Research & Development
2024, Vol. 5, No. 4, pp. 106-109
https://doi.org/10.11648/j.rd.20240504.12

SciencePG
Science Publishing Group

Research Article

Determination of Appropriate Time of Nitrogen Application to Improve Productivity of Sorghum Crops in Assosa Zone, Benishangul Gumuz Region

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Abstract

The research was conducted to determine the appropriate application time of nitrogen fertilizer on yield and yield components of sorghum in Benishangul gumuz region. Treatments consisted of eight application times of nitrogen: all recommended rate of N at planting (T1), ½ at planting + ½ at knee height (T2), Applying $^{1}/_{2}$ at planting+$^{1}/_{2}$ at near flowering (T3), Applying $^{1}/_{3}$ at planting+$^{1}/_{3}$ at knee height+$^{1}/_{3}$ at near flowering (T4), Applying $^{1}/_{3}$ at planting+$^{2}/_{3}$ at knee height (T5), Applying $^{1}/_{3}$ at planting+$^{2}/_{3}$ at near flowering (T6), Applying $^{2}/_{3}$ at planting+$^{1}/_{3}$ knee height (T7), and Applying $^{2}/_{3}$ at planting+$^{1}/_{3}$ knee height (T8) Days to 50% maturity, plant height, and grain yield were the parameters significantly affected by treatment effect, while, days to heading, and thousand kernel weight showed non-significant. The maximum grain yield was 5658 kg ha^{-1}, in two split applications (1/2 dose at sowing and 1/2 dose at knee height. The use of nitrogen in two split applications (1/2 dose at sowing and 1/2 dose at knee height stage) can be recommended for farmers for production of sorghum in the study area and other areas with similar agro ecological conditions.

Keywords

Productivity, Planting Time, Sorghum, Nitrogen, Yield

1. Introduction

Sorghum (Sorghum bicolor (L.) Moench) is one of the most important food crop in many under develop countries. It is the second most important cereal (after maize) in Sub-Saharan Africa in terms of production. Sorghum is widely adapted crop than other cereal crops in the country which can be grown in the high lands, low lands and semi-arid regions of Ethiopia; especially in moisture stressed parts where other crops can hardly survive [1]. But farmers in East Africa apply little or no additional fertilizers to the soil and due to this reason; soil nutrient is depleting yearly which in turn decreases production.

The most important soil macro nutrients which are critical for cereal crop production is nitrogen and one of these crops is sorghum. There should be replacement of nutrient taken by plant and lost during the past cropping years. Literature revealed that balanced addition of NPK caused an increase in sorghum yield up to 122 % in India [2]. In a study by [3] when the rate of application nitrogen fertilizer was increased by 30%, the yield was increased by 4%, on the other hand

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Received: 11 August 2024; **Accepted:** 24 September 2024; **Published:** 18 October 2024

the amount of nitrate lost through leaching increased by 53%. When the amount of nitrogen is insufficient in the soil, the whole growth results in stunted growth and chlorotic leaves caused by poor assimilate formation that results to premature flowering and shortening of the growth cycle. Over dose of nitrogen application on the other hand also leads to exaggerated growth of biomass and poor root growth which leads to lodging and yield reduction.

Not only applying proper rate but application time of N is decisive for meeting crop needs, and considerable opportunities exist for yield improvement [1]. Also the efficiency of the N applied in satisfying the N demand of the crop depends on the type and timing of fertilizer application and seasonal trends [4]. It can be possible that by improving management practices, sorghum production can be increased. One of management practice is the wise use of application of time of nitrogen. The main objective of the study was to determine the appropriate application time of nitrogen fertilizer for sorghum production.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted under rain fed condition at research farm of Assosa Agricultural Research Center (ASARC) at Assosa on station during 2017 and 2018 cropping year from mid May to December. Assosa Agricultural Research Center is 660 km away from Addis Ababa which is located at latitude of 10°04’ N and longitude of 34°56’ E in western Ethiopia. The altitude of the site is 1553 m above sea level which is in mid altitude and total annual rainfall of the cropping season was 1075.7 mm. The rainy season extends from April to October and maximum rain is received in the months of June to August. It has a warm humid climate with mean maximum and minimum temperatures of 25℃ and 16℃, respectively. The soil of the site was characteristically reddish brown (Nitosol), which is slightly acidic with pH of 5.7 and texturally clay.

