SCREENING FOR STRIGA (S*TRIGA HERMONTHICA* DEL BENTH)RESISTANCE IN SOME SORGHUM GERMPLASM

BY

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DECLARATION

I Ogundele Temitope Christy hereby declare that this Thesis entitled "Screening for Striga (*Striga hermonthica*(*D*el).Benth)resistance in some Sorghum Germplasm" has been written by me in the Department of Plant Science under the supervision of Professor Mary Yeye, Prof. D.A. Aba and Dr. S.M. Bugaje. The information derived from other literature has been duly acknowledged in the text and a list of reference provided. There is no part of this Thesis that was previously presented for another degree

| --- | --- | --- |
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CERTIFICATION

This thesis titled "Screening for Striga (*Striga hermonthica*Del.Benth)resistance in some Sorghum Germplasm" written by Ogundele Temitope Christy, in the Department of Plant Science, and meets the regulations governing the award of the Degree of Masters in Plant Breeding of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literature presentation.

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DEDICATION

This work is dedicated to the only faithful God who makes all things beautiful in his time. Also to my darling, husband Mr. Olasunkanmi for his love and to my son Phronesis.

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I give my sincere thanks to my only merciful and faithful God for being there for me throughout my study period.

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ABSTRACT

In this research, 43 Sorghum genotypes were screened for resistance to *Striga hermonthica* (Del) Benthin the screen house and on*Striga* sick plot of Institute for Agricultural Research (IAR) Samaru in 2013. The genotypes screened included two ICRISAT resistant materials (ICSR94407 and ICSR94405),SRN 39, SAMSORG - 12 (KSV4) as the susceptible check and 32 locally collected germplasm.The objectives of the study were to determine genetic variability among the Sorghum genotypes, to suggest possible lines to be exploited in the development of resistant Sorghum genotypes and to elucidate the association, if any between Striga shoot counts with other important agronomic traits. All experiments were arranged in Randomized Complete Block Design with three replicates. In the screen house 129 plastic Buckets were used while the ridges on the Striga sick plot were 5m long with spacing of 75cm x 30 cm. Data was recorded on Striga shoot count(s), Plant height, number of Leaves, Panicle length, Panicle weight, Grain weight, 1000 Grain weight, 50% days to heading and Striga damage score using a scale of 0-9. The data was subjected to analysis of variance and the means were separated using Duncan Multiple Range Test. Striga seeds inoculation was done by mixing 1kg of fine soil with 70g of Striga seeds. Although Striga plant emerged on all the roots of the genotypes used in this study indicating that none exhibited true resistance mechanism but ICSR94405 and ICSR94407 indicated the least damage score so they were regarded as resistant genotypes. Gizo 1, Gizo 2, Garau 2, Kastal, NRL 1,Kaura Maiguduna and Yandargako sustained lower Striga emergence and no significant decrease in host biomass so they were regarded as resistant genotypes. RIBX 98-78, IS17562, Fara Kano, Twin seeded, Macedakuya, Gwajamai, Kaura Borno and NRL 3 were found unstable being susceptible in the screen house and resistant on the field and SRN 39 was also found to be susceptible.

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CHAPTER ONE

1 INTRODUCTION

Sorghum*[Sorghum bicolor* (L.) Moench], is a cereal belonging to the genus Sorghum, family Poaceae; tribe *Andropogoneae.* Sorghum is thought to have been domesticated in Africa by the Gushite people who migrated into Ethiopia from the Middle East around 7,000BC . After domestication, Sorghum spread to other parts of Africa, India and from there to China, the middle East and Europe .The most extensive area of cultivation are within Latitude 53°N and 40°S of the equator but the highest yields are recorded between 30° and 40°N in the countries like China, Japan, Australia and Indian (Haussmann*et al.*, 2000).

Sorghum is now one of the major cereals providing world's food supply (Talley*et al.*, 1991). On world basis, sorghum ranks fourthamong the major cereals after wheat, rice and maize. Although, Doggette (1988) ranked itfifth after wheat, rice, maize and barley. Sorghum is grown by farmers on more than 48 million hectare in sub-Saharan Africa (Sinebo *and* Drennan 2001;Berner*et al.*, 1996). In some parts of West Africa e.g. Nigeria andGhana, Sorghum is used as an industrial raw material for the production of livestockfeeds, malted and alcoholic drink while some parts of Nigeria accept sorghum not only for the grain yield but also forthe use of the stalks as fencing and fuelling materials. Sorghum is consumed as solid food, thinporridgesand Kunu. In the western part of Nigeria, the red sorghum stem is used as a herb. In the semi-arid region of Cameroon, the plant stem and foliage are used for hay, silage, building material and pasture while plant

remains are used for fuel (Jean-Baptiste et al.,2012) Sorghum is one of the universal sources of carbohydrates, vitamins, and a little protein. Some sorghum cultivars are used for starch which is used in makingpaper and textile materials and for making adhesives. Oil extracted from the embryo can be used for cooking. In 2006 FAO ranked US as the largest sorghum producer while Nigeria was third on the list but by 2012 Nigeria was ranked as the largest producer with over 6.9million metric tons. It was also recorded that Sorghum was tenth most produced crop in Africa but number 17th most valued in the world but 8th in Nigeria after Maize. (FAO, 2012).

In Northern Nigeria, a large area is cropped to sorghum and it accounts for about 90% of the total area cropped to crop. (Ezeaku and Gupta, 2004). Despite the increase in area under cultivation, the average yield trend is downward.The largest group of the producers in Africa is the small-scale subsistence farmers with minimal access to production inputs such as fertilizers, pesticides, improved seeds (hybrids or varieties), good soil, water and improved credit facilities in addition to many socio-economic obstacles. In view of the low input systems, productivity levels are very low throughout the African countries and India, ranging from l.5 to less than 0.6 ton per hectare in Ethiopia and Sudan respectively (FAO, 2010). As at 2012 Sorghum production in Nigeria was around 6.9m metric tonnes but by 2013 the production reduced to 6.7m metric tones, yield around 12,182 kg/ha and seed tonnes of 110000 (FAO 2013).

So many constraints are militating against sorghum production, which include use of varieties, which are low yielding, non-responsive to fertilizers and susceptible to major pests and diseases.Weeds if not well controlled, can even make the production worst. Loses due toweeds and the degree of infestation to weeds in

sorghum fields are often determined by the type ofvarieties such as susceptible, tolerant or resistant varieties planted, cultural practices like crop rotation, bush fallowing, planting method and time ofplanting. The most common weed of sorghum is *Striga hermonthica*. Striga generally causes losses of between 60-70% of the cereal crop (Udom *et al.,* 2007). Striga causes about 75% of its damage to the host plant while it is still underground being soil borne before it emerges (Parker and Riches, 1995; Berner *et al.,* 1997). Striga serious infestation can also lead to fields' abandonment (Doggette, 1991). Crop yield losses due to Striga parasitism amountsto 10.67 million tons per year in sub-Saharah Africa (Gressel *et al.*, 2004). Striga infestation is extending in Africa because of the high pressure on land due to population growth. In a recent survey conducted in northeast Nigeria, Dugje *et al*. (2006) reported that out of 266 farmers' sorghum fields sampled, 94% were infested with S. *hermonthica.*

The control of *Striga* in cereals has been a major challenge to peasant farmers. Although several control measures have been recommended, yield levels of cereal crops continue to decline as a result of *Striga.* In northern Nigeria, out of all existing *Striga* control techniques identified, hoe weeding, hand pulling, application of inorganic fertilizer and manure, crop rotations, fallowing, and early planting are widelyused (Emechebe *et al*.,1994). In the Guinea and Sudan savannas of Nigeria sorghum is the major host for *Striga* reproduction (Weber *et al.,* 1995).Dugje*et al.* (2006) reported that *Striga* emergence counts were generally lower in maize fields than in sorghum fields in the savannah zones of northeast Nigeria.

A combination of sound cultural practices and resistant/tolerant crop cultivars had been proposed as a means of reducing losses from *Striga* infestation on crops (Wilson *et al.*, 2000). Being able to identify these resistant varieties will reduce cost of production of sorghum thereby increasing farmers income i.e. less Striga, will amount to greateryield, greater foodsecurity and more income.Evaluation of germplasm collection is very important because until desirable traits have been identified, the germplasm will not be used for crop improvement. The major problem associated with the use of resistant cultivars is the lack of universal resistance and that resistance is said to decrease with time. There is always a need for continuous screeningof germplasm to be able to ascertain varieties to use in resistance breeding.

Theobjectives of this work were to;

- determine the genetic variability among the Sorghum genotypes
- suggest possible lines to be exploited in the development of resistant Sorghum genotypes.
- estimate the association, if any between Striga shoot counts and other important agronomic traits.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Striga

The Italian botanist, Loureiro, detected the genus Striga, an important genus of parasitic weeds in the world (Parker and Riches, 1995), in 1790; but the name was used by Linnaeus in Species Plantarum in 1753. It belongs to the family *Scrophulariaceae*(Berner *et al*., 1995).Witch weed is the common name applied to members of the genus Striga (Hosmani, 1978).

According to Saueborn (1991) the probable origin of the name Striga is the Latin word Striga or Strix, which means a bloodthirsty witch (sorcerer). Striga is known as a root parasite of grasses which is a serious problem of the Sorghum crop in semi-arid and tropical (SAT)countries. Seven Striga species of economic importance have been identified;

- *Striga hermonthica* (Del.) Benth. =S. *senegalensis*Benth.
- *S. asiatica* (L.)Kuntze=*S. luteaLonr.*
- *S. hirsute* Benth. = *S. coccinea* Benth
- *S. gesnerioides* (Wild) *Vatke =S. orobanchoides* Benth =*S.densifloro* Benth;
- *S. euphrasioide Benth =S. angustifolia (*Don) Saidana*;*
- S. *aspera* (Wild)*;*
- S. *forbesiipenth*

Each of these species is adapted to different ecological zones. *Striga asiatica* (L)Kuntze, which

is more widespread than S. *hermonthica*,has been identified as animportant weed in North and South Carolina in the United States andIndia while S. *hermonthica* is important and the most serious in sub-Saharan Africa(Ramaiah, 1999). Striga species are parasitic and they cause serious damage whenever they appear among crops. *Striga hermonthica* is a seriousbiotic constraint to cereal production in the dry savannas of sub-Saharan Africa where over 100 million people lose half their crop production to this hemi-parasitic weed (Kanampiu *et al*., 1999). In West Africa, *Striga* infests over 64% (17 million ha) of the land planted to cereals, resulting in significant yield losses that range from 10 to 100% depending on the crop and cultivar (Lagoke *et al.,* 1991; Obilana and Ramaiah, 1992;Gressel *et al*., 2004). In Nigeria, sorghum, which accounts for 34%of total cereal production (Akintayo and Sedgo, 2001) is one of the major cerealsseverely affected. *Striga* infestation in sorghum is reported to be higher in Nigeria thanin other West African countries with about 80% (8.7 million ha) of land cropped tosorghum infested by this weed (Gressel *et al*., 2004).

