



EFFECT OF LIQUID NITROGEN FERTILIZER AND TIME OF APPLICATION ON THE GROWTH AND YIELD OF SORGHUM IN BAUCHI STATE, NIGERIA

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ABSTRACT

Field experiment was conducted to study the effect of foliar nitrogen fertilizer and time of application on the growth and yield of sorghum at Student's Demonstration Farm of the Bauchi State Collage of Agriculture, during the rainy season of 2018 and 2019. The treatments consisted of four rates of foliar nitrogen fertilizer (0, 1, 2 and 3 L/ha) and three times of application (once, twice and thrice). These were factorially combined to give 12 treatment combination and laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on plant height, number of leaves, leaf area, 1000 grain weight and grain yield. Data collected during the experiment were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted in separating the means. Results of the experiment indicated that, growing of sorghum using foliar nitrogen fertilizer with different times of application had significant ($P \leq 0.05$) effect on all the characters measured. It was further revealed that, application of foliar nitrogen fertilizer at rate of 1, 2 and 3 L/ha significantly ($P \leq 0.05$) influenced the growth and yield of sorghum better than the control. The result further revealed that, application of liquid nitrogen fertilizer twice and thrice significantly ($P \leq 0.05$) promoted growth and yield of sorghum and proved to be better than applying once. Based on the result of this study, growing sorghum with the application of foliar nitrogen fertilizer at the rates of 1 to 2 L/ha two to three times promoted the growth and yield of sorghum and can be adopted by farmers in the study area for improved sorghum production.

Keywords: Liquid nitrogen; Fertilizer; Sorghum; Time of application

INTRODUCTION

Sorghum (*sorghum bicolor* L. moench) belong to the family *poaceae* sub family *ponicoideae* and tribe *andropogoneae*, it is the 5th most important cereal crop in the world after rice, wheat, maize and barley (Mudalagiriappa, 2012). It is used for food in Africa and many parts of Asia, cattle feed, bio-energy, thatch making, roofing of houses, brewing beer and for the manufacture of starch (Raun *et al.* 2015). Cultivated sorghum is believed to have originated near Lake Chad in Africa 3000-5000 years ago and is widely distributed throughout the continent (Tesfaye *et al.*, 2008). Even though the migration of sorghum out of Africa is not clear, it is believe that human activity may be responsible for this process from Africa it was carried to Asia and spread in India, Indonesia, China and Pakistan (Dawadi, 2012). Grain sorghum entered the US as "Guinea corn" (Raun *et al.* 2015). It is adapted to the hot, semi-arid tropical and dry temperate areas of the world (Bishani, 2005). Sorghum is better suited to high temperature and moisture stress conditions bio-chemically and physiological than rice, wheat and barley, it can give useful yield in areas unfavorable to other cereal crops like rice, wheat and Barley (Adeniyi, 2004), sorghum is adopted to a wide range of environmental and ecological conditions, having the ability to thrive in the hot, semi-arid, tropical and dry temperate areas of the world (Bishani, 2005). Despite lack of stable food supply and the



importance of cereals crops notably sorghum as a source of carbohydrate, farmers in the region do not use enough nutrient in sorghum production. Savannah soils on the other hand are low in fertility and therefore cannot satisfactorily support crops like sorghum without addition of fertilizer. Organic fertilizers are simple to apply and available locally while inorganic fertilizers on the other hand are generally costly and not readily available to small scale farmers. This necessitates the use of organic and inorganic fertilizer as a means of soil fertility restoration in order to determine the best combination that gives optimum growth and yield of sorghum in the study area.

The traditional system of low cropping intensity practiced several decades in West African savannah involves the use of fallow as a means of soil fertility restoration. However, the increase in population growth leading to increasing pressure on the land has led to continuous cropping at the expense of soil fertility management. This has resulted in rapid nutrient depletion and soil structure deterioration over the years (Gebrelibanos, 2005). Nitrogen has been identified to be a major constraint to increased sorghum production in the savannah zone of Nigeria (Singh, 2005). Therefore, the use of nitrogen fertilizer will have a positive impact towards reducing the problem of nutrient supply of the soil and consequently improve growth and yield of sorghum in the study area. This study was therefore conducted to determine the best liquid Nitrogen fertilizer rate on the growth and yield of sorghum and to investigate on the appropriate time of application of liquid Nitrogen fertilizer for optimum growth and yield of sorghum in the study area.

