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FARMERS' PERCEPTION OF SORGHUM (*SORGHUM bicolor* [L.] Moench) PRODUCTION CONSTRAINTS AND TRAIT PREFERENCES IN NORTH EASTERN NIGERIA: IMPLICATIONS FOR STRIGA RESISTANCE BREEDING

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ABSTRACT
The study was conducted to assess farmers' perception of sorghum (*Sorghum bicolor* [L.] *moench*) production constraints and trait preferences in north eastern Nigeria: Implications for striga resistance breeding. Sorghum (*Sorghum bicolor* **L.** Moench), is globally an important cereal crop and a major staple crop in sub-Saharan Africa. However, its production is seriously constrained by myriads of biotic and abiotic problems. Combining pest resistance and good agronomic traits can increase sorghum productivity through systematic breeding programs. A field survey was conducted across three (3) States namely; Adamawa, Gombe and Bauchi selected in North Eastern Nigeria. The research was to determine farmers' preferred traits and production constraints, with special emphasis on *S. hermonthica* and its breeding priorities. A multi-stage cluster sampling technique was employed to interview 156 farmers. Analysis of data revealed that majority (77%) of the respondents was subsistence farmers with a mean farm size of 6 hectares. Farmers identified inadequate capital, infestation due to striga incidence, drought and soil degradation as major sorghum production constraints. Incidence of striga was widespread (78.2%) across the three (3) States. About 83% of the respondents agreed that land degradation was the main cause of striga infestation. Majority of farmers (41%) considered yield as the most preferred trait in sorghum followed by early crop maturity (32.6%); and the most popular striga control measure was physical methods. To improve sorghum productivity, farmers preferred traits and production constraints need to be integrated into future breeding programs in order to improve level of adoption of new varieties.

Keywords: Plant breeding, Production constraints, Sorghum, Striga, Trait preference.

INTRODUCTION
Sorghum (*Sorghum bicolor* L. Moench), (2n = 2x = 20), of the family Po*aceae*, is the world fifth most important cereal crop with multiple uses; providing food, animal feed and raw material for many industries (Food and Agriculture Organization [FAO], 2018). Sorghum is well accepted and widely cultivated in sub-Saharan Africa, owing to its adaptation to marginal areas, unique tolerance to drought (water use efficiency), ability to thrive on poor and water logged soils, saline and alkaline conditions and ability to flourish under high temperatures. Although the crop is cultivated in both temperate and tropical countries, its consumption as food is greater in poor and the most food-insecure regions of the world (Ejeta and Knoll, 2007).

Sorghum is a staple food for nearly 750 million people living in semi-arid regions of Africa, Asia and Latin America (Ramatoulaye *et al*., 2016). Globally, Nigeria is the second largest producer of sorghum, while at national level sorghum is the most important cereal crop. Nonetheless, its productivity in Africa, Nigeria inclusive, is generally low (800 kg ha-1) compared to its potential yield of 12 tonnes ha-1 recorded under optimum farming conditions (FAOSTAT, 2011). Poor productivity has been closely linked to biotic factors like; insect pest, diseases and parasitic weeds, as well as, abiotic factors like moisture stress, poor soil fertility

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and the vagaries of climate change that exacerbates drought and crop failures (Aissata *et al*., 2018; and Quenum *et al*., 2019).

Among these factors, infestation due to striga species and moisture stress due to erratic rainfalls are probably the two most devastating elements that limit sorghum production in the savanna regions of West Africa (Parker, 2012). Striga affect major cereal crops grown in Nigeria, namely: sorghum, pearl millet, maize, rice, sugar cane and fonio millet. In Particular, *S. hermonthica* causes substantial losses in sorghum (Samejima and Sujimoto, 2018). Hearne *et al*. (2009) reported that on a global scale about 100 million hectares of land are infested with striga. Under mono-cropping, poor soil management, planting of Striga susceptible varieties infestation due to striga can become worse. The current study is aimed at investigating farmer perceptions of production constraints and their trait preferences of sorghum (*Sorghum bicolor* **L.** Moench) with special attention paid to sorghum breeding priorities in agro-ecologies in North Eastern Nigeria.

MATERIALS AND METHODS

The Study Area

The research was conducted in Adamawa, Bauchi and Gombe States in North Eastern Nigeria; from where data were collected among sorghum farmers through direct interview with individual farmers and group discussion with farming communities. The study was conducted between March and September 2018.

