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Response of Grain Sorghum to Split Application of Nitrogen at Tanqua Abergelle Wereda, North Ethiopia

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Abstract

In *Tanqua Abergelle*, where the study has conducted, application of fertilizer particularly nitrogen is done once in either of the crop growth stages. To this fact, it is known that nitrogen is an easy going chemical fertilizer that can simply undertake nitrification and be washed away by heavy rainfall without meeting the required objectives. Not only this but also, the sensitive fertilizer requirement of the crop growth stage is not known which this varies even from crop to crop. Hence, the objective of this study was to improve the nitrogen utilization efficiency of sorghum by split application of nitrogen there by obtaining higher yields while simultaneously identifying the best time of fertilizer application. The research was undertaken in *Abergelle* agricultural research center testing site (*Mearey*). There were seven treatments replicated three times and for doing so, randomized complete block design was used. Split application of nitrogen at different growth stages of sorghum didn't brought a statistically significant difference in plant height, panicle length, biomass yield and thousand seed weight. Moreover, application of nitrogen at initial, development, mid, Initial Dev, Initial Mid and Development Mid were statistically the same in grain yield. However, there was statistically significant difference ($p<0.05$) in yield between application of nitrogen at development growth stage (application at once) and application of nitrogen at the three growth stages (Initial, Development and Mid) in splitting form. Application of nitrogen during development growth stage provides the highest grain yield (3.2 t/ha) followed by initial (3.1 t/ha) and initial mid (2.98 t/ha). The lowest grain yield was obtained in Initial, Development and Mid growth stages (2.4 t/ha) i.e., with application of the same amount of nitrogen during initial, development and mid growth stages in split form. Even though, sorghum (Meko1) grain yield poorly responds to spilt application of nitrogen, further multiple years' research data is needed to reach at strong conclusions.

Keywords: Initial; Development; Mid; Split application; Growth stage

Introduction

The large need of plants for nitrogen and the limited ability of soils to supply available nitrogen cause nitrogen to be the most limiting nutrient for crop production on the globe [1]. Worldwide interest associated with increasing cereal grain protein has added an attention on improving the utilization of nitrogen in cereals [2]. Moreover, the concern of ground water contamination, cost of manufacturing and distribution has pressurized farmers to use nitrogen more efficiently [3].

Proper nitrogen application time and rates are critical to meet crop needs and indicate considerable opportunities for improving nitrogen use efficiency [4]. The growth stage of crops at which fertilizer is applied determines the nitrogen use efficiency; however, the response can vary by genotype. Luxuriant application of nitrogen fertilizer at sowing increases the emergence of broad leaf weeds, thereby the labor requirements for hand weeding, hence, split application of nitrogen is considered as more economical both in terms of weed management and nitrogen use efficiency for optimizing grain yield [5].

The most commonly used practice in improving nitrogen use efficiency of crops is split application of fertilizers, selection of crop growth environment (soil type and climate) and management practices (sowing date and rate of nitrogen application). The efficiency of the applied nitrogen in satisfying the demand of the crop depends on the type of fertilizer, timing of application, crop sequence, the supply of residual and mineralized nitrogen and seasonal trends [4,6].

Worldwide, nitrogen use efficiency (NUE) of cereal crops (such as wheat, maize, rice, barley, sorghum, millet and oat) is approximately 33% [7]. Loss of fertilizer nitrogen results from gaseous plant emission, soil denitrification, surface runoff, volatilization, and leaching. Increasing cereal NUE is unlikely, unless a system approach is implemented that uses numerous strategies such as use of nitrogen sources, timing of application, slow release fertilizer, placement techniques and nitrification inhibitors have been devised to reduce nitrogen losses and improve fertilizer use efficiency [8,9]. Therefore, this study was conducted for evaluating the response of grain sorghum [*Sorghum bicolor* (L) Moench] to nitrogen time of application of each growth stages.

Limitations of the study

This study was conducted at one agricultural research testing site and doesn't have replication across different locations. Soil and leaf sample were not collected for nitrogen use efficiency analysis, but was indirectly evaluated using the yield response of the crop to the applied nitrogen per each growth stages. Moreover, the blanket recommendation of nitrogen per hectare (46 kg of N) was equally split in to the crop growth stages, while actually each growth stage has different fertilizer requirements.

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Materials and Methods

Area description

The experiment was undertaken at *Tanqua Abergelle Wereda* at *Abergelle* agricultural research center testing site. *Tanqua Abergelle* is found in central zone of Tigray regional state. It is located at about 120 kilometers away from the capital city of Tigray regional state, Mekelle, to the west direction. The research was undertaken at a specific site called *Mearey* (Figure 1).