MATERIALS AND METHODS

Description of the Study Area

Field experiment was conducted at Student's Demonstration Farm of the Bauchi State Collage of Agriculture, during the rainy season of 2018 and 2019. The experimental site is located at approximately 10° 17N 9°4E and 609.3 meter above sea level, in the northern guinea savannah agro-ecological zone. The site experienced rainfall from the month of May - October and the major part of the rain is received from the month of August to September with an average annual rainfall of about 700.3mm.

Experimental Materials and their Sources

The sorghum seed (variety CSR-01) was obtained from the seeds multiplication unit of Bauchi State Agricultural Development Programme while the liquid nitrogen fertilizer used for the experiment was obtained from the Bauchi State Agricultural Supply Company (BASAC). The measuring instrument used during field layout were ranging pole, gutters chain, pegs, arrows and hand hoe so as to demarcate between plots.

Treatment and Experimental Design

The treatments consisted of four levels of liquid nitrogen fertilizer (0, 1, 2 and 3 L/ha.) and three different time of application (once, twice and three times), factorially combined to give a total of 12 treatments and laid out in a Randomized Complete Block Design (RCBD) replicated three times. Net plot size of 4mx4m was adopted for the experiment and a boarder row of 0.5m was left between plots while 1m was left out as a walk way between replicates. The land was cleared of all plants residues and weeds and then ploughed mechanically using tractor, it was then harrowed to a fine tilt using a simple implement (hand hoe). From these the total plots were 36 which comprised all the treatments combinations. Sorghum seed was planted at a spacing of 0.25m x 0.75m (inter and intra row respectively). Five seeds were planted and thinned to two plants per stand after seedling emergence. After land preparation and before planting, chemical means of controlling weeds infestation was carried out by applying Paraquat and Atrazine by mixing the two with water at required level in a container



before spraying, and on the other hand manual weeding was carried out at 2 and 5 weeks after emergence using hand hoe. The nitrogen liquid fertilizer was applied at three-three week's interval after emergence in both the seasons.

Data Collection and Analysis

Data were collected at bi-weekly interval from five randomly tagged plants on plant height, number of leaves, leaf area, 1000 grain weight and grain yield. All data collected during the experiment were subjected to analysis of variance (ANOVA) using SPSS version 2.0 and Duncan's Multiple Range Test (DMRT) was adopted in separating the significantly different means.

RESULTS AND DISCUSSION

Plant height

Table 1 presented the result on the effect of liquid nitrogen fertilizer and time of application on plant height. The results revealed a significant ($P \leq 0.05$) difference among the treatments throughout the study period. The result further showed that, all the rate at application was statistically ($P \leq 0.05$) similar but significantly ($P \leq 0.05$) better than the control. Time of application on the other hand, the result indicated that, except at 2 weeks, where application once prove to be statistically better ($P \leq 0.05$), twice and thrice application produced significantly ($P \leq 0.05$) taller plant throughout the study period, year of study however, except at 2 WAS where 2018 produced significantly ($P \leq 0.05$) taller plant than 2019, no significant ($P \leq 0.05$) difference was observed throughout the study period. Result of the interaction (Table 2) indicated that, application of liquid nitrogen at the rate of 1L/ha in 2018 produced significant ($P \leq 0.05$) taller plant than the other treatments combinations used.

The significant ($P \leq 0.05$) difference observed throughout the study period on plant height indicated that, plant height of sorghum is increasing with an increased rate of liquid nitrogen fertilizer and increasing nitrogen fertilizer increased the growth of sorghum. It further revealed the importance of foliar nitrogen fertilizer application on sorghum. The increased in Plant height could also be as a result of increased in nitrogen fertilizer use efficiency of sorghum as a result of time of foliar nitrogen fertilizer application. The result of this findings is in line with the report of Fageria and Baligar *et al.* (2005) who indicated the possibility of limiting mineral fertilizer use by means of applying foliar nitrogen fertilizer. Aerial spray of nutrients is preferred and gives quicker and better result than the soil applied (Jassim *et al.* 2017). Nitrogen use efficiency (NUE) and apparent N recoveries (ANR) were improved by two equal application of N compared with single application (Buah and Mwinkara, 2009). The increased in plant height could also be as a result of other favorable environmental factors or requirement for production of sorghum. This is in line with the findings of Khalid. (2010) who reported that the environmental factors that determine sorghum development and final yield are water, temperature, humidity, light and soil nutrients availability.