In a recent survey conducted in northeast Nigeria, Dugje *et al*. (2006) reported that out of 266 farmers' sorghum fields sampled, 94% were infested with *S. hermonthica.*Each*striga* plant is capable of producing up to 500,000 seeds, which may remain viable in the soil for over 10 years.Its seeds germinate in the presence of host root exudates and develop haustoria which penetrate host root cells. Host root exudates contain strigolactones, signaling molecules that promote Striga seed germination (Matusova, *et.al* 2005). A bell-like swell forms where the parasitic roots attach to the roots of the host, the pathogen colonizes underground where it may spend the next 4-7 weeks before emergence, then it rapidly flowers and produces seeds. Witchweed seeds spread

easily by wind, water, and soil via animal.

Host plant symptoms such as stunting, wilting, and chlorosis are similar to those seen from severe drought damage, nutrient deficiency, and vascular diseases.

2.2 Environment suitable for Striga growth

Temperatures ranging from 30-35°C in a moist environment are ideal for*Striga* seed germination. Witchweed will not develop in temperatures below 20°C. Agricultural land with light soil and low nitrogen levels tend to favor the development of the witchweed. Still, witchweed has demonstrated a wide tolerance for soil types if soil temperatures are favorably high. Seeds shown to survive in frozen soil of temperatures as low as -15°C attesting to their aptitude as over wintering structure (Nickrent and Musselman, 2004).Soil temperature, air temperature, photoperiod, soil type, and soil nutrient andmoisture levels do not greatly determine the development of witchweed.

2.3 Losses from *Striga* Infestation

Losses due to *S. hermonthica* have assumed economic proportions on Sorghum and millets in many African countries. Striga causes about 75% of its damage to host plant while it is still underground being soil borne before it emerges (Parker and Riches 1995, Berner *et.al*, 1997. Striga serious infestation can also lead to fields' abandonment (Doggette 1991). Crop yield losses due to Striga parasitism amount to10. 67 million tons per year in sub-Sahara Africa (Gressel *etal.*, 2004). Striga infestation is extending in Africa because of the high pressure on land due to population crowding (Berner *et.al*, 1997.) Striga infestation is increasing in Chad so much that farmers sometimes abandon their

fields. Similar situation prevails in Nigeria and Burkina Faso.

Striga hermonthica, which is the most parasitic weed specie in Nigeria Savannah(Emechebe 1991; Marley *et al.*,2004), is the major witch weed of Africa formerlycalled *S. senegalensis* Benth. (Doggette 1988,). Local Cereals have shown some tolerance but good evidence for resistance is lacking (Saueborn 1991).Incidence and severity of *S.hermonthica* are exceptionally high in Sorghum, pearl millet and maize, the main staple food for over 300 million people in sub-saharan African (Scholes and Press, 2008.).

Losses due to *S.hermonthica* vary from 5 to 90% (Obilana and Ramaiah, 1992), from 60 to 70% (Lagoke *et al*.,1991) and from 25 to 100% (Abbasher *et al.,* 1995). In Mali, S. *hermonthica* is present in 31% of maize fields, 53 sorghum fields and 56% of millet fields (Hess and Ejeta, 1992). S. *hermonthica* reduced the growth of millet, sorghum and maize, by 28, 33 and 82%, respectively (Ejeta*et al.,* 1991). Striga generally causes losses of between 60-70% of cereal crops (Udom *et al.,* 2007)

2.4 Management and Control of *Striga*

Management of witchweed is difficult because the majority of its life cycle takes place below ground. If it is not detected before emergence, it is too late to reduce crop loss. To prevent witchweed from spreading, growers should plant uncontaminated seeds and clean soil and plant debris off machinery, shoes, clothing, and tools before entering fields (Johnson 2005). If there is little witchweed, hand weeding before seeds are produced is an option. If there is a lot then a more intense management plan will need to be used. The control of *Striga* in cereals has been a major challenge to peasant

farmers. Although several control measures have been recommended, yield levels of cereal crops continue to decline as a result of *Striga* damage. However, Gressel *etal.*,(2004) noted that if practiced long enough, a combination of nitrogen fertilizer, intercropping and crop rotations, the use of tolerant cultivars and clean seed significantly reduces *Striga* damage. In northern Nigeria, out of all existing *Striga* control techniques identified, hoe weeding and hand pulling, the application of inorganic fertilizer and manure, crop rotations, fallowing, and early-planting are widely used (Emechebe *etal.*,1994).

According to Dugje*etal.*, (2008) *Striga* control in sorghum is more challenging than in other cereal crops because sorghum matures late compared to maize and produces after-harvest sprouts, which support the *Striga* plant to produce seeds. A combination of sound cultural practices and use of resistant/tolerant crop cultivars has been proposed as a means of reducing losses from *Striga* infestation on crops (Rodenburg etal., 2006). Sowing date as an essential component of crop management could be manipulated to better control *S.hermonthica*in sorghum. As noted by Dugje*et al.*,(2008) managing sowing dates tries to exploit the opportunities while avoiding the risk associated with sowing at the time of optimal rainfall. Early sowing has drought risks but the advantage that the cereal has grown sufficiently before the parasite seeds are preconditioned and germinated. Late sowing may cause drought stress that could reduce grain yields but the advantage that *Strigaseeds* may have gone into secondary dormancy in the absence of a suitable host made it an option of control.

InBenin, Gbehounou*et al.,* (2004) reported a linear relationship between sowing date and *Striga* infestation in sorghum. Vissoh *etal.*,(2008) as cited by Jean-Baptiste et al.,2012 in

southern Benin observed four times more *Striga* in direct early sowing than in direct late sowing. Dugje*etal.*,(2008) reportedthat sowing maize in mid-July reduced *Striga* infestation compared to sowing in mid-May or mid-June in parts of the northern and southern Guinea savanna of Nigeria, but grain yield in these zones was lower when maize was sown in mid-July than when sown mid-May or mid-June.

Striga in the United States has been controlled through the use of several management strategies, including quarantines imposed on affected areas, control of movement of farm equipment between infected and non-infected areas, herbicide application, and imposed "suicidal germination." For the latter, in fields not yet planted to crops, seeds present in the soil are induced to germinate by injecting ethylene gas which mimics the natural physiological response tied to host recognition. Because no host roots are available, the seedlings die. Unfortunately, each *Striga* plant can produce tens of thousands of tiny seeds and these can remain dormant in the soil for many years (Mourik, 2007). Thus, such treatments do not remove all seeds from the soil. Moreover, this method is expensive and not generally available to many farmers in developing nations of Africa and Asia.

Another method called trap cropping involves planting a species in an infested field that will induce the *Striga* seeds to germinate but will not support attachment of the parasite. This method has been used in sorghum plantations by planting *Celosia argentea*between the sorghum. Planting silver leaf (*Desmodiumuncinatum*)has worked in maize crops. Cotton, sunflower, linseed, and witchweed resistant maize are also effective trap -crop. Increasing Nitrogen levels in the soil, growing tolerant varieties, and trap-cropping, planting crops that are susceptible but are harvested before witch weed seed is produced,

can also beused.

2.5 Achievement so far

The national programme of cereal breeding has attempted to identify striga resistant varieties of sorghum, based on the number of emerged Striga plants in cultivation plots. The existence of genetic resistance differences to S. *hermonthica* in Sorghum has been reported in Burkina Faso (Yonli *et al.*, 2011) but no sorghum variety withstood *S. hermonthica* in different local agro-ecological zones. The major problem associated with the use of resistant cultivars is the lack of universal resistance; therefore, there is a need for continuous screening to be able to ascertain varieties to use in resistance breeding (Weber *et.al* 1995).

Omanya *et al*., (1999) screened some Sorghum germplasm in laboratory, pot, and field experiment for resistance to *Striga*. They discovered that in the pot experiment at individual locations, genetic variation was significant for S86 and ASNPC in both RIPS whereas in the field studies with both RIPs, $f_{3:5}$ families differed significantly both at individual and across location for S88, ASNPC and GY. Ado *et al,.(*2000) , in breeding Maize for tolerance and resistance to Striga at the Institute for Agricultural Research Samaru, Nigeria, discovered that Striga *aspera* emergence ranged between O and 37.3 shoots m^{-2}. Using eighty S_1 lines of maize (*zea mays*), four lines did not support *S. aspera* emergence throughout the crop life cycle. Line 5057 susceptible to *S. hermonthica* (Del.) Benth, appears resistant to *S. aspera* while line 9050 that is resistant to S. *hermonthica* appears susceptible to *S. aspera*. Alabi *et al*., (1999) also evaluated improved maize varieties for reaction to *Striga hermonthica* and *S. aspera* at Bagauda in the Sudan Savana

of Nigeria and found that the low emergence pool C_I supported low emergence of both striga species and produced good yield.

Sorghum [*sorghum bicolor* (L) Moench] varieties from breeding programmes of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Institute for Agricultural Research (IAR) at Samaru, Nigeria and of other National Agricultural Research Stations(NARES) in Africa were evaluated for reaction to *Striga hermonthica* (Del.) Benth, at Bida, Samaru & Bagauda in Nigeria. Framida red, in all trials as well as Mallisor 92-1 and ICSV III at Bagauda exhibited resistance through support of low emergence of *Striga* and production of high sorghum grain yield. Many of the varieties, which also supported low *Striga* emergence, produced low sorghum yield (Lagoke*et al.*, 2000). In Nigeria Gupta and Lagoke (1999) screened some sorghum germplasm which included six elite varieties (ICSV III, ICSV400 KSV4, Gaya Early, CS54 and CS95) for *Striga*resistance through pedigree breeding and two lines SRN 39 and IS 9830 were identified at Bagauda for resistance to *Striga hermonthica* (Del.) Benth, in field trials conducted in 1995 and 1996 under Striga infestation. At the end of the research 50% more plants were selected from the crosses involving SRN 39 as donor parent for Striga resistance than the crosses involving IS 9830. Innocent (2000), screened some mutant sorghum lines for *Striga hermonthica* resistance in a pot experiment at the Institute for Agricultural Research (IAR) Samaru. The result obtained showed that all the lines including the checks were susceptible to *Striga hermonthica*. In other words, the exposure of these lines to cobalt irradiation did not result into the evolution of any line that is resistance to *Striga*. The proven resistant strain to *Striga hermonthica*, which is SRN 39, was badly affected by *Striga hermonthica*.