The study area is situated in the Sudano-sahelian regions in north eastern Nigeria. It extends from Manaba, (Latitude 12N, Longitude 10.59E in Bauchi State, in the northern part of the study area, an area characterized by very sparse vegetation, and Lamja- Bura, (Latitude 9.09N, Longitude, 12.06 E) in Mayo Belwa LGA of Adamawa State) located in the southern part of the study area. From Yelwan Jiga (10.1N, 9.3E) in Toro local government area (LGA) of Bauchi state on the western side the study area spread to Mubi South (10.0E, 13.3N) on the eastern side of the study area. The climate of the study area is generally of the hot humid tropical type, with two (2) distinct seasons: the wet seasons and dry seasons, characterized by dry harmattan weather that last between November and March and a short (mono-modal) rain season (May-September). In the extreme northern part of the study area, rainfall is usually short, erratic and hardly exceeds 700mm and droughts are frequent. The land scape is characterized by sparse vegetation and sandy soils (See plate 1). The most extensively cultivated crops in this area are: millets sorghum, cassava, cowpea, sesame and ground nuts.

Comparatively, the southern part of the study area represented by Mayobelwa, Fufore receive rainfall between 1000-1200mm per annum (Ikusemoran and Hajjatu, 2009) and is characterized by moderate savanna vegetation, hilly topography along the river Benue tributaries, and a moderate rainy season that last for six months between May and October. The predominant crops in this region include: Maize, sorghum, rice, yams and groundnuts. Details on some of the geographical features of surveyed communities' areas are provided on Table 1 and Figure 1.

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Table 1: Geographical Features; LGAs (coordinates), Ecology Rainfall, and Type of Soil in the Study Area

State	LGAs	Communities	Ecology	Coordinates	Rainfall (mm)	Soil type
Adamawa	Mubi South	Gella, Gude, Kwaja, Lamorde,	SGS	10'05E 13'3N	935	Lithisols
	Song	K/Dumne, Song and loko	SGS	9.48N,12.66E	911	Geric combisol
	Guyuk	Guyuk, Bobini and Banjiram	SGS	9.82N,11.93E	885	Ferric luvisols
	Yola South	Njoboli, Bole III and Damare	SGS	9.11N, 12.28E	940	Geric combisols
	Fufore	Gurin, Beti , Gawi	SGS	9.13N, 12.42E	1038	Geric combisols
	M/Belwa	Lamja-bura Batare	SGS	9.30N, 12 30E	1016	Lithisols
Bauchi	Alkaleri	Duguri, Galambi , Kafi	NGS	9.91N, 10.17E	1066	Acrisols
	Dambam	Badagoshi Dalleri, Rijiya, Jallam,	NGS	11.40N, 9.59E	754	Litisols
	Ganjuwa	Marga-kona, Miya, Zongoro	NGS	10.88N, 9.82E	925	Luvisols
	Gamawa	Bulaburin Manaba,	NGS	10.13N, , 12.53N	642	Cambols
	Ningi	Anguwa Jakin. Gangare, Gidan baki	NGS	11.09N, 9.59E	905	Luvisols
	Toro	Tashan kaji and Yelwn Jiga	SGS	10.17N, 9.34E	1232	Alfisols
Gombe	Akko	Kembu, Akko, Wuro-Yola	NGS	10.35N , 11.07E	915	Nitisols
	Billiri	Tal, Lawiltu I, Laushi daji, Lawiltu II	SGS	9.92N, 11.27E 9.86N, 11.23E	819	Luvisols Vertisols
	Kaltungo	Ture Balam, Tula	SGS	9.82N, 11.48E	973	Luvisols
	Kwami	Jabla, Shongo, Roddo/ Dirango	NGS	10.34N, 10.95E	907	Nitisols
	Y- Deba	Kanawa, Baure and Deba	NGS	10.18N, 11.18E	887	Cambisol