Table 1: Effect of Liquid Nitrogen Fertilizer and Time of Application on Plant Height of Sorghum

Treatments	WAS					
	2	4	6	8	10	12
LIQUID NITROGEN (L/ha)						
0	5.57 ^b	20.97 ^b	40.52 ^b	57.09 ^b	86.18 ^b	135.112 ^b
1	7.94 ^a	31.21 ^a	53.07 ^a	75.90 ^a	110.41 ^b	166.74 ^a
2	7.46 ^a	28.45 ^a	58.28 ^a	79.39 ^a	118.40 ^a	170.88 ^a
3	7.76 ^a	30.78 ^a	52.87 ^a	82.16 ^a	118.94 ^a	166.67 ^a
LS	**	**	**	**	**	**
SE±	0.208	1.714	2.703	4.160	1.656	6.313
Time of Application						
Once	7.51 ^a	18.74 ^b	41.05 ^a	57.31 ^b	86.10 ^b	122.57 ^b
Twice	7.11 ^b	31.74 ^a	58.58 ^a	76.63 ^a	117.10 ^a	172.42 ^a
Thrice	6.95 ^b	33.07 ^a	58.93 ^a	86.63 ^a	113.57 ^a	180.07 ^a
LS	**	**	**	**	**	**
SE±	0.180	1.484	2.341	3.603	3.168	5.467
Year						
2018	8.05 ^a	28.00	49.46	74.53	105.82	184.83
2019	6.32 ^b	27.71	52.91	72.75	108.95	131.87
LS	**	NS	NS	NS	NS	NS
SE±	0.147	1.212	1.911	2.942	2.585	4.46
Interaction						
N×T	NS	NS	NS	NS	NS	NS
N×Y	**	NS	NS	NS	NS	NS
T×Y	NS	NS	NS	NS	NS	NS
N×T×Y	NS	NS	NS	NS	NS	NS

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, **= significant at 0.01 probability level. WAS= Week after sowing, NS= Not significant.

Table 2: Interaction of Liquid Nitrogen fertilizer and Year of study on Plant Height at 2 WAS

Treatments	YEAR	
	2018	2019
Liquid Nitrogen (L/ha)		
0	5.32 ^d	5.81 ^{cd}
1	9.50 ^a	6.36 ^c
2	8.44 ^b	6.53 ^c
3	8.95 ^{ab}	6.58 ^c
LS	**	
SE±	0.30	

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, **= significant @ 0.001 probability level.

Number of Leaves

Table 3, presented the result of the effect of liquid nitrogen fertilizer and time of application number of leaves. The result revealed a significant ($P \leq 0.05$) difference among the



treatments throughout the study period, the result further showed that, all the rate of applications were statistically ($P \leq 0.05$) similar but significantly ($P \leq 0.05$) better than the control. Time of application on the other hand, the result indicated that, except at 2 WAS where no significant ($P \leq 0.05$) difference observed, a significant difference ($P \leq 0.05$) was observed at throughout the study period. Year of study however, no significant ($P \leq 0.05$) difference was observed throughout the study period. Results of the interaction (Table 4) indicated that, liquid nitrogen fertilizer at the rate of 1L/ha with three application times proved to be better than the other rates of liquid nitrogen of fertilizer at 6 WAS.

The significance ($P \leq 0.05$) difference observed on the number of leaves throughout the study period revealed the importance of foliar nitrogen fertilizer on growth characters of sorghum. The result of this study agrees with the findings of Hugar *et al.* (2010) who reported that, growth attribute (plant height, number of leaves, leave area index) of sorghum has significantly increased with an increase application time and rate of foliar nitrogen fertilizer with maximum number of leaves and leave area index recorded under the highest rate. The nature of the soil in the study area could also be seen as a factor contributing to the number of leaves as confirmed by Richard Verma *et al.*, (2005), Who affirmed that the impact of fertilizers on the growth of cereals strongly depends on the soil.

Table 3: Effect of Liquid Nitrogen Fertilizer and Time of Application on number of leaves of Sorghum

Treatments	WAS					
	2	4	6	8	10	12
Liquid Nitrogen (L/Ha)						
0	4.09 ^b	5.40 ^b	6.38 ^b	7.26 ^b	7.69 ^b	8.85 ^b
1	4.88 ^a	5.86 ^a	7.12 ^a	8.67 ^a	8.86 ^b	10.51 ^a
2	4.476 ^a	6.12 ^a	7.16 ^a	8.29 ^a	8.84 ^a	10.33 ^a
3	4.36 ^a	5.92 ^a	7.22 ^a	8.27 ^a	8.83 ^a	10.43 ^a
LS	*	*	**	**	**	**
SE \pm	0.106	0.120	0.128	0.153	0.172	0.190
Time of Application						
Once	4.33 ^a	5.43 ^b	6.37 ^c	7.59 ^b	7.96 ^b	9.74 ^b
Twice	4.28 ^b	5.45 ^b	7.05 ^a	8.33 ^a	8.74 ^a	10.25 ^a
Thrice	4.33 ^b	6.49 ^a	7.46 ^a	8.45 ^a	8.96 ^a	10.10 ^a
LS	**	**	**	**	**	*
SE \pm	0.075	0.104	0.111	0.133	0.149	0.165
Year						
2018	4.31	5.89	6.94	8.15	8.64	10.632
2019	4.38	5.75	6.10	8.09	8.47	9.42
LS	NS	NS	NS	NS	NS	NS
SE \pm	0.05	0.085	0.091	0.108	0.121	0.134
Interaction						
N \times T	NS	NS	**	NS	NS	NS
N \times Y	NS	NS	NS	NS	NS	NS
T \times Y	NS	**	*	**	NS	NS
N \times T \times Y	NS	NS	NS	NS	NS	NS