Evaluation of germplasm collection is very important because until desirable traits have been identified, the germplasm will not be used for crop improvement. Because of the vast amount of germplasm residing in some of the larger repositories, it has been suggested that germplasm from the same geographical areas should be bulked. Any bulking of germplasm would be premature if done before screening. About 300 land races of pearl millet collected in Burkina Faso were received by the USDA-ARS Forage and Turf Research Unit. Screening of these materials revealed several sources of diseases resistance and diverse groups were identified (Wilson *et al*, 1991)

2.6 Correlation and Cluster Analysis

Correlation provides only limited information because they disregard complex interrelationships among traits. Accordingly, they must be used with caution in making decision regarding indirect selection criteria (Board *et al*, 1997). Bos and Qi (1997) also reported that within clones, purelines and single cross hybrid the phenotypic correlation between two traits is equal to the environmental correlation. Variation between plants due to the quality of growing conditions, cause plants environmental deviation for another trait to be correlated. Singh *et al*.,(2010) reported significant association between plant height and yield. The association can be positive when the two characters tend to rise or fall together or negative when rise or fall in one of the characters leads to a change in the other character in the opposite direction. The importance of correlation studies in selection programmes is appreciable when highly heritable characters are associated with the important character like yield (Manggoel, 2012).Knowledge of correlations between traits of economic importance is not only of interest from a theoretical consideration of

quantitative inheritance of characters, but of practical value since selection is usually concerned with changing two or more traits simultaneously (Yeye, 2000). Most economically important characters are complex in inheritance and may involve several related characters (Robinson *et al.,* 1951). The degree of phenotypic and genotypic correlations between characters is therefore very important. According to Aghughu, (2001), significant positive phenotypic correlation between characters indicates that they can be predicted from each other and that genotypic correlation between them will determine whether this relationship will be passed on to the offspring or not. Hence, this will determine whether or not genetic improvement of one will lead to a corresponding change in the other.

Among the multivariate techniques, Cluster Analysis (CA) is most commonly employed and appears particularly useful (Mohammadi and Prasanna2003,Mohammed *et al.,* 2011).Clustering is a straightforward method to show association among data. The cluster analysis is an appropriate method for determining family relationships (Mellingers, 1972). The analysis can be performed using either presence - absence or quantitative data. The aim of using a cluster technique in the analysis of data from plant breeding trials is to group the varieties into several homogenous groups. This is in such a way that those varieties within a group have similar response pattern across the locations since it is assumed that all the varieties in the trial will not behave independent of one another. Cluster analysis have five methods namely unweighted paired group method using centroids (UPGMA and UPGMC), Single Linkages (SLCA), Complete Linkage (CLCA) and Median Linkage (MLCA). UPGMA and UPAMC provide more accurate grouping information on breeding materials used in accordance with pedigrees and calculated results found most consistent

with known heterotic groups than the other clusters (Aremu *et al*., (2007). Genotypes within clusters often showed great geographical diversity If the entire data array containing information on a number of varieties can be reduced to the information on a number of groups of varieties this will simplify the interpretation of data by the breeder. Cluster Analysis has been widely used in different crops like Apple (Pereira *et al*.,2008); Deciduous Forest trees (Nath *et al.,* 2006).According to the findings by Ali *et al*., (2008) who reported that cluster analysis can be useful for finding high yielding wheat genotypes, Singh*et al.,* (2010) and Mohammed *et al.,* (2011) also worked on wheat, the results of their study showed the presence of a high genetic divergence among wheat genotypes using cluster analysis

2.7 Screening Methods

The recognition and influence of the host roots on the parasite occur during three stages of parasite development: seed germination, haustorial establishment, and the final growth and establishment of *Striga.* Three mechanisms—low stimulant production, mechanical barriers to haustorial establishment (ICRISAT 1977), and antibiosis—that confer resistance on sorghum roots against the parasitizetion by *Striga* have been recorded. Field resistance to *Striga* is the combined expression of one or more of these mechanisms. Laboratory techniques screen for mechanisms either individually or in combination.

Laboratory Techniques;

Several laboratory-screening techniques are available,such as the double-pot technique, the Pasteur pipette technique, the root-slope technique, sandwich techniques, antihaustorial factor screening,etc. Though laboratory techniques have several advantages, they are not often well correlated with field screening, mainly for two reasons: first, the field resistance

to *Striga* cannot be explained by any single mechanism alone; second, field results are influenced by strong environmental interactions that are not allowed to act in laboratory techniques.

Pot-Screening Techniques;

Generally, pot screening involves growing the host in pots artificially inoculated with *Striga* seeds; the reaction of the host is judged by counting the *Striga* seedlings that emerge above the ground. Although these techniques are not completely reliable, they could be useful, since the *Striga* infestation in pots is more definite than in artificially infested fields.

Field-Screening Techniques;

Growing the sorghum lines in a field that is naturally or artificially infested with *Striga* and screening for field reaction is a commonly used technique; however, field screening is often not reliable because of various' uncontrollable factors. Therefore, efficiency requirements expected of the screening technique depend on the kind of material and the degree of accuracy required.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Description of experimental location

The research was conducted at the screen house and Institute for Agricultural Research (IAR)*Striga* sick plot atSamaru. Samaru is located in Northern Guinea Savanna Zone of Nigeria,rainfall of about 404mm to 472mm per annum and lies at $11^0$11N latitude, $07^0$38E longitude with an altitude of 686m above sea level(IAR Metrological station)

3.2 Description of experimental materials

The plant materials were 32 locally collected germplasm and six IAR improved materials, four checks, two of which were obtained from ICRISAT. The descriptions of these materials are provided in Table 3.**1.**

3.3 Establishment of the screen house experiment;

129 Plastic buckets were filled with humus soil from IAR field after being mixed with poultry drops as fertilizer and were arranged in three replicates; i.e. three pots for each entry. By 6^{th} of April 2013 the Striga inoculum was prepared by thoroughly mixing one kilogram of fine sieved soil with 70g of Striga seeds (ICRISAT 1977). After mixing, the *Striga*- sandy soil was measured into each pot by measuring two

Table 3.1; Morphological Description and Origin of Genotypes Used In the Study

GENOTYPE	ORIGIN	DESCRIPTION
SAMSORG- 14	IAR	Tall plant (200cm – 300cm) panicle is long, elliptical and has single seed in each spikelet. Seeds are round, big and white in colour. Matures within 125 - 135 days (Chukwu 2014).
SAMSORG- 17	IAR	Medium height plant (170 - 190cm), panicle is compact, bears single seed per spikelet. Seeds are of large size and yellow in colour . Maturity days > 150 days (Chukwu 2014)
SAMSORG – 40	IAR	Short plant (130cm-165cm) with slim stem bears single seed per spikelet. Seeds are of medium size and cream in colour, the maturity date is between 110-120 days (Chukwu 2014)
SAMSORG- 42	IAR	A very tall plant (290-320cm), bears single seed per spikelet. Seeds are round ~~o~~f big size and matures in>120 days (Aba *et a*l., 2011)
SAMSORG – 43	IAR	A tall height plant (260-280cm), bears single seed per spikelet seeds are of medium size and yellow in colour. (Aba *et a*l., 2011)
SAMSORG- 44	IAR	It is a medium height plant (190-200cm) bears single seeds per spikelet. Seeds are of large size, round and white in colour and heads within 95-100days (Aba *et a*l., 2011)
FARA KANO	KANO	It is a medium height plant (165cm-180cm) bears single seeds per spikelet, seeds are big and white. It matures between 104-110 days(Technician report)
KAURA KADUNA 3	KADUNA	It is a short height plant (110-120) bears single seeds per spikelet; the seeds are of medium size and yellow. It matures within 140-150 days (Tech.Report)
YALA JIGAWA	JIGAWA	It is a tall plant of height 200cm to 220cm, the seeds are round, medium size and white. It heads within 97-100days.(Tech.Report)
FARA BORNO	BORNO	It is a medium height plant 160-200cm, bears single seeds per spikelet, seeds are big and white.(Techn.Report)
KAURA ZUNAINUWA	LOCAL	An average height plant with height 150cm-165cm bears single seeds per spikelet. Seeds are medium in size and yellow in colour.(Techn.Report)
BURULU BORNO	BORNO	It is tall plant height (190-220cm). Seeds are small and yellow.It heads within 110 days(Techn.Report)
KAURA MAIGUDUNA	LOCAL	It is a tall plant height (200cm-215cm), the stem is robust with compact panicle bears single seeds per spikelet, seeds are of medium size and yellow, heads within 100 days.(Techn.Report)

RIBX 98-5B-F3-78	LOCAL	It is a medium height plant (130cm-165cm).The panicle bears single seeds per spikelet the seeds are small and white. it heads within 101days
KAURA BORNO	BORNO	It is a tall plant with height (200cm-205cm). the stem is robust with panicle that bears single seeds per spikelet. Seeds are medium and yellow. It heads within 90days
SSV2006008X (Grinkanzabuwa)	LOCAL	It is an average height plant with height ranges within 135-165cm. the stem bears a panicle with single seeds per spikelet. The seeds are oval and white in colour, heads within 114days
SAWIYA INUWA	LOCAL	It is an average height plant,(155cm-165cm).The panicle bears single seeds per spikelet, the seeds are of medium size and yellow in colour.It matures within 121-130 days
KASHU PARAM	LOCAL	It is a very tall plant of height 290-320cm. the stem is robust with medium to large compact panicle, that bear single seed per spikelet. The seeds are big and white in colour.
KAURA KADUNA 1	KADUNA	It is a short plant (110cm-120cm). the seeds are of medium size, round and yellow in colour. It Heads within 115days
IS17561	REGIONAL GERMPLASM	A medium plant of height 120cm-140cm. The seeds are very small and white. It attains 50% heading within 90days.
FARA KADUNA 1	KADUNA	A tall plant of height 210cm-250cm.The seeds are big and yellow. It matures within 110-124 days
FARA BAUCHI 2	BAUCHI	A tall height (210cm-220cm) plant long panicles, seeds are relatively big and white, heads within 102 days
NRL 1	IAR	A short height plant (135cm-155cm). seeds are round medium size and white.
SSV20041-W	IAR	A short plant of height 130cm-160cm.The seeds are of medium size and white. It Heads within 110days
FARA 1 BAUCHI	BAUCHI	A tall plant of height 215cm-230cm, the seeds are big and cream. It heads within 110days .
KAURA KADUNA 2	KADUNA	A short plant of height (100cm-120cm), the seeds are medium size and yellow. It matures within 120-136days
DALWANDA	LOCAL	Average plant of height 180cm-200cm, the seeds are big. It heads within 96 days.
GWAJAMAI	LOCAL	Average plant of height (170cm-220cm) plant stem is robust with a compact panicle, bearing single seed per spikelet seeds are big round and yellow.
GIZO-1	LOCAL	A short height (105cm-125cm) plant, seeds are small and yellow.It matures within 120-134days