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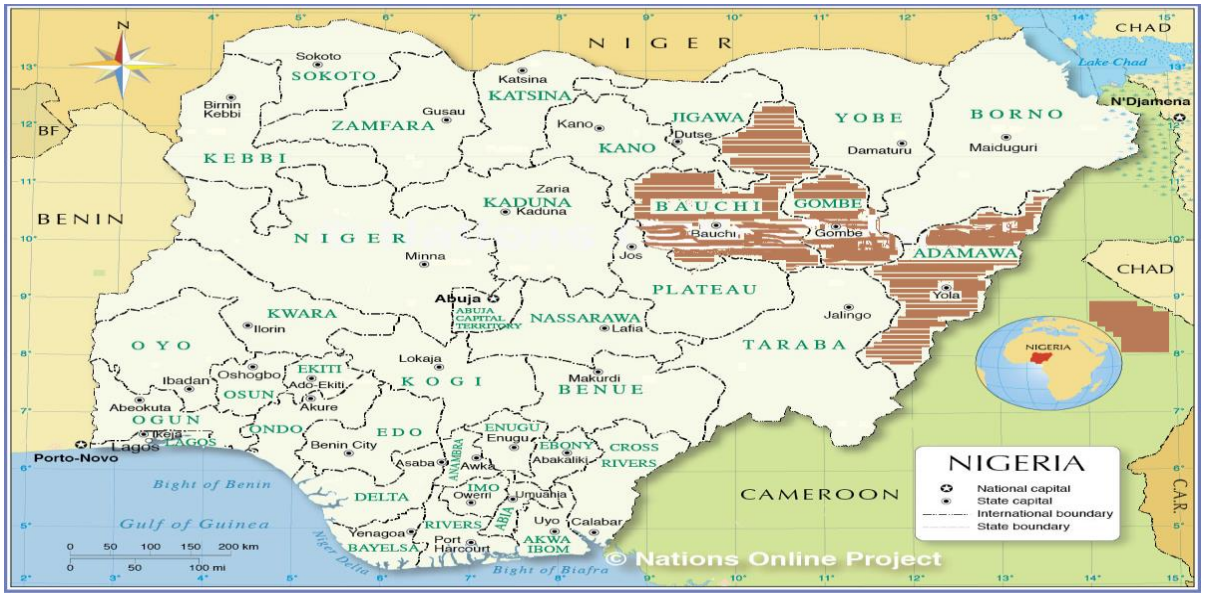

Figure 1: *Map of Nigeria indicating Adamawa, Bauchi and Gombe states in brown colour*

Sampling Procedure and Sample Size

A multi-stage cluster sampling technique was used to delineate the study area following the hierarchical administrative set-up of the North eastern region. Three states were selected (Adamawa, Bauchi and Gombe) among the six (6) States that make up the Northeastern region (others being Borno Yobe and Taraba). Five (5) local government areas were selected in each State, while at the LGAs, three (3) to four (4) villages were subsampled. Finally, six (6) to eight (8) farmers were randomly selected in each village. In all, a total of 156 farmers were interviewed using semi-structured questionnaires.

Selection of study sites and individual farmers at the local government and village levels were made based on prior information on the relative importance of sorghum. However, number of respondents selected for consultation per community was often based on farmer distribution. The formal survey involved individual interviews that allow each farmer to express his /her personal opinion, after which group discussions were conducted.

Method of Data Collection

The survey sought to answer questions on farmer age and farming experience, number and types of crops cultivated, cropping system, soil fertility management, types of fertilizers used, estimates of sorghum yield harvested annually per hectare, presence of extension service, farmer perception of sorghum production constraints, incidence of striga, causes of striga infestation, level of its damage, extent of spread, and training received on striga management, sorghum varieties cultivated, as well as, striga management challenges. The study also sought to define farmer desired traits in sorghum as they are related to breeding. Farmers were requested to provide samples of the sorghum varieties they cultivate for evaluation, and other relevant information on those accessions. In most cases the head of the village identified potential respondents based on their experience and active participation in sorghum production. The most regular language of communication was Hausa and Fulfulde, being the most widely spoken languages in the study area.

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Method of Data Analysis

Data collected were analyzed using IBM statistical package for social sciences (SPSS), Version 16th (IBM Corporation 2007) and Microsoft Excel, 2010. Simple descriptive statistics, frequencies and percentages were used to analyze and explain farmer responses.

RESULTS AND DISCUSSION

Farmer Production Capacity and Type of Cropping System

Following the identification of target participants through relevant authorities and village heads, farmers were approached individually for interviews, after which group discussions were held to deliberate on the subject matter. Most respondents in the study area were men, except in Billiri and Kaltungo LGAs where women gave significant contribution to the study.

