Determination of rate and time of nitrogen application on wheat (Triticum aestivum) yield and yield related components

Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia

TECHNICAL REPORT OF EXPERIMENTAL ACTIVITIES

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Implemented by

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Cover photo: N split application experiment in the Gumara- Maksegnit watershed | 28 July 2014 | Picture by Nigus Demelash.

About ICARDA

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Synthesis

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Report submitted by: Baye Ayalew

Summary Report

The objective of this study - in the framework of the project 'Reducing land degradation and farmers' vulnerability to climate change in the highland dry areas of north-western Ethiopia'- was to investigate the effect of rate and time of nitrogen application on growth and yield of bread wheat. The experiment contains thirteen treatments in Randomized Complete Bock Design with three replications. Total plot size was 12 m2. 46 Kg/ha P2O5 was applied for all treatments. The experiment was carried out during the 2013 main cropping season from June to November in Gondar Zuria on a farmers' field. All other agronomic practices were applied. 23 kg/ha N application ½ at planting + ½ tillering, 23 kg/ha ½ at planting + ½ flag leaf (booting stage), 23 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 23 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage);46 kg/ha N application ½ at planting + ½ tillering, 46 kg/ha ½ at planting + ½ flag leaf (booting stage), 46 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 46 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage); 69 kg/ha N application ½ at planting + ½ tillering, 69 kg/ha ½ at planting + ½ flag leaf (booting stage), 69 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 69 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage); control (No N fertilizer). In the second experimental year (2014), three additional treatments where 23kg/ha, 46kg/ha and 69kg/ha are applied during tillering stage, were included.

Composite soil samples were collected before planting. In both years, the various split applications of nitrogen treatments applied at different stages, significantly affect grain yield and yield parameters of bread wheat (Table1. and Table2.). In 2013, maximum plant height was observed at 46 kg/ha and 69 kg/ha of N fertilizer with split application 1/3 at planting, 1/3 at tillering and 1/3 at booting stage gave 3848.3 kg/ha and 3933.2 kg/ha respectively. Similarly, maximum wheat grain yield was obtained at 46 kg/ha and 69 kg/ha of N with split application of 1/3 at planting, 1/3 at tillering and 1/3 at booting stage. On the contrary, similar rates of N fertilizer with split application half at planting and half at booting stage showed lower grain yield. The lowest wheat grain yield was observed at a rate of 23 kg N fertilizer in all split application stages. Spike length was also influenced by the split N fertilizer application. Maximum spike length was obtained at 46 kg/ha and 69 kg/ha of N fertilizer with split application 1/3 at planting, 1/3 at tillering and 1/3 at booting stage. Split N fertilizer also showed statistically significant difference in biomass yield. In 2014, both biomass and grain yield were affected with split application of N. Applying 69 kg/ha of N with 1/3 at planting, 1/3 at tillering and 1/3 at booting stage gave better grain yield with an extent of 3277.8kg/ha.

The experiments showed that split application of nitrogen fertilizer was effective in improving grain yield of wheat and yield related components. Therefore, three times split application that is 1/3 at planting, 1/3 at tillering and 1/3 at booting stage was found to be best practice for Gumara-Maksegnit watershed.

Schematic summary of information

Location (locality, town, province….):	Abakaloye village, Gumara-Maksegnit watershed, Gondar
Easting:	0346223
Northing:	1373200
Elevation:	1982m a.s.l.
Period of implementation:	June, 2013 to January, 2014
Duration of trials:	Two years
Activity leader(s):	Nigus D. and Meron L.
Other researchers involved:	Baye A., Ayalew A., Tamrat W, Melkamu A

1 Background and rationale

Wheat (*Triticum aestivum*) growth, development and yield depend mainly on available water and fertilizer (Halitligil et al., 2000). Fertilizer management is an important part of the overall management package target towards realizing higher yield (Bayoumi and El-Demardash, 2008). Application of nitrogenous fertilizer improves various crop parameters like 1000– grain weight (Warraich et al., 2002), grain yield (Warraich et al., 2002). Nitrogen fertilization strongly influences the quality of protein in wheat flour. Tolbert (2004) found that increasing nitrogen fertilizer increased protein content, flour and the arrival time of dough. Nitrogen fertilization management offers the opportunity for increasing wheat protein content and quality.

Nitrogen is a key factor in achieving optimum grain yield. Plant use efficiency of nitrogen depends on several factors including application time, rate of nitrogen applied, cultivar and climatic conditions (Moll et al., 1982). Among the most important management practices influencing grain protein content is N fertilizer application rate and timing.