TWIN SEEDED	LOCAL	A tall height (220cm-255cm) plant the stem is robust bear a panicle that bears double (two) seeds per spikelet. The seeds are of medium size and white. It heads within 105 to 110 days.
SSV 2009	LOCAL	A tall height (220cm-240cm) plant, the seeds are big in size and yellow
FARA 3 BAUCHI	BAUCHI	Average height (152cm-160cm) plants has a robust stem, seeds are of medium size and cream in colour. It heads within 104-118 days
MACEDAKUYA	LOCAL	Tall height (190-200cm) plant, the stem is slight robust, bears medium sized panicle that bears single seeds per spikelet. The seeds are medium size and yellow.
JARDAWA	LOCAL	Tall height (200-240cm) plant, with a robust stem, the seeds are big and red in colour. Matures within 125-140days
GIZO 2	LOCAL	Tall height (200cm-210cm) long panicle that bears single seed per spikelet. The seeds are of medium size and yellow in colour. It heads within 103 to 105 days .
GARAU 2	LOCAL	An average to tall height (145cm-224cm) plant, seeds are of medium size and yellow in colour.
KASTAL	LOCAL	A tall height (215-250cm) plant with robust stem, long panicle, bears single seeds per spikelet, seeds are big and white, heads within 103 to 108 days.
YARDANGARKO	LOCAL	A medium height (145cm-160cm) plant, medium length panicle bears single seeds per spikelet, seeds are big round and white.
NRL 3	LOCAL	A short height (130cm-170cm) plant, seeds are big and yellow.
SRN 39(resistant check)	IAR	A short plant with slim stem that bears relatively short panicle with single seeds per spikelet. The seeds are of medium size, oval and yellow. Matures within 90-110 day
ICSR94407(resistant check)	ICRISAT	A short height (135-160cm) plant slim stem compacted small panicle single seeds per spikelet, seeds are small, round and cream. Mature within (91-95) days (Chukwu 2014)
ICSR94405(resistant check)	ICRISAT	A medium to tall height (165-210cm) plant, slim stem, small panicle with single seeds per spikelet, the seeds are relatively small, round and cream in colour. Matures within 98-100 days(Chukwu 2013)
SAMSORG-12(KSV 4) (susceptible check)	IAR	A tall height (210cm-220cm) plant long panicle, single seeds per spikelet.The seeds are relatively big and white.

IAR; Institute for Agricultural Research Samaru.ICRISAT; International Crop Research Institute for the Semi-Arid Tropics

soft drink bottle coverinto each pot,at two days interval for seven days as a preconditioning of the Striga seeds (Rodenburg*et.al* 2006)0.5 litre of water was applied to each pot. On the eighth day- 13th April 2013-, the sorghumseeds were sownat the rate of five seeds per pot. Thinning was done two weeks after to two seedlings per pot. Hand pulling of every other weed was done continually and watering every two day for 80 days. The experiment was left for 3 month, and then each plant was uprooted in order to count *Striga* plants that were yet to shoot out but had attached themselves to the host (Striga subterranean count)

3.4 Establishment of the field experiment

After clearing of the field, ridges were made at five metrelong. On the 5th of July 2013, Striga seeds were inoculated into the soil using the samemeasurement as that of the screen house in each hole.

The experiment was arranged in Randomized Complete Block Design in three replications. The ridges were five metre long, with spacing of 75cm x30cm as inter and intra- row spacing respectively. The genotypes were planted in one row of five seeds of sorghum per hole in three replications. The Sorghum seedlings were thinned to two per stand on the 14th day after sowing. On the 24th of July 2013(19th day after sowing), NPK 15-15-15 fertilizer at 60kg/ha was applied. Hoe weeding was done three weeks after sowing (3WAS) and hand weeding was done as required. Furadan was applied on 31st of August (56 DAS) to control Stem borer infestation. All the plants were left till maturity because they have different maturity days and the following data were measured.

3.5 Data Collection

Data were collected on the following

- Number of leaves per sorghum plants were taken at 28 and 80 DAS
- Striga count per plant at 40, 50,60,70,80 days after planting - the number of *Striga* that emerged on each plant at these days were counted and recorded.
- Days to 50% heading - days taken from sowing to when 50% of the plants in a plot had complete heading.
- Plant height(cm) - distance in centimeter from soil surface to tip of panicle was measured using meter rule at maturity.
- Number of panicles harvested/plot; the number of panicles harvested from each plot was recorded.
- Panicle length (cm) - the distance in centimeter between ligules and inflorescence base to its tip was measured using measuring tape.
- Panicle weight (g) - the weight in grams of un-threshed single panicle was recorded with weighing balance.
- Grain yield per plant (g) - Grains separated from the panicle of each plant were weighed and the weight of the grains recorded and expressed in grams using weighing balance.
- 1000 grain weight (g) - the weight in grams of 1000 randomly selected grains from individual plant was recorded using sensitive weighing balance.
- Striga damage score - crop syndrome rating which reflect the damage caused to the

host plant in reaction to Striga infestation was recorded. This was done using a scale of 0 to 9 rating (Sinebo and Drennan2001). The assessment considered chlorosis, blotching, scorching, and stunting, where 0 indicates no symptom development and 9 indicates the highest intensity of symptoms as shown below.

0 No chlorosis or other symptoms: normal sorghum growth.

1 Chlorosis or other symptoms just visible at about 1%; normal plant growth.

2 Leaf blotching and scorching on about 10% of leaves with purplish-brown necrotic spots; almost normal plant growth. No stunting.

3 Moderate leaf blotching and scorching on about 20% of leaves with some purplish-brown necrotic spots mild stunting.

4 Leaf scorching on about 30% of leaves with some purplish-brown necrotic spots. Some stunting.

5 Leaf scorching on about 40% of leaves with some gray-brown necrotic spots. Some stunting.

6 Leaf scorching on about 50% of leaves with mostly gray necrotic spots. Some stunting.

7 Leaf scorching on about 60% of leaves with severe gray necrotic spots and leaf wilting and rolling. Definite stunting.

8 Leaf scorching on about 70% of leaves with definite gray necrotic spots. Conspicuous stunting and leaf wilting. Death of host plant.

9 Complete scorching of all (100%); death of host plant.

Based on this scale, sorghugenotype with damage score of 0 to 4 were regarded as resistant genotypes while those sorghum genotypes with Striga damage score above 4 were considered

to be susceptible.

3.6 Data Analysis

The data was subjected to analysis of variance using generalized linear model procedure of SAS package (SAS, 2009).

The model for RCBD; $\gamma_{ij}=\mu+\alpha_i+\beta_j+\varepsilon_{ij}$ i = 1.....a , j.....b

Where;

γ_{ij}=An observation in treatment i and block j

μ = The overall mean

α_i = The effect of treatment

β_j = The effect of block j

ε_{ij} = Random error with mean 0 and variance σ^2

a = The number of treatment; b=number of the blocks

Table 3.2;Form of Analysis of Variance with expected mean square(EMS) for each Trait

Source of variation	d.f	MS	EMS
Replications	(r-1)		
Genotypes	(g-1)	Mg	$\sigma_e^2 + \mathrm{r}\sigma_{\mathrm{g}}^2$
Error	(r-1)(g-1)	Me	σ_e^2

Where;

r = number of replications

g = number of genotypes

σ_e^2 = error variance

σ_g^2 = $\frac{ms_g - ms_e}{r}$

$M_{\text{subscript}}$ = Observed mean squares of the subscripted effect

Mean separation was done using Duncan Multiple Range Test (DMRT). A phenotypic and genotypic correlation was done to establish the association between the Striga related traits and agronomic traits. Genetic distances and cluster analysis were also estimated using Mean Euclidean Distance as follows:

$$d_{ij} = \sqrt{\frac{1}{k}\sum_{1}^{k}\left(X_{ik} - X_{jk}\right)^2}$$

Where d_{ij}= genetic distance between two genotypes

K =number of genotypes

X_{ik}= genotype 1

X_{jk}= genotype 2

3.7 Correlations

Phenotypic and genotypic correlation coefficients were estimated for all possible pairs of characters examined. Phenotypic and genotypic correlations were estimated using the standard procedure suggested by Kashiani and Saleh (2010) from the corresponding variance and covariance components using the equations:

$$rpxy = \frac{\sigma pxy}{\sqrt{\sigma^2 px * \sigma^2 py}} \quad \text{and} \quad rgxy = \frac{\sigma gxy}{\sqrt{\sigma^2 gx * \sigma^2 gy}}$$

Where,

$rpxy$ = Phenotypic correlation coefficient between characters X and Y

$\sigma^2 px$ = Phenotypic variance of character X, $\sigma^2 py$ = Phenotypic variance of character Y

$rgxy$ =Genotypic correlation coefficient between characters X and Y $\sigma^2 gx$ = Genotypic variance of character X, $\sigma^2 gx$ = Genotypic variance of character Y

CHAPTER FOUR

4 RESULTS

4.1 Analysis of Variance

The mean squares from analysis of variance for both field and screen house data for all the traits were presented in Table 4.1. Striga shoot count at 50 DAS, Striga shoot count at 70 days, Striga shoot count at 80 days,50% days to heading, Plant height, Panicle weight, number of leaves per Plant at 80 days, number of Panicles harvested per plot, Panicle length, Grain weight, 1000grain weight and *Striga* damage score were highly significant ($p \leq 0.01$) for the genotypes. Striga shoot counts at 60 days after sowing and number of leaves at 28 days after sowing were not significant. On the other hand, Panicle weight, grain weight and number of panicles harvested per plot showed significant differences ($p \leq 0.05$) among the replications.

Analysis of variance for screen house data showed highly significant differences ($P \leq 0.01$) among genotypes for all the traits tested. Only numbers of leaves at 28days after sowing showed significant difference among the replications.

Table 4.1; Mean square from analysis of variance for the traits studied in the field and screen house

		No of Leaves		Striga shoots count											
Source	DF	28DAS	80DAS	50DAS	60DAS	70DAS	80DAS	SSC	50%DH	PH	SDS	NPH	PaL	PaW	GrW	1000GW
Rep	2	0.21	5.43	0.31	0.65	0.78	1.46		11.67	279.42	1.47	145.76*	8.5	1035942.46*	930163.13*	6.59
Entry	42	0.03	3.26**	0.22*	0.2	0.42**	0.48**		375.43**	5012.88**	0.36**	67.63**	123.15**	274248.19**	101830.98**	88.32**
Error	84	0.02	1.48	0.11	0.14	0.18	0.2		3.52	180.85	0.15	21.34	28.31	88370.42	48165.35	1.78
								screen house								
Rep	2	0.005*	1.03	0.03	0.24	0.28	0.37	0.1		548.83	0.24					
Entry	42	0.003*	13.49**	0.47**	0.54**	0.61**	0.69**	0.67**		2402.43**	0.33**					
Error	84	0.1	3.09	0.16	0.13	0.13	0.14	0.14		642.93	0.12					

50%DH=Days to 50% heading; 50DAS=Striga shoot count at 50 days after sowing; 60 DAS= Striga shoot count at 60 days after sowing; 70 DAS= Striga shoots count at 70days after sowing, 80 DAS= Striga Shoot count at 80 days after sowing; PH=Plant height; PaW=Panicle weight; NPH=Number of panicles harvested, 28DAS=number of leaves at 28 days after sowing, 80DAS=number of leaves at 80 days after sowing. PaL=panicle length;GrW; Grain weight; 1000GrW=1000 Grain weight; SDS= Striga damage score; SSC=Striga subterranean count;* =significant at 5% probability level; ** Significant at 1% probability level.