It is located at 13° 14' 06" N latitude and 38° 58' 50" E longitudes and agro ecologically characterized as hot warm sub- moist low land (SM1- 4b) below 1500 masl. Textural class of Mearey site soil in Tanqua Abergelle district was sandy loam and it was sandy dominated soil. The pH of the experimental site was 7.5. According to FAO the preferable and productive soils pH ranges for most crops ranges from 4 to 8. Thus, the pH of the experimental site soil was within the range of productive soils. Both the organic matter and total nitrogen content [10] of the experimental site Mearey were low (Table 1).

The low organic matter and total nitrogen contents of soils of the experimental site could be due to the properties of the soil which is sandy dominated that accelerates rate of oxidation of organic matter. Soil texture influences the rate of soil organic matter (SOM) decomposition. Soils with high clay content may have higher soil organic matter content, due to slower decomposition of organic matter.

The rainfall pattern of the district is monomodal with a wet season of about two months occurring in July to August. The mean annual rain fall and temperature are 350-700 mm and 24-41°C respectively.

There is high interannual variability of rainfall in the area. As the experiment was held in 2011, the recorded annual rainfall during that year was very low (Figure 2) and even erratic. Loss of fertilizer particularly nitrogen in such areas which are manifested by erratic rainfall could most likely be due to volatilization and even can be washed away when it rains heavy rainfall.

Research design

For conducting this research the total growing period of sorghum were used as a milestone to commence the experiment. The sorghum variety that was used in this experiment was Mekol. According to food and agricultural organization, the estimated total growing days of sorghum is 130 days in warm semi-arid climates. These total growing days were then, categorized in to different growth stages called initial, development, mid and late. Therefore, the initial, development, mid and late growing days of the vegetables was stratified in the following ways.

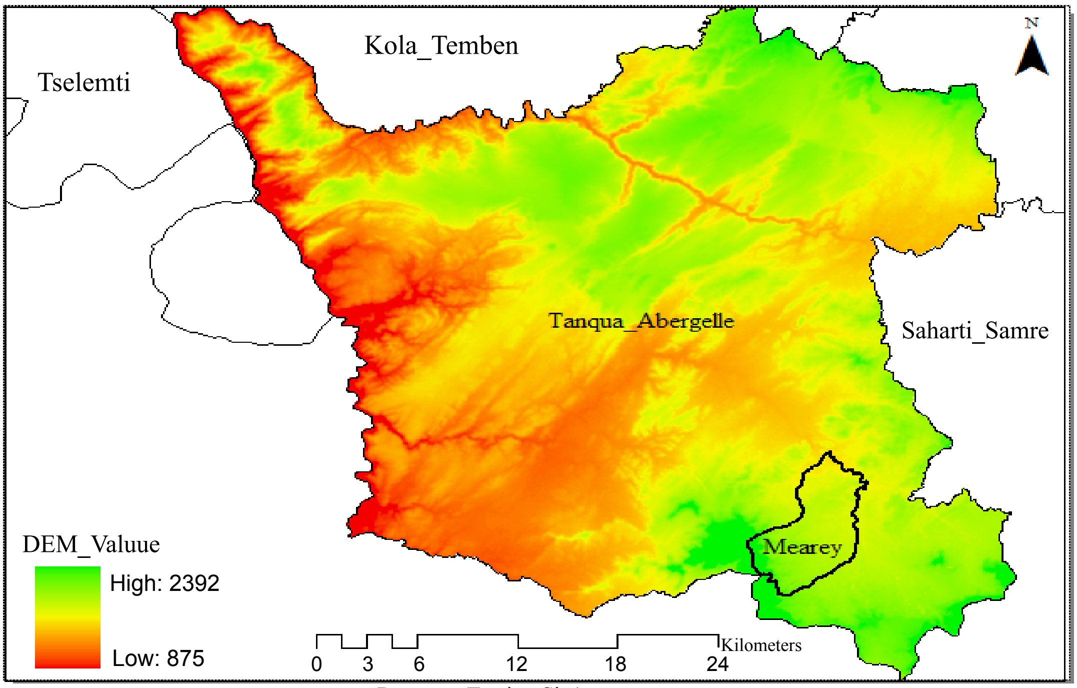
Having this information, split fertilizer application was done in the three crop growth stages (Table 2), but, application of fertilizer at the late growth stage is not recommended and hence, was excluded from our study. Treatments were replicated three times and randomized complete block design with plot size of 4.5 × 5 m (22.5 m^2) was used. The spacing between plots, rows, blocks and plants were 50, 75, 100 and 20 cm respectively. The recommended amount of nitrogen applied in the area is 46 kg per hectare, accordingly, per 22.5 m^2 sizes of land 103.5 gram, and hence, in splitting form the application was 51.75 gram for two times that is at two growth stages and 34.5 gram for three times (three growth stages). The treatments were arranged in the following ways.

