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INFLUENCE OF LEGUME RESIDUE AND NITROGEN FERTILIZER ON THE GROWTH AND YIELD OF SORGHUM (*Sorghum bicolor* (L.) Moench) IN BAUCHI STATE, NIGERIA

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ABSTRACT

A field experiment was conducted at the Abubakar Tafawa Balewa University teaching and research farm Bauchi (10^{o}22' N and 9^{o}47'E) and also at Bulkachuwa village of Katagum LGA. (11^{o}38'N and 10 ^{o}31'E) both in Bauchi state, during the rainy seasons of 2011 and 2012 to determine the influence of legume residue and nitrogen fertilizer on the growth and yield of sorghum (*Sorghum bicolor* (L.) Moench). The treatments consist of two legumes (cowpea and soybean), nitrogen fertilizer applied at the rate of 0, 15, 30 and 60kgN/ha, both used to determine the performance of a Sorghum (variety; KSV 8). The legumes were sown in the first year while using the same site/plots, sorghum was then sown in the second year. The experiment was laid out in both years using Randomized Complete Block Design (RCBD) replicated three times. No data were collected on the legumes in the first year while data collected on sorghum in the second year included; plant height, number of leaves, 1000 grain weight and grain yield (kg/ha). The results of the experiment revealed that, growing sorghum on cowpea and soybean residue had significant ($P \leq 0.05$) effect on all the characters measured than on fallow. The results further revealed that, application of nitrogen fertilizer at the rate of 60kgN/ha gave significantly ($P \leq 0.01$) higher effects on all the characters studied than when the other rates were used. Control plots on the other hand recorded the least. It was also observed that, siting the experiment at Bauchi significantly ($P \leq 0.05$) produced higher yield than when the experiment was carried out at Bulkachuwa. Studies on interaction revealed that, irrespective of the location used, application of 60kgN/ha following cowpea and soybean in rotation significantly ($P \leq 0.01$) increased yield of sorghum. Based on the results obtained, application of 60kgN/ha as top dress to sorghum grown on cowpea or soybean residue should be adopted by farmers in and around Bauchi state for higher yield.

Key words: Legume, Residue, Nitrogen, Sorghum, Yield

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INTRODUCTION

Soil fertility decline in Africa is approaching a crisis dimension. This is mainly due to the fragile nature of the soils coupled with poor nutrient management by farmers. Population growth leading to greater pressure on the land, causing deforestation, leading to search for more arable land with reduction in fallow period and decline in fertility are among the constraints of cereal production in northern Nigeria. Nigeria like other African countries is among the highest facing challenges in soil fertility decline especially the northern part of the country. Due to socio economic factors and high cost of fertilizer leading to un-availability of the commodity has resulted in low yields of crops. A well-designed crop rotation creates farm diversity and improves soil condition and fertility. Despite its associated problems such as production of legumes at the expense of cereal crops, research findings support many benefits attributable to good crop rotation systems[1]. The benefits usually are: maintenance of good soil physical condition and organic matter, improvement in the distribution of plant nutrients in the soil by varying the feeding range of roots, improvement in fertility with legume nitrogen and green manure crops and help in control of weeds, plant diseases and pests. Some legume crops are traditionally cultivated by farmers in rotation and intercropped with cereals, notably among them, is sorghum. Sorghum is a cereal crop grown in Nigeria for food, feed and industrial uses. The stalks are used as feed, fuel, thatch making and in roofing houses. The industrial demand of sorghum is estimated at 200,00MT. In terms of production, Bauchi state is among the leading states following Kaduna and Borno states with a total production of 453,000MT as at 2005[2].

Savannah soils are known to be inherently low in organic matter and nitrogen is known to be the most limiting factor for cereal production in this ecological zone. The traditional system of low cropping intensity practiced for several decades in West African savanna involves the use of fallow as a means of soil fertility restoration. However, the increase in population growth leading to increasing pressure on land has led to continued cropping at the expense of soil fertility management. This led to a rapid nutrient depletion and soil structure deterioration over the years [3]. Among all the depleted nutrient elements under continued cropping, nitrogen is the most limiting and the major constraint to increased sorghum production in the Savanna zone of Nigeria [1]. The use of legumes to improve soil nitrogen content can be a practicable alternative to reduce the use of chemical fertilizer. Apart from increase in soil nitrogen supply, legume residue improves soil physical and biological properties resulting in high and sustainable productivity of the succeeding crop. The increasing high cost of chemical fertilizers and their scarcity calls for a relatively cheaper alternative to fertilizer application, so as to increase production while improving the fertility of the soil. Given this scenario, the integration of grain legumes into the cropping system has the potential to enhance yields of subsequent crops. This necessitates the search for easy and relatively affordable means of soil fertility management practices like crop rotation which is fundamental to a sustainable cropping system.