4.2 Mean performance of*Striga* related traits and agronomic traits

4.2.1 Striga Count

Mean Striga count per sorghum at 50days after sowing(DAS) varied between 0.33 in Farakano, KauraMaiguduna, KauraKaduna 1,IS17562, FaraKaduna, Gwajamai, Twin seeded, Gizo-2 and Garau to 4.00 inSAMSORG- 14. Kaura Borno,FaraBauch 2 and Jardawa had means that were significantly different from all the checks(3.00, 2.00, and 2.00 respectively).There was no significant difference between all the checks and the other genotypes. On the other hand, for the screen house the highest mean performance was found in SAMSORG - 14 to be 5.0, which was not significantly different from the two susceptible checks (KSV4 and SRN 39) which was also 5.0.The lowest mean value was 0.33 for Kaura Kaduna 1 which was not significantly different from the two resistant checks and(ICSR94407 and ICSR94405).

At 60 days after sowing, the highest Striga shoot count mean was 4.00 in SAMSORG -14, which was not significantly different from SRN 39 while the lowest count was found in Kaura Maiguduna, which was not significantly different from three of the checks (KSV4, ICSR94405 and ICSR 94407). For the screen house experiment, the mean performance for Striga shoot count at 60 DAS ranges from 5.33 for Fara 1 Bauchi and Fara 3 Bauchi which were not significantly different from KSV4 (Susceptible check) to 0.00 for ICSR94405 and ICSR94407, while SRN had a mean of 6.33.

At 70 (DAS), the highest mean performance was found in Samsorg 14 with a mean value of 4.33 and the lowest 0.33 inFara Kaduna and Garau, which were not significantly different from ICSR94407(resistant check). In the screen house, Fara 1 Bauchi had the highest mean of 6.33 while Burulu Borno had the lowest Striga shoot count to be 1.00.

SRN 39 had the highest Striga count of 7.33 among all the genotypes. At 80 DAS, the highest mean performance was found in SAMSORG - 14 (8.33) which was not significantly different from SRN 39 and the lowest count(1.00) was found in Twin seeded genotype. On the other hand, the screen house mean performance ranged from 7.23 for Fara 1 Bauchi to 1.67 for Kaura Maiguduna. The mean performance for Striga Subterranean Count (SSC) ranged from 8.67 inSAMSORG - 14 which was not significantly different from one of the checks(SRN 39) to 2.33 for Gwajamai (Table 4.2ai)

The *Striga* damage score in the screen house ranged from 3.33 for Kastal to 7.67 for NRL 3. Whereas on the field the highest was 6.33 for FaraBauchi 2, IS 17562, SSV 20041-W and SSV2009 while the lowest damage score was 3.04 for KauraMaiguduna and Gwajamai, which was even more than the damage mean of the two resistant checks i.e ICSR 94405 and ICSR 94407 (Table 4.2ai).

Table 4.2ai;Mean performance of the genotypes for Striga shoots count and Striga damage score

GENOTYPES	STRIGA COUNT AT 50 DAS		STRIGA COUNT AT 60 DAS		STRIGA COUNT AT 70 DAS		STRIGA COUNT AT 80 DAS		SUBT COUNT	STRIGA DAMAGE SCORE	
	FD	SCR	FD	SCR	FD	SCR	FD	SCR	SCR	FD	SCR
SAMSORG-14	4.00^{a}	5.00^{a}	4.00^{a}	5.00^{abc}	4.33^{ab}	5.67^{abc}	8.33^{a}	7.00^{ab}	8.67^{a}	6.00^{abc}	5.67$^{b\ldots g}$
SAMSORG-17	0.67^{b}	1.00^{bcd}	1.00^{b}	2.33$^{c\ldots h}$	1.67$^{b\ldots e}$	2.67$^{e\ldots h}$	2.03$^{b\ldots e}$	5.67$^{a\ldots d}$	5.67$^{a\ldots g}$	5.33$^{a\ldots d}$	5.67$^{b\ldots g}$
SAMSORG-40	0.67^{b}	1.00^{bcd}	0.67^{b}	1.00^{fgh}	1.00^{de}	1.33$^{f\ldots h}$	1.33^{cde}	5.33$^{a\ldots e}$	5.67$^{a\ldots g}$	5.67^{abc}	6.33$^{b\ldots f}$
SAMSORG-42	0.67^{b}	0.67^{bcd}	1.00^{b}	3.67$^{b\ldots e}$	1.00^{de}	4.67$^{b\ldots e}$	1.67$^{b\ldots e}$	5.33$^{a\ldots e}$	5.67$^{a\ldots g}$	5.67^{abc}	6.33$^{b\ldots.f}$
SAMSORG-43	1.33^{b}	3.00^{ab}	2.00^{ab}	3.67$^{b\ldots e}$	2.67$^{a\ldots e}$	4.00$^{b\ldots f}$	2.67$^{b..e}$	4.33$^{b..f}$	5.67$^{a\ldots g}$	4.43$^{b\ldots f}$	6.33$^{b\ldots f}$
SAMSORG-44	1.67^{b}	2.00$^{a\ldots d}$	1.67^{b}	2.00$^{c\ldots h}$	2.00$^{a\ldots e}$	2.67$^{e\ldots h}$	2.33$^{b..e}$	5.33$^{a\ldots e}$	5.67$^{a\ldots g}$	5.67^{abc}	5.33$^{b\ldots h}$
FARAKANO	0.33^{b}	1.00^{bcd}	0.67^{b}	2.33$^{c\ldots h}$	1.33^{cde}	3.33$^{c\ldots g}$	2.00$^{b\ldots e}$	3.67^{def}	5.03$^{c\ldots i}$	3.67$^{a\ldots f}$	5.33$^{b\ldots h}$
KAURAKADUNA- 3	1.00^{b}	1.33^{bcd}	1.00^{b}	1.33$^{e\ldots h}$	1.67$^{b\ldots e}$	1.67$^{e\ldots h}$	2.00$^{b\ldots e}$	2.67^{def}	3.67$^{e\ldots i}$	4.33$^{b\ldots f}$	4.67$^{c\ldots h}$
YALAJIGAWA	1.00^{b}	1.33^{bcd}	1.00^{b}	3.00$^{b\ldots g}$	1.00^{de}	3.67$^{b\ldots g}$	1.33^{cde}	4.03$^{d\ldots e}$	6.03$^{a\ldots f}$	5.33$^{a\ldots d}$	6.33$^{b\ldots f}$
FARABORNO	1.67^{b}	2.33$^{a\ldots d}$	1.67^{b}	3.33$^{b\ldots g}$	2.67$^{a\ldots e}$	4.00$^{b\ldots f}$	3.33$^{b..e}$	4.03$^{d\ldots e}$	4.67$^{d\ldots i}$	5.00$^{a\ldots e}$	6.33$^{b\ldots f}$
KAURAZUNAINUWA	1.00^{b}	1.00^{bcd}	2.00^{ab}	2.00$^{c\ldots h}$	2.33$^{a\ldots e}$	2.33$^{e\ldots h}$	3.00$^{b..e}$	2.67^{def}	3.33$^{e\ldots j}$	4.67$^{a\ldots e}$	5.03$^{b\ldots h}$
BURULUBORNO	1.00^{b}	1.00^{bcd}	1.67^{b}	1.00^{fgh}	1.33^{cde}	1.00^{gh}	2.00$^{b\ldots e}$	5.67$^{a\ldots d}$	5.67$^{a\ldots g}$	4.71$^{a\ldots e}$	5.67$^{b\ldots g}$
KAURAMAIGUDUNA	0.33^{b}	0.67^{bcd}	0.33^{b}	1.33$^{e\ldots h}$	0.67^{de}	1.33^{fgh}	1.67$^{b\ldots e}$	1.67^{de}	3.67$^{e\ldots i}$	3.04^{def}	3.67$^{e\ldots h}$
RIBX98-78	1.00^{b}	1.00^{bcd}	1.00^{b}	1.00^{fgh}	1.67$^{b\ldots e}$	1.33^{fgh}	1.67$^{b\ldots e}$	2.67^{def}	2.67$^{g\ldots j}$	3.33$^{c\ldots f}$	5.03$^{b\ldots h}$
KAURABORNO	3.00^{ba}	1.00^{bcd}	1.00^{b}	1.67$^{d\ldots h}$	2.00$^{a\ldots e}$	2.00$^{e\ldots h}$	2.67$^{b\ldots e}$	2.01^{de}	3.33$^{e\ldots j}$	4.03$^{b\ldots f}$	5.67$^{b\ldots g}$
SSV2006008X	1.33^{b}	1.33^{bcd}	1.67^{b}	2.67$^{c\ldots g}$	2.67$^{a\ldots e}$	2.67$^{e\ldots h}$	3.67$^{b\ldots e}$	3.33^{def}	4.67$^{d\ldots i}$	5.33$^{a\ldots d}$	4.67$^{c\ldots h}$
SAWIYAINUWA	0.67^{b}	0.67^{bcd}	1.00^{b}	1.00^{fgh}	3.00^{abcd}	2.67$^{e\ldots h}$	3.33^{cde}	4.03$^{d\ldots e}$	5.03$^{c\ldots i}$	4.33$^{b\ldots f}$	6.33$^{b\ldots f}$
KASHUPARAM	1.00^{b}	1.33^{bcd}	1.33^{b}	1.33$^{e\ldots h}$	2.00$^{a\ldots e}$	2.00$^{e\ldots h}$	2.67$^{b\ldots e}$	3.33^{def}	4.33$^{d\ldots i}$	5.00$^{a\ldots e}$	6.33$^{b\ldots f}$
KAURAKADUNA-1	0.33^{b}	0.33^{cd}	0.33^{b}	1.00^{fgh}	0.67^{de}	1.00^{fg}	1.67$^{b\ldots e}$	2.33^{de}	3.03$^{f\ldots j}$	5.67^{abc}	4.67$^{c\ldots h}$
IS17562	0.33^{b}	1.00^{bcd}	1.00^{b}	1.67$^{d\ldots h}$	1.00^{de}	1.67$^{e\ldots h}$	1.67$^{b\ldots e}$	2.33^{de}	2.67$^{g\ldots j}$	6.33^{ab}	3.67$^{e\ldots h}$
FARAKADUNA	0.33^{b}	1.33$^{b\ldots d}$	0.33^{b}	1.67$^{d\ldots h}$	0.33^{de}	1.67$^{e\ldots h}$	1.00^{de}	5.33$^{a\ldots e}$	5.33$^{c\ldots i}$	6.01^{ab}	7.03^{bcd}
FARABAUCHI2	2.00^{ba}	1.67$^{a\ldots d}$	2.00^{ab}	1.67$^{d\ldots h}$	4.33^{ab}	3.67$^{b\ldots g}$	4.67^{bc}	5.67$^{a\ldots d}$	5.67$^{a\ldots g}$	6.33^{ab}	7.33^{bc}