Treatments

Application of nitrogen at:

T1: Initial growth stage (103.5 gram)

T2: Development growth stage (103.5 gram)



R Testing Site).

Figure 1: Map of the study area (Mearey Research Testing Site).

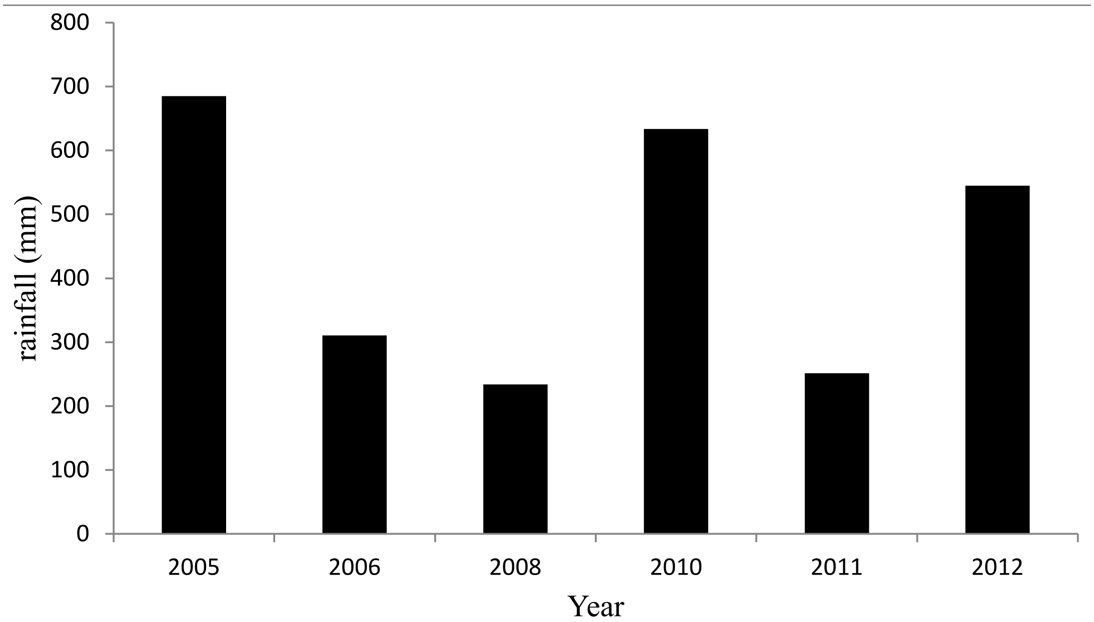


Figure 2: Average annual rainfall of the study area Mearey Research Site.

Soil Parameters	Mearey Experimental Site
Sand (%)	71
Silt (%)	13
Clay (%)	16
Textural Class	Sandy loam
pH (1:2.5 H_2O)	7.5
Organic Matter (%)	0.89
Total Nitrogen (%)	0.012
Available Phosphorous (mg kg^{-1})	7
Available K (ppm)	**78**

Table 1: Soil physicochemical properties of Mearey research testing site.

Crop type	Initial	Development	Mid	Late	Total Growing days
Sorghum	20	85	45	90	130

Table 2: Growing days of sorghum bicolor by each growth stages.

T3: Mid growth stage (103.5 gram)

T4: Initial (51.75 gram) and development (51.75 gram) growth stages

T5: Initial (51.75 gram) and mid (51.75 gram) growth stages

T6: Development (51.75 gram) and mid (51.75 gram) growth stages

T7: Initial (34.5 gram), development (34.5 gram) and mid (34.5 gram) growth stages (Table 3)

Fertilizer can be applied either in banding or broadcasting method, but, for this experiment banding method of application was used to the soil so as to minimize loss of fertilizer which can be due to competition of weeds or other factors. The recommended amount of DAP (92 t/ha) was applied during planting.

Data collection and analysis

The yield and yield components of sorghum which are plant height, panicle length, biomass, grain yield and TSW (thousand seed weight), sowing date, fertilizer application date and weeding frequency were collected. The collected data were statistically analyzed using analysis of variance (ANOVA) procedures with LSD mean separation at 5% level of significance.