Result on Table 2 indicated that majority (66%) of respondents cultivate a maximum of two crops, while the remaining (44%) farmers cultivate three to four crops annually. All most all respondents (>99%) cultivate sorghum among other crops, suggesting that sorghum is a staple crop in the study area. The result also showed that more than 77% of them had a farm size of one to six hectares. This could suggest that majority of these respondents were subsistence farmers with small land holding on which multiple crops were cultivated. It also demonstrated the importance of sorghum within the cropping system or the fact that it is an integral part of the livelihoods of farmers.

Table 2: Farmers' Production Capacity and their Cropping System

Item	Frequency	Percentage	Ranking
Number of crops cultivated:			
1-2	103	66.0	1
3-4	53	22.0	2
Do you cultivate sorghum:			
Yes	155	99.4	1
No	1	0.6	2
Farm size in hectares:			
1-6	121	77.5	1
7-12	29	18.6	2
13-18	2	1.3	3
19-23	2	1.3	3
24-30	2	1.3	3
Type of cropping system:			
Sole cropping	47	30.1	2
mix-cropping	103	66.0	1
Others	6	3.9	3

Majority (66%) practice mix-cropping compared to sole cropping (30.1%), indicating that other crops was simultaneously cultivated with sorghum on the same plot. Hirst (2019) defined mix cropping as the practice of planting two or more crop simultaneously on the same field. A number of researches (Cardwell and Lane 1995; Teka, 2014; Kamara *et al.*, 2014; and Malezieux *et al.*, 2009) have provided empirical evidences that this practice can help in suppressing weeds, insect pests and diseases and also enhances balance of input and soil nutrients. In fact, Simunji *et al.* (2019) reported that inter-cropping cereals with cowpea can fix up to 86.1Kg ha^{-1} of atmospheric N through biological process. However, in this study, it was implicit from farmer's perceptions that the adoption of mix cropping seems to be motived in

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meeting family needs rather than accomplishing the aforementioned benefits. Therefore, there is need to enlighten these farmers on the benefits that they can reap through extension service.

Results obtained in this study is comparable with the findings of Kudajie *et al*. (2004), who conducted a similar study in Ghana and concluded that sorghum hold an important socio cultural position; Mrema *et al.* (2016), who reported that farmers in Ethiopia cultivated 0.4 to 12 ha, with a mean size of 3.0 ha. It is also in agreement with the findings of Mengistu *et al* (2019), who reported that 79% of their respondents generally cultivate less than 4 hectares, indicating predominance of subsistence farming.

Farmer Main Reason for Growing Sorghum

Figure 2 shows farmers' main reason for cultivating sorghum. It revealed that majority of farmers in Bauchi (70.6%) and Gombe (52.9%) states grow sorghum primarily for household consumption. This is an indication that sorghum is the most important staple crop in Bauchi state. On the other hand, a greater proportion (55.3%) of their counterparts in Adamawa State cultivates sorghum for consumption and as a source of income. This could suggest that farmers in Adamawa state do not depend solely on sorghum for food but consume other alternative crops like maize and rice. The result also indicated that less than 10% of the respondents cultivate the crop for commercial purposes or other motivations, which also reaffirm its position as a staple crop.