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MATERIALS AND METHODS

A field experiment was conducted at the Abubakar Tafawa Balewa University teaching and research farm, Bauchi (10°22' N and 9°47'E) located in the northern Guinea savannah ecological zone and also at Bulkachuwa village (11°38'N and 10°31'E) located in the Sudan savannah ecological zone, both in Bauchi state Nigeria during the rainy seasons of 2011 and 2012. The research was carried out to study the influence of cowpea and soybean residue and nitrogen fertilizer on the growth and yield of sorghum. The treatments consisted of two legumes (cowpea and soybean) grown in the first year. Cowpea (variety: ITA 248) and Soybean (variety; TGX 1448-2E) with a fallow were used during the investigation. During the second year and using the experimental site and plots, sorghum (variety, KSV 8) was sown and under it, four nitrogen levels consisting of 0, 15, 30 and 60 kg N/ha were applied. The two legumes and fallow with the four levels of nitrogen, gave 12 treatment combinations. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. No data was collected on the legumes in the first year while data collected on sorghum in the second year included; plant height, number of leaves and leaf area. Others were 1000grain weight and grain yield (kg/ha). All the data collected were subjected to analysis of variance (ANOVA) through the use of combine analysis of variance to determine, among others, effect of location. Duncan’s Multiple Range Test (DMRT) was adopted during the analysis to separate significantly different treatment means.

RESULTS

Plant height (cm)

Influence of legume residue, nitrogen levels and location on plant height of sorghum is presented in Table 1. The result in table 1 revealed that, except for the two locations where no significant difference was observed throughout the study period, significant ($P \leq 0.01$) differences were observed in nitrogen rates and legume residue throughout the study period. With the different legume residues used, growing sorghum after cowpea and soybean was found to produce significantly ($P \leq 0.01$) taller plants than when the land was left fallow. The application of 60 kg N/ha was observed to produce significantly ($P \leq 0.01$) taller plants than the other levels of nitrogen.

Number of leaves per plant

The results revealed that, growing sorghum after cowpea and soybean residue was observed to produce more leaves than the fallow. It also indicated that, application of 60kgN/ha produced significantly ($P \leq 0.01$) more leaves than the other treatments used. On the other hand, the control plots had the least number of leaves throughout the study period. Except for 8WAS where growing sorghum at Bauchi was found to produce significantly ($P \leq 0.05$) higher number of leaves than in Bulkachuwa, no significant ($P \leq 0.05$) difference was observed between the two locations throughout the study period.

1000 grain weight

The result in table 6 revealed that, Growing sorghum on cowpea residue was observed to produce significantly ($P \leq 0.05$) heavier grains than that of soybean and the control. The two legumes, however, were significantly ($P \leq 0.05$) better than when the land was left fallow. Similarly the result showed that, application of 60 kg N/ha was observed to produce significantly (P≤0.05) heavier grains than the other treatments used with the control plots having the lowest grain weight among all the treatments considered.

Grain Yield (kg/ha)

The results obtained revealed that, growing sorghum on cowpea and soybean residue was found to give significantly (P≤0.05) higher grain yield than when the land was left fallow. On the other hand, application of 60kgN/ha was found to produce significantly (P≤0.05) higher grain yield than the other treatments used. However, control plots had the lowest yield. Based on the locations considered, Bauchi location gave significantly higher grain yield than Bulkachuwa location.

DISCUSSION

Plant height (cm)

The significant (P≤0.01) difference observed throughout the study period on plant height of sorghum clearly indicated the importance of cowpea and soybean rotation in cropping system. The increase in plant height could be as a result of increase in soil nitrogen as a result of nitrogen fixed by the legumes [3]. It could also be attributed to the positive effect of rotation on soil biological and physical properties. An earlier study reported a positive effect of rotation on soil biological and physical properties and the ability of some legumes to solubilize occluded P and highly insoluble calcium bounded phosphorous by root exudates [4].

The increase in plant height as a result of increase in nitrogen fertilizer rate indicated that increasing nitrogen fertilizer increases growth of sorghum. It further revealed the importance of inorganic fertilizer in rotation system. The increase in plant height could be as a result of increase in nitrogen use efficiency of sorghum as a result of the presence of legume in the rotation. It was reported that, legume in crop rotation will increase not only the yield of succeeding crop, but also its nitrogen use efficiency[4]. A significant effect of nitrogen fertilizer and legume residue on growth components of grain sorghum was also reported [5]. The present study was also supported by an earlier report, in which increasing nitrogen fertilizer increases plant growth [6].