Table 4.2ai continues

Genotypes	STRIGA COUNT AT 50DAS		STRIGA COUNT AT 60DAS		STRIGA COUNT AT 70DAS		STRIGA COUNT AT 80DAS		SUBT COUNT	STRIGA DAMAGE SCORE	
	FD	SCR	FD	SCR	FD	SCR	FD	SCR	SCR	FD	SCR
NRL-1	1.33^{b}	1.67$^{a\ldots d}$	1.33^{b}	2.33$^{c\ldots h}$	1.33^{cde}	2.33$^{e\ldots h}$	2.67$^{b\ldots e}$	3.33^{def}	4.33$^{d\ldots i}$	4.01$^{a\ldots f}$	4.03$^{d\ldots h}$
SSV20041-W	0.67^{b}	2.33$^{a\ldots d}$	0.67^{b}	3.00$^{b\ldots g}$	1.33^{cde}	3.00$^{c\ldots g}$	1.33^{cde}	4.67$^{d\ldots e}$	5.33$^{c\ldots i}$	6.33^{ab}	6.33$^{b\ldots f}$
FARA BAUCHI 1	1.33^{b}	1.67$^{a\ldots d}$	1.67^{b}	5.33^{ab}	4.00^{ab}	6.33^{ab}	4.33^{bcd}	7.23^{ab}	8.33^{ab}	5.67^{abc}	6.33$^{b\ldots f}$
KAURAKADUNA -2	0.67^{b}	4.00^{b}	1.33^{b}	4.00$^{a\ldots d}$	2.00$^{a..e}$	4.33$^{b\ldots e}$	2.33$^{b\ldots e}$	5.33$^{a..e}$	5.67$^{a\ldots g}$	4.67$^{a\ldots e}$	5.67$^{b\ldots g}$
DALWANDA	1.00^{b}	1.00^{bcd}	1.33^{b}	1.67$^{d\ldots h}$	2.00$^{a\ldots e}$	2.33$^{e\ldots h}$	2.67$^{b..e}$	2.33^{de}	2.33^{hij}	4.43$^{a\ldots f}$	4.60$^{d\ldots h}$
GWAJAMAI	0.33^{b}	1.00^{bcd}	0.33^{b}	1.67$^{d\ldots h}$	0.67^{de}	2.33$^{e\ldots h}$	1.00^{de}	2.33^{de}	3.33$^{e\ldots j}$	3.04^{def}	4.67$^{c\ldots h}$
GIZO-1	0.67^{b}	2.67^{abc}	0.67^{b}	2.67$^{c\ldots g}$	1.00^{de}	3.33$^{c\ldots g}$	1.00^{de}	3.67^{def}	5.03$^{c\ldots i}$	3.23$^{c\ldots f}$	4.03$^{d\ldots h}$
TWINSEEDED	0.33^{b}	2.67^{abc}	0.67^{b}	3.33$^{b\ldots f}$	1.00^{de}	4.00$^{b\ldots f}$	1.00^{de}	4.33$^{b\ldots f}$	5.67$^{a\ldots g}$	3.33$^{c\ldots f}$	5.03$^{b\ldots h}$
SSV2009	0.67^{b}	1.67$^{a\ldots d}$	1.00^{b}	3.00$^{b\ldots g}$	1.33^{cde}	3.67$^{b\ldots g}$	1.67$^{b\ldots e}$	4.67$^{a\ldots e}$	6.03$^{a\ldots f}$	6.33^{ab}	5.03$^{b\ldots h}$
FARA BAUCHI 3	1.00^{b}	4.00^{b}	1.00^{b}	5.33^{ab}	2.67$^{a\ldots e}$	5.33$^{a\ldots d}$	3.67^{bcd}	6.67^{abc}	7.67^{abc}	4.67$^{a\ldots e}$	4.67$^{c\ldots h}$
MACEDAKUYA	0.00^{b}	2.01$^{a\ldots d}$	0.67^{b}	3.33$^{b\ldots f}$	0.67^{de}	4.33$^{b\ldots e}$	1.00^{de}	4.33$^{b\ldots f}$	5.03$^{c\ldots i}$	3.67$^{b\ldots f}$	5.67$^{b\ldots g}$
JARDAWA	2.00^{ba}	1.67$^{a\ldots d}$	2.33^{ab}	3.00$^{b\ldots g}$	4.67^{a}	4.00$^{b\ldots f}$	5.00^{b}	4.67$^{a\ldots e}$	6.33$^{a\ldots e}$	4.67$^{a\ldots e}$	5.33$^{b\ldots h}$
GIZO-2	1.33^{b}	1.33$^{b\ldots d}$	1.33^{b}	2.00$^{c\ldots h}$	2.03$^{a\ldots e}$	3.67$^{b\ldots g}$	2.03$^{b\ldots e}$	4.33$^{b\ldots f}$	4.67$^{d\ldots i}$	3.33$^{c\ldots f}$	4.33$^{d\ldots h}$
GARAU-2	0.33^{b}	1.67$^{a\ldots d}$	0.33^{b}	2.33$^{c\ldots h}$	0.33^{de}	4.00$^{b\ldots f}$	0.67^{e}	4.33$^{b\ldots f}$	5.03$^{c\ldots i}$	4.33$^{a\ldots e}$	4.03$^{d\ldots h}$
KASTAL	0.00^{b}	0.67^{bcd}	0.67^{b}	1.33$^{e\ldots h}$	1.33^{cde}	1.67$^{e\ldots h}$	1.67$^{b\ldots e}$	3.33^{def}	3.67$^{e\ldots i}$	4.33$^{a\ldots e}$	3.33^{fgh}
YARDANGARKO	0.33^{b}	0.00^{d}	0.33^{b}	1.33$^{e\ldots h}$	1.33^{cde}	1.67$^{e\ldots h}$	1.33^{cde}	2.33^{de}	3.33$^{e\ldots j}$	4.03$^{a\ldots d}$	4.03$^{d\ldots h}$
NRL-3	0.00^{b}	0.67^{bcd}	1.33^{b}	1.33$^{e\ldots h}$	1.67$^{b..e}$	1.67$^{e\ldots h}$	1.67$^{b\ldots e}$	2.33^{de}	2.67$^{g\ldots j}$	3.33$^{c\ldots f}$	7.67^{ab}
KSV 4	0.33^{b}	5.00^{a}	0.33^{b}	5.33^{ab}	4.67^{a}	5.33$^{a\ldots d}$	5.33^{bc}	7.03^{ab}	7.33$^{a\ldots d}$	6.01^{ab}	6.67$^{b\ldots e}$
SRN39	0.00^{b}	5.00^{a}	4..00^{a}	6.33^{a}	4.33^{a}	7.33^{a}	8.00^{a}	7.33^{a}	8.67^{a}	6.67^{a}	8.67^{a}
ICSR94405	0.00^{b}	0.00^{d}	0.00^{b}	0.00^{h}	0.00^{e}	0.00^{h}	0.67^{e}	0.71^{f}	0.71^{j}	1.67^{f}	1.33^{gh}
ICSR94407	0.00^{b}	0.00^{d}	0.00^{b}	0.00^{h}	0.33^{de}	0.00^{h}	0.33^{e}	0.88^{f}	0.88^{j}	2.23^{ef}	1.03^{h}
Mean	0.83	1.40	1.05	1.60	1.65	1.76	2.18	1.90	2.15	3.71	2.11

FD=Field data, SCR=Screen house data, Subt count=Striga subterranean count, DAS=Days after sowing.

Table 4.2aii ; Transformed Mean performance of the genotypes for Striga shoots count and Striga damage score