Increased use of fertilizer nitrogen (N) in agricultural production has however raised concerns, because the N surplus is at risk of leaving the plant-soil system and thereby causing environmental contamination. This is in addition to increased costs associated with the manufacture and distribution of N fertilizer (Alizadeh and Ghadeai, 2006). Wheat being a shallow-rooted crop with the domain root zone at 20 cm below the soil surface, can lead to considerable nitrate loss by leaching under irrigated or high rainfall conditions

(Ren et al., 2003). Liberal application of nitrogen fertilizer results in nitrate accumulation in ground water, due to nitrate leaching (Chaney, 1990) and can thus lead to human and environmental health problems

The efficiency of the N applied in satisfying the N demand of the crop depends on the type of fertilizer, timing of fertilizer application and seasonal trends (Borghi, 2000; Blankenau et al., 2002). Crop response to N fertilizer is also influenced by soil type, crop sequence and the supply of residual and mineralized N. Therefore, numerous strategies such as: use of N sources, slow release of fertilizer, placement techniques and nitrification inhibitors have been devised to reduce nitrogen losses and improve fertilizer use efficiency (Slanger and Kerkhoff, 1984; Freney et al., 1992).

Researchers have found that the majority of the total amount of essential nutrients used by wheat is absorbed from the soil between the growth stages of tillering and heading. Therefore, it is important to have an adequate supply of all nutrients in the root zone early in the growing season.

For wheat production because of the potential for losses due to leaching, split N applications are encouraged. For these situations, the first application can be made at planting followed by the remainder between tillering and jointing. N applications at tillering may be justified if loss of previously applied N from leaching or denitrification is suspected. Application of N at this time would also be appropriate where a yield goal is set and where available soil moisture advocates a high probability for a higher yield.

There is also a potential for N loss if urea (46-0-0) or urea-ammonium nitrate (28-0-0) is broadcast on the soil surface without incorporation when soil pH is higher than 7.3, air temperatures are high and there is residue on the soil surface. Shallow incorporation of urea or fertilizers containing urea within 48 hours of application is encouraged when these N sources are used for wheat production. Optimal strategies for using nitrogen fertilizer with wheat (Triticum aestivum.) must aim to maximize yield while maintaining low N. Nitrogen fertilizer rates and timing of application are a decisive factor in the obtaining of high yields, increased protein content and improved grain quality, numerous studies have been done in order to determine the optimum rate and time of N application (Garrido- Lestache et al., 2005; Marino et al., 2009; Cui et al., 2010).

2 Objective

The main objective of this research activity was to determine optimum rate and time application of nitrogen fertilizer for wheat production at Gumara-Maksegnit watershed.

3 Experimental Methods

The experiment contains thirteen treatments in Randomized Complete Bock Design with three replications. Total plot size was 12 m2. A rate of 46 Kg/ha P2O5 was applied for all treatments. Sowing was done in the third ploughing. Broad bed furrow, with furrow width of 40cm and furrow depth of 15cm was used while seed sowing was done in rows on 80cm widths' bed. The spacing between each row was 10cm. Weeding was done three times in the full growth season.

23 kg/ha N application ½ at planting + ½ tillering, 23 kg/ha ½ at planting + ½ flag leaf (booting stage), 23 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 23 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage);46 kg/ha N application ½ at planting + ½ tillering, 46 kg/ha ½ at planting + ½ flag leaf (booting stage), 46 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 46 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage); 69 kg/ha N application ½ at planting + ½ tillering, 69 kg/ha ½ at planting + ½ flag leaf (booting stage), 69 kg/ha N ½ at tillering + ½ flag leaf (booting stage), 69 kg/ha N 1/3 at planting + 1/3 tillering + flag leaf (booting stage); control (No N fertilizer). In the second experimental year (2014), three additional treatments were tested to which are full N rates are applied at tillering stage. Composite soil samples were collected before planting. Soil chemical analysis was done at Gondar Soil Laboratory (Table 1).

Table 1: Initial soil parameters of experimental site (2014)

Parameters	Datum
PH	7.05
Available P, ppm	2.42
Organic matter, %	5.96
CEC, cmol (+) kg-1	62.40
Exchangeable Cacmol (+) kg-1	38.31
Exchangeable Mgcmol (+) kg-1	22.09
Exchangeable k, cmol (+) kg-1	2.16
Exchangeable Na, cmol (+) kg-1	0.33

4 Statistical aspects

The data collected from the field study were subjected for analysis of variance (ANOVA) using SAS software. Whenever treatment effects were significant, mean comparison were made using least significant difference (LSD).

5 Results

The analysis of variance of the experiment conducted indicated that there was statistically significant difference ($p < 0.05$) among the parameters in plant height, spike length, biomass yield and grain yield. However, there was no statistically significant difference ($p > 0.05$) in thousand seed weight. The various split applications of nitrogen treatments applied at different stages, significantly affect grain yield and yield parameters of bread wheat (Table1.). Maximum plant height was observed at 46 kg/ha and 69 kg/ha of N fertilizer with split application 1/3 at planting, 1/3 at tillering and 1/3 at booting stage.