Interaction of nitrogen fertilizer rate and legume residue (Table 2) indicated that, nitrogen application at the rate of 60 kg N/ha on cowpea and soybean residue produced taller plants than the other rates used. Fallow on the other hand, produced the shortest plants. The result of this finding is in line with an earlier report that cowpea and soybean are among the better nitrogen fixers in legumes [7].

Interaction of nitrogen fertilizer rate and location also in table 2 indicated that, despite the variation recorded in terms of rainfall between the two locations, taller plants observed at both locations with the general supplementation of nitrogen revealed the importance of augmenting inorganic fertilizer in rotation system. It also indicated that, cereals following legumes in rotation can grow with reduced nitrogen application. This is in agreement with an earlier report that nitrogen requirement is lower for cereals following legumes than cereals following cereals [8].

Number of leaves per plant

The significant (P≤0.01) difference observed throughout the study period in terms of number of leaves could be due to the effect of residual nitrogen added by the legumes on the vegetative growth of sorghum. It also indicated the importance of legume residue on improving soil condition for the benefit of succeeding crops. The present study concurs with an earlier report, that legumes are excellent components within the various cropping systems [9].

On the various rates of nitrogen fertilizer used, the significant (P≤0.01) difference observed on number of leaves of sorghum throughout the study period showed the effect of nitrogen fertilizer as well as its importance in rotation. This conforms to an earlier study which reported that nitrogen has a significant contribution to vegetative growth of plants [10]. It also proved the findings of an earlier study that presented a similar report on sorghum following legumes in rotation [11]. The present result also indicated that, the number of leaves is synonymous with increase in plant height. This is in conformity with an earlier finding, which reported that number of leaves of sorghum is a result of increase in plant height [12].

A significant (P≤0.05) difference observed between the two locations at 8WAS could be as a result of differences in agro-ecology as well as variation in soil fertility between the two locations. The present study is in agreement with an earlier report which showed that, nitrogen availability after growing legume from previous season and the efficiency of fertilizer nitrogen on the subsequent crop is under the influence of weather conditions, especially rainfall and temperature [13].

Interaction of nitrogen fertilizer rate and location showed that, more leaves were produced at Bauchi than Bulkachuwa when 30 and 60 kg N/ha were applied. This might be due to variation in the amount and spread of rainfall received in the study areas as higher rainfall was experienced at Bauchi location than Bulkachuwa location. Similarly, the production of more leaves even at 0 kg N/ha revealed the importance of legumes in rotation.

1000 grain weight

The significant (P≤0.01) difference observed on 1000 grain weight could be attributed to the increase in soil fertility through nitrogen fixed and addition of organic matter by the legumes. It further revealed the importance of legume residue on the performance of subsequent cereals, as reported that grain weight is affected by legume residue and fertilizer application in legume – cereal rotation [14].

The application of nitrogen fertilizer up to 60 kg/ha had a significant effect on grain weight of sorghum (Table 6). This showed the importance of nitrogen fertilizer to cereals even after legume is planted. A similar trend was reported in legume – cereal intercrop [15].

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Grain Yield (kg/ha)

The significant (P≤0.01) difference observed in this study indicated the importance of cowpea and soybean residue on the performance of sorghum. This revealed the significance of legume in nitrogen fixation and its inclusion to cropping system. It could also be due to the importance of legumes in improving the physico-chemical properties of the soil. This is due to increased availability of nitrogen in the soil and the increase in the amount of nitrogen as a result of nitrogen contributed by the legumes through nitrogen fixation [16]. The result of the present study is in agreement with an earlier result, which reported an increase in the yield of sorghum following legumes in rotation [17]. A similar trend was also reported in cereals – legumes intercrop [18].

The increase in grain yield with increase in nitrogen fertilizer application clearly indicates the importance of inorganic fertilizer in the performance of sorghum. This indicated the effect of nitrogen as a basic component of many physiological processes in plants. The present findings is in support of an earlier report that, nitrogen is a basic constituent of many compounds of physiological importance to plant metabolism such as chlorophyll, nucleotides, alkaloids, proteins, enzymes, hormones and vitamins[19].

The higher grain yield obtained at Bauchi location than Bulkachuwa location is due to differences in soil fertility, temperature, amount and spread of rainfall received during the study period. It was reported that, although legumes contribute to the increase in yield of cereals in rotation, the yield response in most cases depend on the location [20]. The differences in the performance of the legumes used between the two locations could also be the reason.