2.2. Treatments and Experimental Design

The experiment composed of eight treatments in a Randomized Complete Block Design (RCBD) with three replications. Sorghum variety Assosa one was sown at the onset of rains (mid of May 2017 and 29 May 2018).

2.3. Soil Sampling and Analysis

In order to determine the physical and chemical properties of the soil, three representative soil samples were taken using auger from the depth of 0 to 30 cm for each block of the experimental site before planting and application of any type of fertilizer. The samples were mixed, after about 1kg of a single composite soil sample was prepared. The sample was taken to the ASARC soil testing laboratory and tested for total nitrogen, soil pH, organic carbon, available phosphorus, potassium, Cation Exchange Capacity (CEC) and texture analysis. Soil pH in water was measured potentiometrically using pH meter with combined glass electrode in a 1:2.5 soil to water supernatant suspension [5].

Cation Exchange Capacity (CEC) of the soil was determined by 1M ammonium acetate (NH_4OAc) saturated sample at pH 7 (Chapman, 1965) where the standard paste was distilled to estimate the ammonium liberated by titration with acid. Particle size distribution was done by hydrometer method (differential settling within a water column) according to [6].

Table 1. *Treatment arrangements of the experiment.*

Treatment No	Nitrogen application time
1	Applying all recommended N rate at planting
2	Applying $^1/_2$ at planting+$^1/_2$ at knee height (control),
3	Applying $^1/_2$ at planting+$^1/_2$ at near flowering,
4	Applying $^1/_3$ at planting+$^1/_3$ at knee height+$^1/_3$ at near flowering
5	Applying $^1/_3$ at planting+$^2/_3$ at knee height
6	Applying $^1/_3$ at planting+$^2/_3$ at near flowering,
7	Applying $^2/_3$ at planting+$^1/_3$ knee height
8	Applying $^2/_3$ at planting+$^1/_3$ at near flowering.

2.4. Experimental Procedures and Field Management

The experimental land was ploughed, disked and harrowed and rows were prepared manually with traditional hoes. Triple super phosphate (TSP) 109 kg ha^{-1} was applied at sowing time. Nitrogen (219 kg ha^{-1}) was splited and applied as: all recommended rate of N at planting (T1), ½ at planting + ½ at knee height (T2), Applying $^1/_2$ at planting+$^1/_2$ at near flowering (T3), Applying $^1/_3$ at planting+$^1/_3$ at knee height+$^1/_3$ at near flowering (T4), Applying $^1/_3$ at planting+$^2/_3$ at knee height (T5), Applying $^1/_3$ at planting+$^2/_3$ at near flowering (T6), Applying $^2/_3$ at planting+$^1/_3$ knee height (T7), and Applying $^2/_3$ at planting+$^1/_3$ knee height (T8) (Table 1). Plot size was 4.5 m*5.1 m. The spacing was 75 and 20 cm between row and plant respectively. The spacing between plot and block was 1 m and 1.5 m respectively.

All other agronomic practices were kept uniform for all treatments. The parameters such as plant height (cm), number of head $plot^{-1}$, head weight $plot^{-1}$ (g), grain yield (kg ha^{-1}) were recorded. Data collected were analyzed statistically by using SAS 9.2 version program.

3. Result and Discussion

3.1. Soil Physico-chemical Properties of the Experimental Site

The soil sample collected from the experimental site before planting was analyzed for some selected soil properties. Data on these soil properties were determined in our center laboratory and it has slightly acidic soil reaction with a pH value of 5.2 for the surface of 0-30 cm depth.. Furthermore, the results obtained showed a total nitrogen content of 0.33%, which is medium according to the rating by Landon [7]. who classified soils having total N of greater than 1.0% as very high, 0.5-1.0% high, 0.2-0.5% medium, 0.1-0.2% low and less than 0.1% as very low in total nitrogen content.

Table 2. *Some physical properties of soil before planting.*

Parameters	Result	Rating
Texture class	**48% clay**	**Clay**
pH	5.82	Slightly acidic
OC	1.73%	Medium
Available P	5.4ppm	Low
CEC	12.65cmol (+)/kg	Low

3.2. Growth, Yield, and Yield Parameters

Days to 50% heading was not significantly affected by nitrogen application time (Table 3). From the analysis it can be revealed that time of heading was not dependent on the application time of nitrogen. Days to 50% maturity was revealed that application of nitrogen $^{1}/_{2}$ at planting+ $^{1}/_{2}$ at knee height is proper time and dose of nitrogen application for sorghum (Table 3). This finding is in line with [8] and he was stated that the time where sorghum is at its active vegetative growth and nutrient uptake starts around the 30 day mark post-emergence at the six to eight leaf growth stage and continues all the way through pollination and early grain fill.