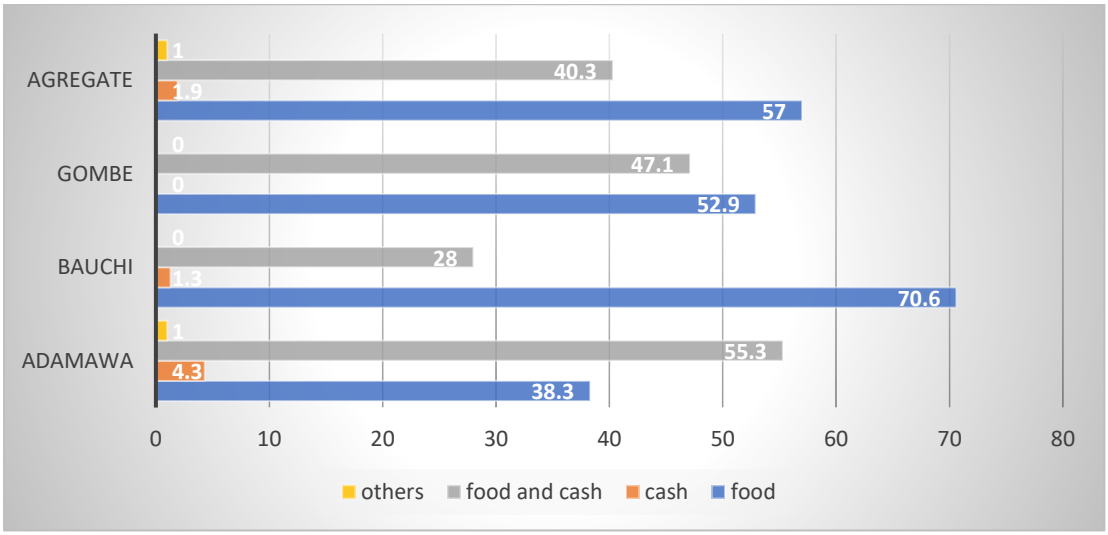

Figure 2: *Farmers based on their major purpose for growing sorghum*

Farmer Perceived Production Constraints

Table 3 results revealed that farmers in the study area perceived farm capital/funding as the most significant production constraint, followed by striga infestation and incidence of drought. When respondents were grouped according to their states the results indicated that majority (40%) of farmers from Adamawa state perceived striga infestation as the most serious impediment to sorghum production, however, their counterparts from Bauchi and Gombe representing 54% and 58% respectively identified striga as the second most important production problem next to shortage of capital. This suggests that poor access to capital is the most limiting factor militating against sorghum production in the study area. This finding is similar to what was reported by Atera *et al*. (2012) who also identified poverty as the major production constraint in Western Kenya.

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Table 3: Farmers' Major Production Constraints in the Study Area

Item	Frequency distribution of farmers					
	Adamawa	**Bauchi**	**Gombe**	**Total**	**Percentage**	**Ranking**
Soil fertility	5	12	3	20	12.8	3
Low yield	5	1	1	7	4.5	5
Capital	16	41	20	77	49.4	1
Striga	18	17	6	41	26.3	2
Others	3	4	4	11	7.1	4

The implications of Table 3 results for breeders is that the development and deployment of striga resistant/ tolerant genotypes to peasant farmers would help in alleviating the impact of striga infestation on the production capacity of such farmers who have poor purchasing power to acquire alternative farming inputs like fertilizers and herbicide. Apart from striga farmers also experience drought. In this study 92% of the respondents stated that incidence of drought is frequently encountered at three critical stages; at the time of planting, at sorghum flowering and in-between (midseason). This creates a serious challenge for breeders, as varieties to be developed have been resilient to drought throughout the growing season.

Types of Crop Species Grown in Rotation with Sorghum

Figure 3 shows types of crops grown in rotation with sorghum. Farmers rotate cereals with another cereal, as well as, cereals with legumes, with the former being more predominant. Rotating maize with sorghum or millet with sorghum were common practices. However, a number field researches have shown that rotating legumes with cereals is not only known to fix nitrogen but it is also one of the potential ways to reverse land degradation (Abdel-Wahab *et al*., 1996; and Kamara *et al.*, 2014). Conversely, rotating one cereal with another has many disadvantages: it does not contribute in improving soil fertility, because of the fact that component crops do not have the ability of fixing atmospheric nitrogen. In addition, *S. hermonthica* is host specific to cereals like sorghum, maize and millet, therefore, crop rotation involving susceptible varieties among such species could only increase striga seed bank in the soil (Cardwell and Lane, 1995). Unlike non–host species, planting false host species like cotton and soya beans in association with sorghum can cause suicidal germination of seeds of the parasitic plant (*S hermonthica*) in the soil (Dugje *et al*., 2008). The far reaching implication for farmers in this area who practice cereal - cereal rotation is that without the adoption of an integrated striga management approach which normally involved the use of resistant varieties, capable of reducing striga seed bank in the soil, they will continue to witness increase in striga infestation.