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE \pm = standard error, * & **= significant @ 0.05 & 0.001 probability level. NS= Not significant.

Table 4: Interaction of liquid nitrogen fertilizer and time of application on number of leaves of sorghum at 6 WAS

Treatments	Time of application		
	Once	Twice	Thrice
Liquid Nitrogen (l/ha)			
0	5.95 ^g	6.85 ^d	6.33 ^{efg}
1	6.27 ^{fg}	7.22 ^{bcd}	7.87 ^{ab}
2	6.43 ^{fg}	7.00 ^{cde}	8.03 ^a
3	6.83 ^{ef}	7.15 ^{cd}	7.67 ^{abc}
LS		**	
SE±		0.222	

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, * & **= significant @ 0.05 & 0.001 probability level. WAS= Week after sowing, NS= Not significant.

Leaf Area

Results of the effect of liquid nitrogen fertilizer and time of application on leaf area of sorghum is presented in Table 5. The results revealed a significant ($P \leq 0.05$) difference among the treatments throughout the study period. The result further showed that, all the rate of application were statistically similar but significantly ($P \leq 0.05$) better than the control. The result further indicated that, liquid nitrogen fertilizer at the rate of 2 l/ha at 2, 6 and 8 WAS found to produce significantly ($P \leq 0.05$) wider leaf area than other treatments combination. Similarly at 12 WAS liquid nitrogen fertilizer at the rate of 1 and 2 l/ha statistically ($P \leq 0.05$) produced wider leaf area than the other rates. Time of application on the other hand except at 10 WAS where no difference statistically, a significant ($P \leq 0.05$) difference was observed throughout the study period. Study on year however, wider leaf area was statistically ($P \leq 0.05$) produced in 2018 than 2019. Result of the interaction of liquid nitrogen fertilizer and year of study (Table 6) revealed that, all the rates of application with the exception of control produced statistically ($P \leq 0.05$) wider leaf area in 2018 than 2019.

The wider leaf area observed throughout the study period revealed the influence of foliar applied nitrogen leaf area of sorghum. The result of this study lend support to the report of Fageria and Baligar *et al.* (2005) who reported that increased in nitrogen liquid fertilizer increased growth characters of sorghum. The result is also in conformity with the findings of Imran *et al.* (2015) who stated that increasing N application from 0 - 210kg/ha-1 increased leaf area from 1973 cm² to 2757cm² in maize. Similarly, Berhane *et al.* (2015) reported that application of high N fertilizer at 61.5kgN/ha-1 increased leaf area of sorghum



Table 5: Effect of Liquid Nitrogen Fertilizer and Time of Application on Leaf Area of Sorghum

TREATMENTS	WAS					
	2	4	6	8	10	12
LIQUID NITROGEN (l/ha)						
0	170.02 ^c	1344.31	1329.17 ^c	2485.77	2664.75	3198.41
1	228.58 ^b	1472.78	1750.67 ^b	2624.75	3094.34	3763.58
2	251.98 ^b	1688.33	1852.11 ^b	2274.80	3438.33	4262.16
3	260.98 ^{ab}	1797.23	2221.64 ^a	2932.11	5983	4400.12
LS	*	NS	**	**	NS	**
SE±	10.140	164.027	98.934	118.481	1123.869	82.283
TIME OF APPLICATION						
ONCE	180.38 ^b	1100.31 ^b	1221.06 ^c	1958.13	3243.73	3766.18
TWICE	261.29 ^a	1627.45 ^a	2050.24 ^a	2800.24	4814.73	4007.60
THRICE	24.86 ^a	1999.37 ^a	2093.88 ^a	2979.37	3327.27	3944.43
LS	**	**	**	**	NS	*
SE±	8.781	142.052	85.680	102.61	973.299	71.259
YEAR						
2018	364.33	2314.84	2216.74	2596.67	4542.32	4141.51
2019	91.31	2314.84	1360.05	2261.79	3048.16	3670
LS	**	**	**	**	NS	**
SE±						
INTERACTION						
N×T	NS	NS	**	NS	NS	NS
N×Y	**	*	NS	**	NS	*
T×Y	**	NS	*	*	NS	NS
N×T×Y	NS	NS	NS	NS	NS	NS

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, * & **= significant @ 0.05 & 0.001 probability level. NS= Not significant.