Table 3. *Mean results for phenological and growth parameters of sorghum as affected by treatments.*

Treatment code	DH	DM	TSW	PH	YLD
1	138.70a	179.00b	15.50	184.3ab	3558.00 c
2	136.00	168.00 a	16.67	203.7a	5680.00a
3	138.30	181.30bc	15.67	178.00c	4870.00b
4	140.00	178.00b	15.00	180.00ab	4787.00 b
5	138.70	178.00b	15.50	182.70ab	4797.00b
6	138.30	184.00c	16.17	183.70ab	4619.00b
7	139.00	180.30bc	16.33	185.00ab	4851.00 b
8	136.70	178.30b	15.00	203.70 a	4851.00 b
LSD (5%)	NS	5.7	NS	15.31	809.20
CV	1.7	1.8	12.2	4.6	9.2

DH days to heading, DM days to Maturity, TSW Thousand seed weight, PH Plant height, YLD Yield

The delayed 50% days to maturity period was seen at treatment (T6) which was 184 (Table 3) and this might be due to late addition of nitrogen at flowering which enabled vegetative growth rather than sink [9]. As [10] stated, the delaying of nitrogen application over the 5th phase of the growing cycle may no longer be as beneficial to the crop, and could damage the sorghum head. [11] reported that delaying in maturity of sorghum plants in response to the split applications of N, 1/2 at mid vegetative and 1/2 at booting stage might be because of two-time applications in critical time promoted vigorous vegetative growth and development of the plants possibly due to synchrony of the active time of need of the plant which enabled the crop for uptake of the nutrient and availability of the nutrient in the soil. On the other hand thousand seed weight was not significantly affected by time of application at all levels. Plant height was significantly affected by the treatments and the tallest plant height was observed at (T2 and T8), and the shortest plant height was seen at T3 which was 178cm.

The result of the analysis of variance revealed that the highest grain yield (5680 kg ha^{-1}) was recorded from application of nitrogen in two split of ½ dose at sowing, 1/2 dose at mid-vegetative (knee height) stage. On the other hand, the lowest grain yield (3558 kg ha^{-1}) was obtained from applying all recommended N rate at planting. This result is similar with [12] maximum grain yield (3.7 t/ha) was obtained at 87 kg/ha of N with split application 1/2 at planting, ½ at knee height. Also, the highest gross and net monetary return was obtained from nitrogen application time of 1/2 at planting, ½ at knee height. Time of nitrogen application is the decisive factor for potential growth of sorghum crop because, if we add all recommended rate of nitrogen at sowing, since nitrogen is volatile and leached in to the soil, the crop and the nutrient may not synchronize and yield reduced. On top of this if we add the nutrient over the 5th phase (at flowering) of the growing cycle may no longer be as beneficial to the crop, and could damage the sorghum head [13]. In the other report, [14] reported that addition of nitrogen in two applications enables to increase N use efficiency in sorghum. Scholars also agree on having sufficient nitrogen available to the sorghum early in the growth cycle to ensure high yield potential, and making sure that there is sufficient nitrogen remaining late in the season are both essential for the best sorghum yield results.

4. Conclusion and Recommendation

From the study, it can be concluded that the efficiency of the N applied in satisfying the N demand of the crop depends on the type and timing of fertilizer application. Addition of nitrogen in two applications splits enables to increase N use efficiency in sorghum production. Application of nitrogen in two split of ½ dose at sowing, 1/2 dose at mid-vegetative (knee height) stage makes sufficient nitrogen available to the sorghum early in the growth cycle to ensure high yield potential, and making sure that there is sufficient nitrogen remaining late in the season which makes big head are for the best sorghum yield results.

Abbreviations

DH	Days to Heading
DM	Days to Maturity
TSW	Thousand Seed Weight
PH	Plant Height
YLD	Yield

Author Contributions

Merga Boru: Data curation, Formal Analysis, Writing – original draft

Megersa Mengasha: Formal Analysis, Writing – original draft

Adisie Dinberu: Conceptualization, Investigation, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Fields

Merga Boru: Agronomy, Plant Protection, Plant Breeding, Entomology, Seed science

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Adisie Dinberu: Agronomy, Plant Protection, Plant Breeding, Entomology, Seed science