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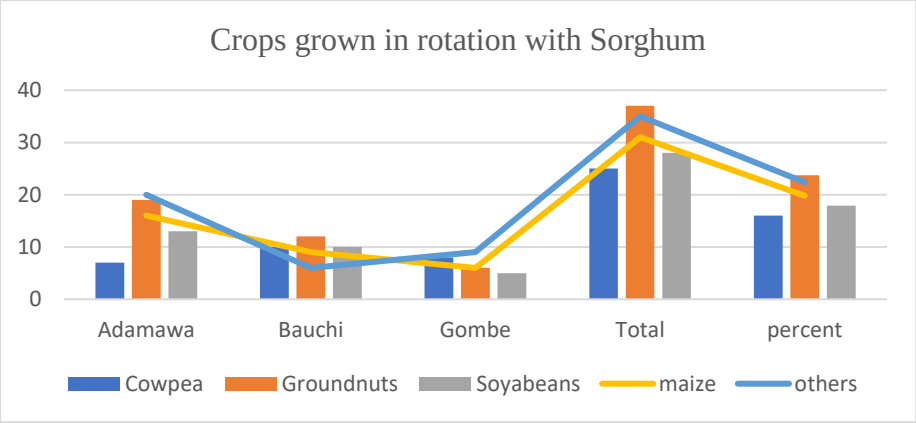

Figure 3: *Farmers' crops grown in rotation with sorghum in the study area*

Incidence of Striga, Perceived` Causes and Level of Damage Due to *Striga Hermonthica*

Results of Table 4 presents level of striga incidence, it causes and extent of damage due to the parasite. Striga was pervasive across the three states, accounting for 78.2%, with little variation in the distribution of farmer perception across the three states under investigation; 85%, 89% and 88% in Adamawa, Bauchi and Gombe, respectively. The outcome of this survey is similar to what was reported by Dugje *et al*. (2006) who found high level of striga infestation and severity in the north eastern region. Majority (60.2%) of farmers testified that they have been struggling with striga infestation for a period ranging from 1 to 12 years, while 14.4% stated that striga has being a problem on their farms for a period of 13 to 24 years. About 6.4% of respondents have being under it siege for a period between 35-45 years. Only 5.7% of respondents encountered striga for more than 45 years. This result could suggest that incidence of striga is relatively a recent phenomenon among a larger segment of these respondents.

On the perceived causes of striga infestation (Table 4), 83% of the respondents agreed that land degradation is the main cause of striga infestation. Others who constituted 7.6% attributed it to poor sanitation, short fallow (6.4%), deforestation (1.9%). This result is in agreement with the submission of Emechebe *et al.* (2004) whose respondents also identified soil degradation as the basis for escalation of striga infestation. Similarly, Mrema *et al.* (2016) reported from Tanzania that poor access to fertilizers, herbicides and other production inputs have indirectly created a favorable condition for striga to thrive. Aissata (2018), working in Niger attributed increase in striga infestation and its spread to the fact that sorghum was grown under marginal conditions with little application of fertilizers.

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Table 4: Incidence and Period of Striga Establishment on Farm, Causes of Infestation and Extent of Damage on Sorghum

Indicators	Frequency distribution				Cumulative	
	Adamawa	Bauchi	Gombe	Total	Mean	%
Incidence of striga on farmer field:						
Presence of striga	40	52	30	122	40.6	78.2
Absence of striga	7	23	4	34	11.3	21.8
Period of striga establishment on farm (years):						
1-12	34	46	14	94	31.3	60.2
13- 24	5	14	4	23	7.6	14.7
25- 35	4	9	7	20	6.6	12.8
36-45	2	4	4	10	3.3	6.4
>45	2	2	5	9	3.0	5.7
Perceived main cause of striga infestation:						
Soil degradation	33	71	27	131	43.6	83.9
Poor sanitation	6	2	4	12	4.0	7.6
Short fallow	6	1	3	10	3.3	6.4
Deforestation	2	1	-	3		1.9
Extent of striga damage on sorghum:						
Very serious	11	28	3	42	14.0	26.9
High	23	36	15	74	24.6	47.4
Moderate	6	5	10	21	7.0	13.4
Low	5	5	5	15	5.0	9.6
Very low	2	1	1	4	1.3	2.5

Result of Table 4 on the level of striga infestation further reveal that up to 47.4% of the respondents stated that incidence of striga is very high on their farms, while 26.9% assert that the prevalence of striga is high. 26.5% of the respondents opined that incidence of striga is moderate or less. The overall inference is that incidence of striga is widespread and causes devastating consequences in the area. This result is similar to the findings of Dugje *et al.* (2006), who reported that 68% of all fields surveyed in Sudan savanna in northern Nigeria were infested by different Striga species that included *S. hermonthica*, while Kamara *et al.* (2014) reported that incidence of *S. hermonthica* ranged from 58% and 100 % on sorghum farms in northern Sudan savanna ecologies in Nigerian with devastating consequences.