Interaction of nitrogen fertilizer rate and legume residue indicated that, 60 kg N/ha can be applied to sorghum following cowpea and soybean in rotation with significant increase in yield in both locations. The interaction of legume residue and location on the other hand showed that higher grain yield (2930.24kg/ha) was obtained at Bauchi location than Bulkachuwa location (2385.35kg/ha). This could be as a result of many factors including soil fertility, pattern of rainfall as well as geographical location. This corroborates with an earlier report that although legumes contribute to increase in yield of cereals in rotation, the yield response in most cases depends on the location [21]. It was also reported that, nitrogen availability after growing legume from previous season and the efficiency of fertilizer nitrogen on the subsequent crop is under the influence of weather conditions, especially rainfall and temperature [22].

CONCLUSION

The application of nitrogen fertilizer has a significant effect on growth and yield of sorghum. Similarly, the use of cowpea and soybean in rotation with sorghum can increase growth and yield of sorghum in the study area. It was also confirmed that Bauchi location gave a higher yield of sorghum than Bulkachuwa location.

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RECOMMENDATIONS

Based on the results obtained, the following recommendations were made:

1. Application of 60kgN/ha to sorghum following cowpea and soybean in rotation can be recommended for the study area.
2. The use of cowpea or soybean residue should be adopted for rotation with sorghum by farmers for sorghum production in the study area.
3. Further research should be conducted to determine the level of nitrogen application that best suits the study area.

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Table 1: Influence of legume residue, nitrogen fertilizer and location on plant height of sorghum

	WAS					
Treatments	2	4	6	8	10	At harvest
Legume residue (LG)						
Fallow	25.69[b]	49.35[b]	92.38[b]	138.21[b]	199.31[b]	280.99[b]
Cowpea	26.23[ab]	54.69[a]	94.88[ab]	165.30[a]	233.05[a]	324.92[a]
Soybean	28.41[a]	55.03[a]	102.49[a]	165.76[a]	234.54[a]	324.01[a]
LS	**	**	**	**	**	**
SE±	0.78	1.06	2.69	2.08	2.48	2.98
Nitrogen Fertilizer (N)						
0	22.42[c]	40.03[c]	80.02[c]	128.47[d]	174.70[c]	265.48[d]
15	24.74[c]	51.17[b]	95.22[b]	141.81[c]	227.49[b]	295.48[c]
30	27.95[b]	53.95[b]	103.41[b]	162.20[b]	233.32[b]	323.11[b]
60	31.99[a]	66.94[a]	107.67[a]	193.23[a]	253.69[a]	355.81[a]
LS	**	**	**	**	**	**
SE±	0.90	1.22	3.10	2.94	2.86	3.44
Location (LC)						
Bauchi	26.78	53.93	96.30	157.51	224.62	311.80
Bulkachuwa	26.80	52.12	96.87	155.35	219.99	308.15
LS	NS	NS	NS	NS	NS	NS
SE±	0.63	0.86	2.19	2.06	2.02	2.98
Interaction						
N×LG	NS	NS	NS	**	**	**
N×LC	NS	NS	*	NS	NS	NS
LG×LC	NS	NS	NS	NS	NS	NS

LS = Level of significance, NS = Not significant, * and ** = significant at 0.05 and 0.01 respectively
Means followed by different letters are statistically different following DMRT

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Table 2: Interaction between nitrogen fertilizer and location and also nitrogen fertilizer and legume residue on plant height at harvest

Treatments	**Locations** Bauchi	Bulkachuwa	**Legume residue** Fallow	Cowpea	Soybean
Nitrogen Fertilizer					
0	84.34[bc]	75.71[c]	226.07[f]	291.57[cd]	278.81[d]
15	97.38[ab]	93.06[abc]	255.02[e]	320.49[b]	310.96[c]
30	106.50[a]	100.32[ab]	304.38[c]	326.89[b]	338.05[b]
60	96.96[ab]	102.38[ab]	338.49[b]	360.74[a]	368.21[a]
LS	*			*	
SE±	4.38			5.96	

LS = Level of significance, * = significant at 0.05. probability level
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Table 3: Influence of legume residue, nitrogen fertilizer and location on number of leaves of sorghum