GENOTYPES	Striga count at 50DAS		Striga count at 60DAS		Striga count at70DAS		Striga count at 80DAS		Subt count	Striga damage score	
	FD	SCR	FD	SCR	FD	SCR	FD	SCR	SCR	FD	SCR
SAMSORG-14	2.35^{a}	2.55^{a}	2.35^{a}	2.55^{abc}	2.41^{ab}	2.68^{abc}	3.14^{a}	2.92^{ab}	3.19^{a}	2.74^{abc}	2.68^{b-g}
SAMSORG-17	1.47^{b}	1.58^{bcd}	1.58^{b}	1.96^{c-h}	1.78^{b-e}	2.04^{e-h}	1.88^{b-e}	2.68^{a-d}	2.68^{a-g}	2.61^{a-d}	2.68^{b-g}
SAMSORG-40	1.47^{b}	1.58^{bcd}	1.47^{b}	1.58^{fgh}	1.58^{de}	1.68^{f-h}	1.68^{cde}	2.61^{a-e}	2.68^{a-g}	2.68^{abc}	2.80^{b-f}
SAMSORG-42	1.47^{b}	1.47^{bcd}	1.58^{b}	2.27^{b-e}	1.58^{de}	2.48^{b-e}	1.78^{b-e}	2.61^{a-e}	2.68^{a-g}	2.68^{abc}	2.80^{b-f}
SAMSORG-43	1.68^{b}	2.12^{ab}	1.87^{ab}	2.27^{b-e}	2.04^{a-e}	2.35^{b-f}	2.04^{b-e}	2.41^{b-f}	2.68^{a-g}	2.44^{b-f}	2.80^{b-f}
SAMSORG-44	1.78^{b}	1.87^{a-d}	1.78^{b}	1.87^{c-h}	1.87^{a-e}	2.04^{e-h}	1.96^{b-e}	2.61^{a-e}	2.68^{a-g}	2.68^{abc}	2.61^{b-h}
FARAKANO	1.35^{b}	1.58^{bcd}	1.47^{b}	1.96^{c-h}	1.68^{cde}	2.20^{c-g}	1.87^{b-e}	2.27^{def}	2.56^{c-i}	2.27^{a-f}	2.61^{b-h}
KAURAKADUNA3	1.58^{b}	1.68^{bcd}	1.58^{b}	1.68^{e-h}	1.78^{b-e}	1.78^{e-h}	1.87^{b-e}	2.04^{def}	2.27^{e-i}	2.41^{b-f}	2.48^{c-h}
YALAJIGAWA	1.58^{b}	1.68^{bcd}	1.58^{b}	2.12^{b-g}	1.58^{de}	2.27^{b-g}	1.68^{cde}	2.35^{b-e}	2.74^{a-f}	2.61^{a-d}	2.80^{b-f}
FARABORNO	1.78^{ab}	1.96^{a-d}	1.78^{b}	2.20^{b-g}	2.04^{a-e}	2.35^{b-f}	2.20^{b-e}	2.35^{b-e}	2.48^{d-i}	2.55^{a-e}	2.80^{b-f}
KAURAZUNAINUWA	1.58^{b}	1.58^{bcd}	1.87^{ab}	1.87^{c-h}	1.96^{a-e}	1.96^{e-h}	2.12^{b-e}	2.04^{def}	2.20^{e-j}	2.48^{a-e}	2.56^{b-h}
BURULUBORNO	1.58^{b}	1.58^{bcd}	1.78^{b}	1.58^{fgh}	1.68^{cde}	1.58^{gh}	1.87^{b-e}	2.68^{a-d}	2.68^{a-g}	2.49^{a-e}	2.68^{b-g}
KAURAMAIGUDUNA	1.35^{b}	1.47^{bcd}	1.35^{b}	1.68^{e-h}	1.47^{de}	1.68^{fgh}	1.78^{b-e}	1.78^{de}	2.27^{e-i}	2.13^{def}	2.27^{e-h}
RIBX98-78	1.58^{b}	1.58^{bcd}	1.58^{b}	1.58^{fgh}	1.78^{b-e}	1.68^{fgh}	1.78^{b-e}	2.04^{def}	2.04^{g-j}	2.20^{c-f}	2.56^{b-h}
KAURABORNO	2.12^{ab}	1.58^{bcd}	1.58^{b}	1.78^{d-h}	1.87^{a-e}	1.87^{e-h}	2.04^{b-e}	1.87^{de}	2.20^{e-j}	2.35^{b-f}	2.68^{b-g}
SSV2006008X	1.68^{b}	1.68^{bcd}	1.78^{b}	2.04^{c-g}	2.04^{a-e}	2.04^{e-h}	2.27^{b-e}	2.20^{def}	2.48^{d-i}	2.61^{a-d}	2.48^{c-h}
SAWIYAINUWA	1.47^{b}	1.47^{bcd}	1.58^{b}	1.58^{fgh}	2.12^{a-d}	2.04^{e-h}	2.20^{cde}	2.35^{d-e}	2.56^{c-i}	2.41^{b-f}	2.80^{b-f}
KASHUPARAM	1.58^{b}	1.68^{bcd}	1.68^{b}	1.68^{e-h}	1.87^{a-e}	1.87^{e-h}	2.04^{b-e}	2.20^{def}	2.41^{d-i}	2.55^{a-e}	2.80^{b-f}
KAURAKADUNA1	1.35^{b}	1.35^{cd}	1.35^{b}	1.58^{fgh}	1.47^{de}	1.58^{fg}	1.78^{b-e}	1.96^{de}	2.13^{f-j}	2.68^{abc}	2.48^{c-h}
IS17562	1.35^{b}	1.58^{bcd}	1.58^{b}	1.78^{d-h}	1.58^{de}	1.78^{e-h}	1.78^{b-e}	1.96^{de}	2.04^{g-i}	2.80^{ab}	2.27^{e-h}
FARAKADUNA	1.35^{b}	1.68^{bcd}	1.35^{b}	1.78^{d-h}	1.35^{de}	1.78^{e-h}	1.58^{de}	2.61^{a-e}	2.61^{c-i}	2.74^{ab}	2.92^{bcd}
FARABAUCHI2	1.87^{ab}	1.78^{ab}	1.87^{ab}	1.78^{d-h}	2.41^{ab}	2.27^{b-g}	2.48^{bc}	2.68^{a-d}	2.68^{a-j}	2.80^{ab}	2.97^{bc}

Table 4.2aii continues

GENOTYPES	Striga count at 50DAS		Striga count at 60DAS		Striga count at70DAS		Striga count at 80DAS		Subt count	Striga damage score	
	FD	SCR	FD	SCR	FD	SCR	FD	SCR		FD	SCR
NRL-1	1.68^{b}	1.78^{a-d}	1.68^{b}	1.96^{c-h}	1.68^{cde}	1.96^{e-h}	2.04^{b-e}	2.20^{def}	2.41^{d-i}	2.35^{a-f}	2.35^{d-h}
SSV20041-W	1.47^{b}	1.96^{a-d}	1.47^{b}	2.12^{b-g}	1.68^{cde}	2.12^{c-g}	1.68^{cde}	2.48^{b-e}	2.61^{c-i}	2.80^{ab}	2.80^{b-f}
FARA BAUCHI 1	1.68^{b}	1.78^{a-d}	1.78^{b}	2.61^{ab}	2.35^{ab}	2.80^{ab}	2.41^{bcd}	2.95^{ab}	3.14^{ab}	2.68^{abc}	2.80^{b-f}
KAURAKADUNA2	1.47^{b}	2.35^{b}	1.68^{b}	2.35^{a-d}	1.87^{a-e}	2.41^{b-e}	1.96^{b-e}	2.61^{a-e}	2.68^{a-g}	2.48^{a-e}	2.68^{b-g}
DALWANDA	1.58^{b}	1.58^{bcd}	1.68^{b}	1.78^{d-h}	1.87^{a-e}	1.96^{e-h}	2.04^{b-e}	1.96^{de}	1.96^{hij}	2.44^{a-e}	2.47^{d-h}
GWAJAMAI	1.35^{b}	1.58^{bcd}	1.35^{b}	1.78^{d-h}	1.47^{de}	1.96^{e-h}	1.58^{de}	1.96^{de}	2.20^{e-j}	2.13^{a-f}	2.48^{c-h}
GIZO-1	1.47^{b}	2.04^{abc}	1.47^{b}	2.04^{c-g}	1.58^{de}	2.20^{c-g}	1.58^{de}	2.27^{def}	2.56^{c-h}	2.17^{c-f}	2.35^{d-h}
TWINSEEDED	1.35^{b}	2.04^{abc}	1.47^{b}	2.20^{b-f}	1.58^{de}	2.35^{b-f}	1.58^{de}	2.41^{b-f}	2.68^{a-g}	2.20^{c-f}	2.56^{b-h}
SSV2009	1.47^{b}	1.78^{a-d}	1.58^{b}	2.12^{b-g}	1.68^{cde}	2.27^{b-g}	1.78^{b-e}	2.48^{a-e}	2.74^{a-f}	2.80^{ab}	2.56^{b-h}
FARA BAUCHI 3	1.58^{b}	2.35^{b}	1.58^{b}	2.61^{ab}	2.04^{a-e}	2.61^{a-d}	2.27^{bcd}	2.86^{abc}	3.03^{abc}	2.48^{a-e}	2.48^{c-h}
MACEDAKUYA	1.22^{b}	1.87^{a-d}	1.47^{b}	2.20^{b-f}	1.47^{de}	2.41^{b-e}	1.58^{de}	2.41^{b-f}	2.56^{c-i}	2.27^{b-f}	2.68^{b-g}
JARDAWA	1.87^{ab}	1.78^{a-d}	1.96^{a-d}	2.12^{b-g}	2.48^{a}	2.35^{b-f}	2.55^{b}	2.48^{a-e}	2.80^{a-e}	2.48^{a-e}	2.61^{b-h}
GIZO-2	1.68^{b}	1.68^{bcd}	1.68^{bcd}	1.87^{c-h}	1.88^{a-e}	2.27^{b-g}	1.88^{b-e}	2.41^{b-f}	2.48^{d-i}	2.20^{c-f}	2.41^{d-h}
GARAU2	1.35^{b}	1.78^{a-d}	1.35^{a-d}	1.96^{c-h}	1.35^{de}	2.35^{b-f}	1.47^{e}	2.41^{b-f}	2.56^{c-i}	2.41^{a-e}	2.35^{d-h}
KASTAL	1.22^{b}	1.47^{bcd}	1.47^{b}	1.68^{e-h}	1.68^{cde}	1.78^{e-h}	1.78^{b-e}	2.20^{def}	2.27^{e-i}	2.41^{a-e}	2.20^{fgh}
YARDANGARKO	1.35^{b}	1.22^{d}	1.35^{b}	1.68^{e-h}	1.68^{cde}	1.78^{e-h}	1.68^{cde}	1.96^{de}	2.20^{e-j}	2.35^{a-d}	2.35^{d-h}
NRL-3	1.22^{b}	1.47^{bcd}	1.68^{b}	1.68^{e-h}	1.78^{b-e}	1.78^{e-h}	1.78^{b-e}	1.96^{de}	2.04^{g-j}	2.20^{c-f}	3.03^{ab}
KSV 4	1.35^{b}	2.55^{a}	1.35^{b}	2.61^{ab}	2.48^{a}	2.61^{a-d}	2.61^{bc}	2.92^{ab}	2.97^{a-d}	2.74^{ab}	2.86^{b-e}
SRN39	1.22^{b}	2.55^{a}	2.35^{a}	2.80^{a}	2.41^{a}	2.97^{a}	3.08^{a}	2.97^{a}	3.19^{a}	2.86^{a}	3.19^{a}
ICSR94405	1.22^{b}	1.22^{d}	1.22^{b}	1.22^{h}	1.22^{e}	1.22^{h}	1.47^{e}	1.49^{f}	1.49^{j}	1.78^{f}	1.68^{gh}
ICSR94407	1.22^{b}	1.22^{d}	1.22^{b}	1.22^{h}	1.35^{de}	1.22^{h}	1.35^{e}	1.54^{f}	1.54^{j}	1.93^{ef}	1.59^{h}
Mean	1.53	1.70	1.60	1.76	1.78	1.81	1.92	1.84	1.91	2.28	1.90

FD=Field data, SCR=Screen house data,Subt count= Striga subterranean count,DAS=Days after sowing.