Method of Controlling Striga and Estimated Yield Losses due to *S. hermonthica*

Result on Table 5 presents the most common control approaches adopted in management of Striga in the study area, indicating that majority (66.6%) of farmers use physical means such as hoe weeding and uprooting of striga plants at flowering stage. Even though weeding of striga can help in reducing striga seed bank in the soil, some workers (Hearne, 2009; and Teka, 2014) stated that physical control methods are not efficient in reducing infestation due to the parasite because sorghum suffers underground damage before it emerges above soil. In the absence of adequate resource to manage striga, it can be suggested that planting resistant/tolerant varieties is relatively cheaper and more reliable than weeding.

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The result shows that less than 4% of farmer's plant resistant varieties, indicating that very few farmers' plant resistant varieties. Group discussion with farmers indicated that majority of respondents are uninformed about the existence of resistant sorghum varieties or they are unable to acquire such varieties. This survey revealed that there is a missing link between agricultural research and target beneficiaries/farmers in the study area, probably due to poor extension services.

Table 5: Method of Controlling Striga and Estimated Yield Losses due to *S. hermonthica*

Method	**Adamawa**	**Bauchi**	**Gombe**	**Total**	**Mean**	**%**
Method of controlling Striga:						
Physical	21	61	22	104	34.6	66.6
Chemical	13	8	8	29	9.6	18.5
Cultural	7	3	4	14	4.6	8.9
Resistant CV	2	3	-	5	1.6	3.2
Others	4	-	-	4	1.3	2.5
Estimated Yield losses due to Striga infestation (%):						
0	-	-	1	1	0.3	0.6
1- 19	8	5	2	15	5.0	9.6
20-40	16	14	9	39	13.0	25.0
41- 55	19	23	16	58	19.3	37.1
56-69	4	24	4	32	10.6	20.5
>70	-	9	2	11	3.6	7.0

Incidence and Type of Drought Experienced and the Most Devastating Type

Next to striga, farmers in the study area perceive the incidence of drought as the third most important production constraint in sorghum (Table 6). Drought at planting season, mid rainy season and at the end of the rainy season has all been confirmed to occur by the majority (92%) of farmers in all the three selected states. On the whole, more than 50.6% among the sampled farmers considered terminal drought as the most devastating type compared too early and mid- season, while 25% perceived early season drought as more damaging type.

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Table 6: Incidence and Type of Drought Experienced and the Most Devastating Type

Indicators	Adamawa	Bauchi	Gombe	Total	Percent	Ranking
Incidence of drought:						
Yes	38	74	33	145	92.9	1
No	9	1	1	10	6.5	2
Undecided	-	-	-	1	0.6	3
Type of drought experienced by farmers:						
Planting season	10	20	9	39	25.0	2
Mid rain season	15	10	13	38	24.4	3
Terminal drought	22	45	12	79	50.6	1
The most devastating drought:						
Planting season	9	19	8	36	23.0	2
Mid rain season	13	8	9	30	17.3	3
Terminal drought	25	48	16	89	57.0	1

The remaining 24.4% opined that drought that occurs during mid-rainy season is the major type of water stress that affects their crop production. Majority of respondents and farmer groups indicated that they grow local sorghum varieties because of their inherent resilience to pest and drought. This was especially emphasized by farmers in Gombe south. The implication of this finding is that breeders aiming to produce farmer accepted varieties should identify land races with desirables genes like early maturing types so as to transfer these genes into farmer accepted cultivars or alternatively involve these lines in multi parent breeding programs the ultimate goal should be to develop drought tolerant varieties. In a similar study Amelowork *et al.* (2016) indicated that drought at the flowering stage was identified as the most devastating type that affect sorghum production in North eastern Ethiopia.

Percentage distribution of farmers based on preferred trait

Figure 4 shows the distribution of farmers according to their trait preferences in sorghum. Majority of them (33.7% on the average) consider yield as most preferred trait, followed by drought tolerance or early maturity (32.6%). Few among the respondents (8.9%) indicated that breeding for grain quality (taste) is given priority. This result highlights farmer's production constraint and their desire for improvement in yield, striga and drought resistance/tolerance. It can therefore be suggested that sorghum improvement program for farmers in the study should give grain yield the first priority, having scored highest selection index of 33.7% across the three States. The second breeding priority should be drought tolerance, followed by striga resistance. From the breeder point of view yield is a complex trait that is determine not solely by yield but also other components (morphological, physiological), genetic factors that determines host resistance or tolerance to pest and diseases as well as, abiotic factors like drought (Allard 1999; and Teka, 2014). It is therefore, imperative that future breeding of sorghum should aim at identifying farmer production constraints and desirable traits targeting a specific location, so that appropriate traits can be "staged" into new sorghum varieties.