Results and Discussion

Phenology and grain yield of sorghum

Split application of nitrogen at different growth stages of sorghum didn't brought a statistically significant difference in plant height, panicle length, biomass yield and thousand seed weight (Table 4). Moreover, application of nitrogen at initial, development, mid, indev, inmid and devmid were statistically the same in grain yield. However, there was statistically significant difference ($p<0.05$) in yield between application of nitrogen at development growth stage (application at once) and application of nitrogen at the three growth stages (initial development and mid) in splitting form.

Application of the recommended nitrogen during development growth stage provides the highest grain yield (3.2 t/ha) followed by initial (3.1 t/ha) and initial mid (2.98 t/ha). The lowest grain yield was obtained at initial development and mid growth stages (2.4 t/ha) i.e., with application of the same amount of nitrogen during initial, development and mid growth stages in split form. Similar to the grain yield, though not statistically significant, the highest biomass yield was recorded in development growth stage (10.321 t/ha) while the lowest (7. 657 t/ha) was in initial development and mid.

It was initially hypothesized that, instead of applying the recommended amount of nitrogen to an area at once, split application of nitrogen would increase the grain yield of sorghum. However, what we found here was in contrary to our hypothesis. The reason why this happens could be due to the allocation of equal amount of nitrogen fertilizer to each growth stages, while, practically their nitrogen requirement is different. The authors in Ref. [11,12] similarly stated that split application of nitrogen had a little effect on yield. In contrary, Ref. [13] found that time of nitrogen application had significant effect on

Treatments		Amount of nitrogen applied and application frequency		
S No		05/08/2011	14/07/2011	24/08/2011
1	Initial	103.5 g	-	-
2	Development	-	103.5 g	-
3	Mid	-	-	103.5 g
4	Initial development	51.75 g	51.75 g	-
5	Initial mid	51.75 g	-	51.75 g
6	Development mid	-	51.75 g	51.75 g
7	Initial development mid	34.5 g	34.5 g	34.5 g

Table 3: Split application of nitrogen at different growth stages of sorghum.

		Crop parameters				
S/N	**Treatments**	**Plant height (cm)**	**Panicle length (cm)**	**Biomass (t/ha)**	**Yield (t/ha)**	**TSW (gm)**
1	Initial	176	24.83	8.59	3.10 ab	36.03
2	Development	179	24.83	10.32	3.18 a	34.93
3	Mid	173	24.00	8.45	2.59 ab	35.67
4	Inidev	174	24.27	8.69	2.73 ab	34.97
5	Inimid	175	23.00	9.48	2.98 ab	39.83
6	devmid	171	22.99	9.14	2.86 ab	34.83
7	Inidevmid	172	24.25	7.66	2.48 b	34.83
	LSD	**0.11**	**3.3**	**2.95**	**0.7**	**7.96**
	CV (%)	**0.19**	**7.7**	**18.66**	**13.83**	

Table 4: Response of Sorghum Yield and yield components to Split Application of N.

sorghum yield attributes. Application of nitrogen in split form worth's a lot than applying the whole doze at once; however, there are many challenges that hinder effectiveness of this practice such as availability of soil moisture during the time of nitrogen application [14].

Conclusion

In the area where this research has undertaken, application of fertilizer particularly nitrogen is done once in either of the crop growth stages. To this fact, it is known that nitrogen is an easy going chemical fertilizer that can simply undertake nitrification, denitrification, surface runoff, volatilization and leaching without meeting the required objectives. Hence, it was initially hypothesized that, instead of applying the recommended full doze of nitrogen at once, split application of nitrogen would increase the grain yield of sorghum through improving the nitrogen use efficiency of the crop. However, split application of nitrogen at different growth stages of sorghum didn't brought a statistically significant difference in plant height, panicle length, biomass yield and thousand seed weight of sorghum. Moreover, application of nitrogen at initial, development, mid, indev, inmid and devmid were statistically the same in grain yield. Application of nitrogen during development growth stage provided the highest grain yield followed by initial and initial mid with the least in the split application (Inidevmid).

Recommendations

Even though this research finding is very crucial, further research should be done using different rates of nitrogen to the different crop growth stages, which helps to know the nitrogen sensitive growth stage of the crop and hence, recommend the estimated rate of applications for each growth stages. On top of this, further research should be held using different crop types and varieties for multiple years to reach at strong conclusions.

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