Kone, respectively. The mean total annual rainfall (which mainly falls in the cropping season) is 1300 mm at Geregera and 1054mm at Kone. The rainfall pattern of the areas is bimodal and its distribution is erratic; the effective rainy period extends from June to September. Mean annual average temperatures are 18 and 17°C at Geregera and Kone, respectively.

2.2 Experimental Treatments, Design and Procedures

Timing of urea fertilizer experiment was conducted in major bread wheat growing areas of Eastern Amhara: Kone and Geregera for one year (2013) at two sites for each location. The experiment was designed in randomized complete block consisting of four urea fertilizer (111 kg/ha) application times: (1) 100% at tillering; (2) 50% at sowing and 50% at tillering; (3) 1/3 at sowing, 1/3 at tillering and 1/3 before heading; and (4) 50% at tillering and 50%before heading . The experiment was replicated three times at each location.. Plot size of the experiment was 4m x 3m. *Dinkinesh* bread wheat variety was sown with the seed rate of 150kg/ha in 20cm row spacing. Soil sample at the time of sowing was collected for laboratory analysis. Basal application of 100 kg/ha DAP fertilizer was made at sowing for each plot. Proper agronomic practices were applied as recommended. Plant height at maturity (cm), number of tillers/m^2, number of effective tillers/m^2, biomass yield, thousand kernels weight and grain yield were collected as growth and yield parameters of bread wheat. Yield was estimated from harvest of 11 central rows out of the total 15 rows of the plot. All other agronomic data listed above were also collected from the 11 central rows of the plot.

A result of composite soil sample analysis of Geregera and Kone were indicated in Table 1. According to the fertility classification of Landon 1991, the result revealed medium organic matter (OC), moderately acidic soil pH, medium available phosphorus (P), medium to high cation exchange capacity (CEC) and medium total nitrogen (N).

2.3 Data Analyses

The analysis of variance (ANOVA) was carried out for growth and yield parameters of the study following statistical procedures appropriate for the experimental design using Statistical Analysis System (SAS) program package version 9.0. Whenever treatment effects were significant at 0.01 or 0.05 level of error, the means were separated by using the least significant difference (LSD) test procedures at 0.05 probability level of significance.

3. Results and Discussion

The analysis of variance result indicated that highly significant differences ($p<0.01$) were obtained in timing of urea fertilizer between biomass yield at Kone on-farm for the year 2013 (Table 2). Similarly, significant difference was obtained between plant height, number of tillers/m^2, number of effective tillers/m^2, thousand seed weight and grain yield at Kone on-farm for the year 2013 (Table 2). The highest grain yield (3992 kg/ha) of bread wheat was recorded with application time of urea fertilizer at 50% at planting and 50% at tillering stage of bread wheatat Kone on-farm for the year 2013 (Table 2). Likewise, the highest grain yield (3778 kg/ha) of bread wheat was obtained with application time of urea fertilizer at 1/3 at planting, 1/3 at tillering and 1/3 before heading.

Application of different timing of urea fertilizer had significant difference between biomass and grain yield at Geregera on-farm for the year 2013 (Table 3). The highest grain yield (2685 and 2561 kg/ha) were recorded with application time of urea fertilizer at 50% at planting and 50% at tillering and 1/3 at planting, 1/3 at tillering and 1/3 before heading, respectively at Geregera on-farm in 2013 (Table 3).

Mean combined analyses between treatments of timing of urea fertilizer application of bread wheat showed highly significant differences for the parameters of plant height, number of tillers/m^2, number of effective tillers/m^2, biomass yield and grain yield at Kone and Geregera for the year 2013 (Table 4). The highest grain yield (3248 kg/ha) was recorded with application time of urea fertilizer at 50% at planting and 50% at tillering stage of bread wheat.

The result of this experiment was not differed from other recommendations given in the country. Split N application at sowing, tillering and boot stages had increased productive tillers m^{-2}, and thousand grains weight, whereas grain yield was higher when N was applied at tillering and boot stages (Mohammad *et al*., 2011). Ermias *et al*. 2007 recommended that the best use of urea fertilizer would be obtained when 50% of the total requirement is applied at sowing and the remaining 50% is given as top dressing at tillering. Similarly, Abraha Arefaine (2013), reported that recommended N fertilizer application time for teff crop 1/2 dose at sowing + 1/2 at tillering stage gave the highest grain and straw yield. It is therefore justifiable to conclude that there should be location specific nitrogen fertilizer application timing. Nitrogen is closely linked to control the vegetative growth of plant and hence determine the fate of reproductive cycle. Increased in nitrogen, number of spike, grain weight (Geleto *et al*., 1995) and grain yield increased. Melaj *et al*. (2003), observed greater yield components when N was applied at tillering compared to sowing. Ayoub *et al*. (1994), stated that split N had a little effect on yield, but decreased lodging and spikes population, while grain weight increased. Generally, split-application of N resulted in superior yield increasing attributes than when the entire N was applied at once (Ooro *et al*., 2011).