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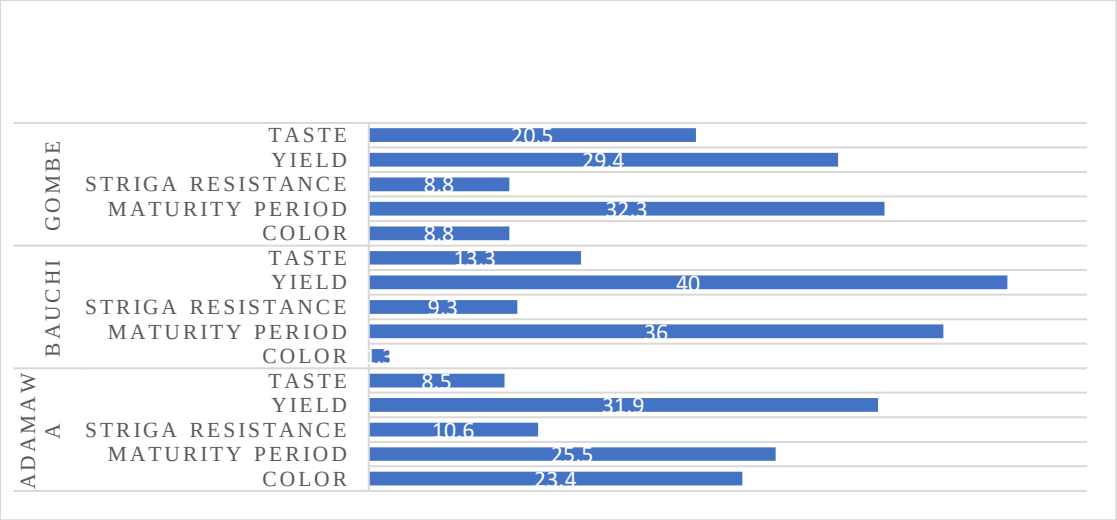

Figure 4: *Percentage distribution of farmers based on preferred trait*

Farmers' Seed Source in the Study Area

Result on Table 7 shows distribution of farmers in the study area based on where they source their planting material. It indicated that majority of them (67.2% on the average).Comprising .96.5% (Adamawa), 71% (Bauchi) and 91% in Gombe State recycle their harvested grain and use them as seed, followed by seed obtained from open market. Less than 4% among these farmers buy their seed from agricultural institutes such as State agricultural development programs. This result strongly suggests that farmers in the study area either do not have access to improve seeds, including striga resistant, or they have strong affinity to their local cultivars.

As presented in Table 7, the cultivation of local ecotypes/landraces normally consist of heterogeneous adaptations is a common practices in most African farming communities (Azeez *et al*. 2018). Land races are excellent reservoir of genes that promote plant genetic diversity and they are valuable sources for disease resistance (Zeven, 1998). However, most landraces give low yield and are rarely tolerant to a wide array of pests and diseases, hence the need to breed them for two or more desirable traits (Bradshaw, 2017). This underscore the need promote seed scaling and the promotion of Striga resistant varieties in the study area.

Table 7: Farmers' Seed Source in the Study Area

Seed source	Own	Market	Agricultural institutes	Others
Adamawa	96.51	3.84	0	0
Bauchi	71.42	22.85	2.85	2.85
Gombe	91.89	2.7	2.7	2.7
Total	67.2	17.6	3.3	3.2

CONCLUSION AND RECOMMENDATIONS

The result of the study has shown that farmers identified shortage of capital/ resources, infestation due to striga incidence, drought and soil degradation as their major production constraints. Incidence of striga was widespread across the three states, accounting for 78.2%. Majority of the respondents (41%) consider yield as the most desired trait in sorghum, followed by early crop maturity (32.6%). To improve sorghum productivity, breeders should put

farmer's challenges into consideration by combing genes and traits that delivers their collective request and preferences in the development of new varieties.

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