Similarly, Maximum wheat grain yield was obtained at 46 kg/ha and 69 kg/ha of N with split application 1/3 at planting, 1/3 at tillering and 1/3 at booting stage. Applying similar rates of N fertilizer with split application half at planting and half at booting stage showed lower yield. The lowest wheat grain yield was observed at a rate of 23 kg N fertilizer in all split application stages.

Spike length was also influenced by the split N fertilizer application. Maximum spike length was obtained at 46 kg/ha and 69 kg/ha of N fertilizer with split application 1/3 at planting, 1/3 at tillering and 1/3 at booting stage. Split N fertilizer also showed statistically significant difference in biomass yield.

Table 2: Grain yield and yield components of wheat as influenced by N rate and N splitting methods in 2013

Nitrogen Rate (kg/ha)	N split	Plant height (cm)	Spike length (cm)	Biomass yield (kg/ha)	Grain yield (kg/ha)	1000 seed weight (gm)
23	$N_{1/2} + N_{1/2} + N_0$	82.0	8.1	7750	1737.1	33.9
	$N_{1/2} + N_0 + N_{1/2}$	59.8	5.7	3916.7	1371.7	34.7
	$N_0 + N_{1/2} + N_{1/2}$	73.7	7.8	7500	2468.6	36
	$N_{1/3} + N_{1/3} + N_{1/3}$	78.1	8.0	7916.7	2549.4	36.6
46	$N_{1/2} + N_{1/2} + N_0$	90.0	8.1	11250	3746.2	30.8
	$N_{1/2} + N_0 + N_{1/2}$	73.4	8.1	6250	1561.1	36.8
	$N_0 + N_{1/2} + N_{1/2}$	80.3	7.8	9583.3	3186.9	37.6
	$N_{1/3} + N_{1/3} + N_{1/3}$	90.3	9.7	11416.7	3848.3	35.9
69	$N_{1/2} + N_{1/2} + N_0$	89.3	9.0	12083.3	3756.3	34.7
	$N_{1/2} + N_0 + N_{1/2}$	76.4	8.0	8333.3	1597.9	33.4
	$N_0 + N_{1/2} + N_{1/2}$	85.2	9.0	11250	3659.3	35
	$N_{1/3} + N_{1/3} + N_{1/3}$	91.7	9.5	11666.7	3933.2	33.6
control	$N_0 + N_0 + N_0$	32.9	2.7	2916.7	530	33.2
CV		6.4	9.8	12.1	10.3	10.21
LSD (5%)		8.3	1.2	1758.6	591.1	NS

Table 3: Grain yield and yield components of wheat as influenced by N rate and N splitting methods in 2014

Nitrogen Rate (kg/ha)	N split	Biomass yield (kg/ha)	Grain yield (kg/ha)

23	N1/2 + N 1/2 + N0	4111.1	1523.1
	N1/2 + 0 + N1/2	2518.5	1119.3
	N0 + N1/2 + N 1/2	4060.2	1730
	N0 + N1 + N0	4048.1	1904.6
	N1/3 +N1/3 + N 1/3	2930.6	1371.3
46	N1/2 + N ½ + N 0	5827.8	1885.2
	N1/2 + N0 + N1/2	5209.2	1767.6
	N0 + N 1/2 + N1/2	4730.5	1640.7
	N0 + N 1 + N0	7081.5	2041.7
	N1/3 +N1/3 + N1/3	6498.1	2695.4
69	N1/2 + N1/2 + N0	7115.7	2746.3
	N1/2 + N0 + N1/2	5710.2	2095.4
	N0 + N1/2 + N1/2	4763.9	2000
	N0 + N1 + N0	8907.4	2713
	N1/3 +N1/3 + N1/3	6912.1	3277.8
control	N0 + N0 + N0	1393.5	237.6
CV		7.49	7.32
LSD (5%)		638.71	234.75

6 Conclusion

The experiments showed that split application of nitrogen fertilizer was effective in improving grain yield of wheat and yield related components. Three times split application that is 1/3 at planting, 1/3 at tillering and 1/3 at booting stage gave the highest yield 3933.2 kg/ha and 3848.3kg/ha at 69 kg/ha of N and 46 kg/ha of N, respectively. Therefore, split application of nitrogen fertilizer at planting, tillering and booting stage was found to be best practice for Gumara-Maksegnit watershed

***NOTE**: The data presented in this report are currently being elaborated for scientific publication, thus some of them are not final. The aim of this report is to summarize the nature and quality of the activities conducted and of the dataset generated, and to illustrate the main results obtained.*

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