It can be concluded that it is wise to have specific nitrogen fertilizer application time recommendations for different bread wheat growing areas (Ermias *et al*., 2007). It was also reported that split-application of N performed better than full dose application in general for bread wheat production (Mohammad *et al*., 2011). Nitrogen availability can be optimized by its timing, and efficient strategies to ensure increased productivity. The present nitrogen split-application recommendation could be used for bread wheat growing areas which have similar amount of recommended fertilizer vis-à-vis soil and climatic condition with that of Kone and Geregera. However, this research finding should be verified at the other major bread wheat growing areas of the region so as to derive a dependable nitrogen fertilizer application recommendation.

4. Conclusions and Recommendations

For bread wheat it was found that urea fertilizer should be applied 1/2 at planting and 1/2 at tillering. The present urea fertilizer split application recommendation could be used for bread wheat growing areas which have similar amount of recommended fertilizer vis-à-vis soil and climatic condition with that of Kone and Geregera. As a future research gap it is better to verify this research finding at the other major bread wheat growing areas of the region so as to derive a dependable urea fertilizer application recommendation.

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Table 1. Mean value of some parameters of soil samples taken at planting at Geregera and Kone

Soil characteristics										
Locations	pH		Total N (%)		Available P (ppm)		O.M (%)		CEC(%)	
	Value	Status	Value	Status	Value	Status	Value	Status	Value	Status
Kone	5.39	MA	0.17	M	13.5	M	2.92	M	30	H
Geregera	5.49	MA	0.18	M	12.5	M	2.84	M	28	H

H = High; MA = Moderately acidic; M = Medium

Table 2. Yield response of bread wheat to timing of urea fertilizer application at Kone in 2013

Treatments	Plant height (cm)	Number of tillers/m^2	Number of effective tillers/m^2	Biomass yield (kg/ha)	Thousand kernels weight (g)	Grain yield (kg/ha)
100% at tillering	89.2b	341.3ab	326.7a	9242b	39.7b	3197c
50% at planting &50% at tillering	100.4a	394a	381.7a	11323a	42.6a	3992a
1/3 at planting, 1/3 at tillering& 1/3 before heading	98.0a	339.3abc	318a	10906a	42a	3778ab
50% at tillering& 50% before heading	95.0ab	264b	246.3b	9742b	41.1ab	3398bc
LSD (5%)	*	*	*	**	*	*
CV (%)	3.4	11.2	10.4	4.3	2.4	6.7

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$. *= Significant at $P< 0.05$; ** = Significant at $P< 0.01$

Table 3. Yield response of bread wheat to timing of urea fertilizer application at Geregera in 2013

Treatments	Plant height (cm)	Number of tillers/m^2	Number of effective tillers/m^2	Biomass yield (kg/ha)	Thousand kernels weight (g)	Grain yield (kg/ha)
100% at tillering	77.3	184.7	159.7	7030ab	41.7	2398ab
50% at planting & 50% at tillering	82.7	236	222	8220a	40.9	2685a
1/3 at planting, 1/3 at tillering & 1/3 before heading	78.6	226	209	8017a	41	2561a
50% at tillering & 50% before heading	75.7	148	138	6326b	41.4	2153b
LSD (5%)	ns	ns	ns	*	ns	*
CV (%)	3.7	20.2	19.4	8.8	1.9	6.9

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$. *= Significant at $P< 0.05$; ** = Significant at $P< 0.01$; ns = non-significant

Table 4. Mean combined analyses over locations of bread wheat to timing of urea fertilizer application at Kone and Geregera in 2013

Treatments	Plant height (cm)	Number of tillers/m^2	Number of effective tillers/m^2	Biomass yield (kg/ha)	Thousand kernels weight (g)	Grain yield (kg/ha)
100% at tillering	83.73b	276.7b	256.4bc	7856b	39.5	2879bc
50% at planting & 50% at tillering	90.35a	331.8a	317.1a	8986a	40.7	3248a
1/3 at planting, 1/3 at tillering & 1/3 before heading	86.44b	286.7b	266.8b	8524a	40.3	3033b
50% at tillering & 50% before heading	84.04b	246.3b	225.4c	7710b	40	2848c
LSD (5%)	**	**	**	**	ns	**
CV (%)	3.9	17.4	16.2	8.7	3.5	6.8

Means within a column followed by the same letter(s) are not significantly different at $P = 0.05$. ** = Significant at $P< 0.01$; ns = non-significant

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