	WAS				
Treatments	2	4	6	8	10
Legume residue (LG)					
Fallow	4.60^{b}	6.06^{b}	8.28	10.11^{b}	10.87^{b}
Cowpea	4.84^{ab}	6.57^{a}	8.66	11.16^{a}	12.77^{a}
Soybean	5.05^{a}	6.44^{a}	8.54	11.07^{a}	12.55^{a}
LS	*	**	NS	**	**
SE±	0.10	0.19	0.12	0.15	0.11
Nitrogen Fertilizer (N)					
0	4.12^{c}	5.72^{c}	7.55^{c}	9.54^{c}	10.63^{d}
15	4.65^{b}	6.17^{b}	8.26^{b}	10.73^{b}	11.88^{c}
30	5.15^{a}	6.41^{b}	8.59^{b}	10.45^{b}	12.32^{b}
60	5.39^{a}	7.13^{a}	9.57^{a}	12.01^{a}	13.44^{a}
LS	**	**	**	**	**
SE±	0.12	0.13	0.14	0.18	0.12
Location (LC)					
Bauchi	4.90	6.31	8.58	11.02^{a}	12.15
Bulkachuwa	4.76	6.40	8.41	10.54^{b}	11.98
LS	NS	NS	NS	*	NS
SE±	0.08	0.09	0.10	0.12	0.09
Interaction					
N×LG	NS	NS	NS	NS	NS
N×LC	*	NS	NS	NS	NS
LG×LC	NS	NS	NS	NS	*

LS = Level of significance, NS = Not significant, * and ** = significant at 0.05 and 0.01 respectively.
Means followed by different letters are statistically different following DMRT

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Table 4: Interaction between nitrogen fertilizer and location on number of leaves of sorghum at 2WAE

	Location	
Treatments	Bauchi	Bulkachuwa
Nitrogen Fertilizer		
0	4.43^{cd}	3.82^{d}
15	4.81^{bc}	4.89^{abc}
30	5.10^{bc}	5.20^{ab}
60	5.25^{ab}	5.52^{a}
LS	*	
SE±	0.17	

LS = Level of significance, * = significant at 0.05 probability level
Means followed by different letters are statistically different following DMRT

Table 5: Interaction between legume residue and location on number of leaves of sorghum at 10WAE

	Location	
Treatments	Bauchi	Bulkachuwa
Legume residue		
Fallow	10.71^{c}	11.02^{b}
Cowpea	12.94^{a}	12.63^{a}
Soybean	12.81^{a}	12.29^{a}
LS	*	
SE±	0.15	

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Table 6: Influence of legume residue, nitrogen fertilizer and location on 1000 grain weight and grain yield of sorghum

Treatments	1000grain weight(g)	Grain yield(kg/ha)
Legume residue (LG)		
Fallow	25.01[c]	1924.73[b]
Cowpea	30.04[a]	2972.50[a]
Soybean	29.01[b]	3076.15[a]
LS	**	**
SE±	0.35	38.42
Nitrogen Fertilizer (N)		
0	24.05[d]	1908.89[d]
15	26.66[c]	2468.73[c]
30	29.60[b]	2788.34[b]
60	31.77[a]	3468.22[a]
LS	**	**
SE±	0.35	44.36
Location (LC)		
Bauchi	28.41	2930.24[a]
Bulkachuwa	27.63	2385.35[b]
LS	NS	**
SE±	0.28	31.37
Interaction		
N×LG	NS	**
N×LC	NS	NS
LG×LC	NS	**

LS = Level of significance, NS = Not significant, ** = significant at 0.01 probability level
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Table 7: Interaction between nitrogen fertilizer and legume residue on yield of sorghum

Treatments	Legume		
Nitrogen Fertilizer	Fallow	Cowpea	Soybean
0	1131.35[g]	2184.35[e]	2410.97[e]
15	1672.08[f]	2810.98[d]	2923.12[cd]
30	1790.29[f]	3234.96[b]	3339.78[b]
60	3105.22[bc]	3659.70[a]	3630.74[a]
LS		**	
SE±		76.83	

LS = Level of significance, ** = significant at 0.01 probability level
Means followed by different letters are statistically different following DMRT

Table 8: Interaction between legume residue and location on yield of sorghum

Treatments	Location	
	Bauchi	Bulkachuwa
Legume residue		
Fallow	2071.09[c]	1778.38[c]
Cowpea	3317.62[a]	2627.38[b]
Soybean	3402.00[a]	2750.29[b]
LS	**	
SE±	54.33	

LS = Level of significance, ** = significant at 0.01probability level
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List of Abreviations

1. RCBD : Randomized Complete Block Design
2. MT : Metric Tonnes
3. ANOVA : Analysis of Variation
4. DMRT : Duncan's Multiple Range Test
5. WAS : Weeks After Sowing
6. LS : Level of Significance
7. NS : Not Significant
8. SE : Standard Error
9. LG : Legumes
10. LC : Location
11. N : Nitrogen

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