Table 6: Interaction of Liquid Nitrogen fertilizer and Year of Study on Leaf Area at 2 WAS.

TREATMENTS	YEAR	
	2018	2019
Liquid nitrogen (l/ha)		
0	251.34 ^c	88.71 ^d
1	372.75 ^b	84.39 ^d
2	413.99 ^{ab}	89.97 ^d
3	419.40 ^a	102.15 ^d
LS	**	
SE±	14.340	

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, * & **= significant @ 0.05 & 0.001 probability level. WAS= Week after sowing, NS= Not significant.

Grain Yield

Table 7 presented the results on the effect of liquid nitrogen and time of application on 1000 grain weight and grain yield of sorghum. The result revealed a significant ($P \leq 0.05$) difference among the treatments throughout the study period. The result further revealed that, all the rate of foliar nitrogen application were statistically ($P \leq 0.05$) similar but significantly better than the control in terms of 1000 grain weight and grain yield of sorghum. Time of



application on the other hand, the result indicated that, application of liquid nitrogen fertilizer twice and thrice statistically produced heavier grain and higher yield of sorghum than well applied once. Result of the interaction (Table 8) showed that, application of 1 L/ha liquid nitrogen fertilizer three times in 2019 statistically ($P \leq 0.05$) produced heavier grains and higher yield of sorghum. The increase in grain weight and grain yield with increase in time of application indicated the significance of spreading foliar nitrogen application throughout the growing period. The result of this study Sheoran and Rana, (2006) who reaffirmed that, supplying N in two or three applications is a good recommendation to increase N use efficiency in sorghum. Conly *et al.* (2005) also reported that greater synchrony between crop demand and nutrient supply is necessary to improve nutrient use efficiency, and split applications of N during the growing season, rather than a single, more application, are known to be effective in increasing N use efficiency.

Table 7: Effect of Liquid Nitrogen Fertilizer and Time of Application on 1000 Grain Weight and Grain Yield of Sorghum of Sorghum

Treatments	Parameters	
	1000 grain weight (g)	Grain Yield (t/ha)
Liquid Nitrogen (l/ha)		
0	153.112 ^b	0.666 ^b
1	0.036 ^a	1.432 ^a
2	0.038 ^a	1.686 ^a
3	0.038 ^a	1.536 ^a
LS	**	**
SE \pm	0.001	0.116
Time of Application		
Once	0.034	1.040 ^b
Twice	0.035	1.474 ^a
Thrice	0.034	1.475 ^a
LS	NS	**
SE \pm	0.001	0.100
Year		
2018	0.037 ^a	1.524 ^a
2019	0.032 ^b	1.135 ^b
LS	**	**
SE \pm	0.001	0.082
Interaction		
N \times T	NS	NS
N \times Y	NS	NS
T \times Y	NS	NS
N \times T \times Y	NS	**

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE \pm = standard error, **= significant @ 0.001 probability level. NS= Not significant.

Table 8: Interaction of Liquid Nitrogen Fertilizer, Time of Application and Year of Study on Grain Yield of Sorghum.

Treatments	Year of Study					
	2018			2019		
	Once	Twice	Thrice	Once	Twice	Thrice
Liquid nitrogen (l/ha)						
0	6.97	7.33	7.93	6.08	8.54	8.39
1	7.69	7.98	7.91	7.02	7.99	9.34
2	7.73	8.45	7.94	7.71	8.02	8.83
3	7.85	8.01	7.55	7.74	6.78	7.89
LS			**			
SE±			0.359			

Means followed by the same letter in a column are statistically similar by DMRT, LS= Level of significance, SE±= standard error, **= significant @ 0.001 probability level.

CONCLUSION AND RECOMMENDATION

The application of foliar nitrogen fertilizer at different rates and time of application had a significant effect on both growth and yield of sorghum. Similarly, application of foliar nitrogen fertilizer at the rates of 1, 2 and 3 L/ha two or three times increased growth and yield of sorghum in the study area. Based on the result of this study, growing sorghum with nitrogen liquid fertilizer at the rates of 1 L/ha two to three times can be adopted by farmers in the study area for higher yield of sorghum.

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