4.2.2 Number of leavesper plant

The mean performance of the sorghum genotypes for growth and yield traits are presented in Table 4.2b.At 28DAS the highest number of leaves was associated with SAMSORG - 42 with value of 7.67 and the lowest was 5.67 in SAMSORG-40, Gizo 1, Gizo 2 and Kaura Kaduna 1. At the screen house the highest was found in SAMSORG-40 with mean values of 7.77 and lowest 7.01 was common to other genotypes. At 80 days after sowing (DAS), the leaf numbers increased and ranged from 12.33 in SAMSORG-17,Fara Borno, Kaurazunainuwa,Sawiyainuwa and Gizo 2. Whereas, at the screen house Gizo-1 had the highest mean value of 20.00 and the lowest 11.33 mean was found in SSV20041-W and Burulu Borno.(Table 4.2b)

4.2.3 50 % Days to Heading (50 % DH)

All the sorghum varieties took an average of 100 days for 50% of them to head,and the individual mean ranged from 76.67 for Yandargako to 121.33 in Kaurakaduna 3.IS17562 took approximately 88 days for 50% to head, which was not significantly different from days taken by KSV4 and ICSR94405. Kaura borno being the earliest took approximately 87 days which had no significant difference with days taken by two of the checks (KSV4 and ICSR94405) to germinate followed by SSV2009, Twin seeded, Fara Kaduna, ICSR94405, Kaura Kaduna 3, YalaJigawa, Kaura Kaduna 1, BuruluBorno, FaraBauchi, Jardawa, Gizo 1, NRL 3, NRL 1, and FaraBorno, . Others including the check took over 100 days for 50% to head (Table 4.2b).

4.2.4 Plant height

The overall mean plant height for the field data was 178.68cm, the tallest was SAMSORG

Table 4.2b; Mean performance of sorghum genotypes for agronomic traits

GENOTYPES	N/Leaves at 28DAS		N/Leaves at 80DAS		50%DH	Plant height(cm)		NPH	PAL(cm)	PAW(g)	GRW(g)	1000GRW(g)
	FD	SCR	FD	SCR		FD	SCR					
SAMSORG-14	7.33^{a}	7.67^{a}	11.67^{abc}	13.67^{h-n}	91.00^{m}	223.30^{bc}	210.33^{bc}	19.33^{a}	39.07^{a-d}	1467.00^{a}	900.00^{a}	32.00^{c}
SAMSORG-17	7.33^{a}	7.67^{a}	12.33^{a}	18.67^{abc}	114.00^{de}	150.00^{h-m}	161.67^{h-m}	16.67^{abc}	28.00^{d-i}	966.70^{a-f}	633.30^{a-d}	23.33^{ijk}
SAMSORG-40	5.67^{bc}	7.77^{a}	10.67^{a-d}	14.03^{g-m}	93.00^{ml}	161.70^{f-k}	161.70^{f-k}	17.33^{ab}	28.73^{d-h}	833.30^{a-g}	300.00^{b-e}	27.00^{efg}
SAMSORG-42	7.76^{a}	7.67^{a}	11.33^{abc}	15.67^{b-k}	111.33^{e}	320.30^{a}	300.33^{a}	12.00^{a-g}	31.67^{c-h}	866.70^{a-g}	600.00^{a-d}	25.33$^{f...j}$
SAMSORG-43	7.33^{a}	7.33^{ab}	9.33^{cd}	14.03^{g-m}	101.33^{i}	168.30^{e-j}	168.30^{e-j}	10.33^{a-h}	28.40^{d-i}	666.70^{c-g}	566.70^{a-d}	23.00^{jkl}
SAMSORG-44	7.33^{a}	7.67^{a}	11.33^{abc}	15.33^{c-l}	96.33^{jk}	150.00^{h-m}	150.00^{h-m}	18.33^{ab}	33.10^{b-h}	1200.00^{a-d}	900.00^{a}	27.00^{efg}
FARA KANO	6.67^{abc}	7.03^{b}	9.67^{bcd}	12.67^{lmn}	83.00^{op}	168.30^{e-j}	168.30^{e-j}	15.33^{a-e}	28.10^{d-i}	1067.00^{a-e}	633.30^{a-d}	34.67^{b}
KAURA KADUNA 3	7.03^{ab}	7.03^{b}	10.67^{a-d}	17.01^{a-h}	121.33^{a}	113.30^{m}	113.30^{m}	2.00^{h}	25.77^{e-i}	233.30^{g}	200.00^{de}	27.33^{ef}
YALA JIGAWA	7.10^{ab}	7.03^{b}	10.33^{a-d}	14.03^{g-m}	106.67^{f}	213.30^{bcd}	213.30^{bcd}	16.67^{abc}	31.93^{b-h}	1000.00^{a-e}	200.00^{de}	10.33^{r}
FARA BORNO	7.10^{ab}	7.03^{b}	12.33^{a}	14.67^{em}	95.33^{jkl}	183.30^{c-i}	183.30^{c-i}	15.33^{a-e}	34.37^{b-h}	1167.00^{a-d}	666.70^{a-d}	30.00^{cd}
KAURA ZUNAINUWA	6.67^{abc}	7.03^{b}	12.33^{a}	13.03^{j-n}	101.33^{i}	160.00^{f-l}	160.00^{f-l}	10.67^{a-h}	43.67^{ab}	1000.00^{a-e}	600.00^{a-d}	27.67^{def}
BURULU BORNO	6.67^{abc}	7.03^{b}	12.00^{ba}	11.33^{n}	117.67^{bc}	206.70^{b-e}	206.70^{be}	4.00^{gh}	13.40^{j}	533.30^{d-g}	366.70^{b-e}	18.00^{op}
KAURA MAIGUDUNA	6.67^{abc}	7.03^{b}	11.33^{abc}	16.01^{b-j}	96.67^{j}	208.30^{b-e}	208.30^{be}	6.67^{d-h}	37.33^{a-e}	866.70^{a-g}	100.00^{e}	17.67^{op}
RIBX 98-78	7.03^{ab}	7.03^{b}	10.67^{a-d}	12.33^{mn}	101.67^{i}	143.30^{i-m}	143.30^{i-m}	12.00^{a-g}	35.00^{b-g}	666.70^{c-g}	533.30^{a-e}	20.33^{mn}
KAURA BORNO	7.10^{ab}	7.03^{b}	10.33^{a-d}	16.67^{a-i}	85.67^{no}	135.00^{j-m}	133.67^{j-m}	9.00^{b-h}	22.07^{hij}	1133.00^{a-e}	533.30^{a-e}	23.67^{ijk}
SSV 2006008X	7.10^{ab}	7.03^{b}	10.67^{a-d}	13.67^{h-n}	93.33^{klm}	148.30^{h-m}	148.33^{h-m}	8.33^{b-h}	36.13^{a-f}	900.00^{a-f}	500.00^{a-e}	20.67^{lmn}
SAWIYA INUWA	7.01^{ab}	7.01^{b}	12.33^{a}	13.03^{j-n}	100.67^{i}	161.70^{f-k}	161.70^{f-k}	10.00^{a-h}	35.40^{b-g}	900.00^{a-f}	666.70^{a-d}	27.00^{efg}
KASHU PARAM	6.67^{abc}	7.01^{b}	12.00^{ab}	18.33^{a-d}	102.00^{hi}	296.70^{a}	296.70^{ab}	11.00^{a-h}	47.43^{a}	833.30^{a-g}	433.30^{a-e}	25.33^{f-j}
KAURA KADUNA 1	5.67^{bc}	7.01^{b}	11.00^{abc}	15.67^{b-k}	113.33^{de}	116.70^{lm}	116.70^{lm}	4.67^{e-h}	39.00^{a-d}	333.30^{fg}	316.70^{b-e}	23.67^{ijk}
IS 17562	7.01^{ab}	7.01^{b}	9.67^{bcd}	15.33^{c-l}	88.00^{n}	136.70^{j-m}	136.70^{j-m}	12.67^{a-g}	25.83^{e-h}	900.00^{a-f}	433.30^{a-e}	16.67^{pq}
FARA KADUNA	7.03^{ab}	7.01^{b}	9.67^{bcd}	16.01^{b-j}	103.33^{ghi}	226.70^{bc}	226.70^{bc}	14.33^{a-f}	29.40^{d-h}	1167.00^{a-d}	500.00^{a-e}	27.67^{def}
FARA BAUCHI 2	7.03^{ab}	7.33^{ab}	10.00^{a-d}	18.33^{a-d}	101.33^{i}	215.00^{bcd}	215.00^{bcd}	16.67^{abc}	32.03^{b-h}	1267.00^{abc}	766.90^{ab}	26.33^{e-h}

Table 4.2b, continues

GENOTYPES	N/Leaves at 28DAS		N/Leaves at 80DAS		50%DH	Plant height(cm)		NPH	PAL(cm)	PAW(cm)	GRW(g)	1000GRW(g)
	FD	SCR	FD	SCR		FD	SCR					
NRL-1	6.67^{abc}	7.01^{b}	12.00^{ab}	17.03^{a-g}	102.00^{hi}	145.00^{i-m}	145.00^{i-m}	18.00^{ab}	30.37^{d-h}	1333.00^{abc}	766.90^{ab}	20.67^{lmn}
SSV 20041-W	6.67^{abc}	7.03^{b}	10.00^{a-d}	11.33^{n}	114.33^{de}	150.00^{g-m}	150.00^{g-m}	6.67^{d-h}	31.33^{d-h}	466.70^{efg}	333.30^{b-e}	19.00^{no}
FARA BAUCHI 1	6.67^{abc}	7.33^{ab}	10.33^{a-d}	17.67^{a-f}	96.67^{j}	221.10^{bc}	221.10^{bc}	16.67^{abc}	32.03^{b-h}	1367.00^{ab}	466.70^{a-e}	14.67^{q}
KAURA KADUNA 2	7.03^{ab}	7.01^{b}	11.33^{abc}	15.01^{d-l}	115.67^{cd}	111.70^{m}	111.70^{m}	7.33^{d-h}	24.67^{f-i}	766.70^{b-g}	433.00^{a-e}	22.67^{klm}
DALWANDA	7.10^{ab}	7.01^{b}	11.33^{abc}	15.33^{c-l}	95.67^{jkl}	176.70^{e-j}	176.70^{e-j}	18.67^{a}	26.77^{d-i}	1000.00^{a-e}	666.70^{a-d}	23.67^{ijk}
GWAJAMAI	7.10^{ab}	7.01^{b}	11.00^{abc}	14.67^{e-m}	95.33^{jkl}	210.00^{b-e}	210.00^{b-e}	5.67^{e-h}	28.47^{d-i}	566.70^{d-g}	266.70^{cde}	43.67^{a}
GIZO 1	5.67^{bc}	7.01^{b}	12.00^{ab}	20.03^{a}	113.33^{de}	116.70^{lm}	116.70^{lm}	12.67^{a-g}	30.67^{d-h}	900.00^{a-f}	700.00^{abc}	24.00^{h-k}
TWIN SEEDED	7.10^{ab}	7.01^{b}	11.00^{abc}	19.67^{a}	105.33^{fgh}	226.70^{bc}	226.70^{bc}	15.67^{a-e}	28.23^{d-i}	1167.00^{a-d}	333.30^{b-e}	24.67^{g-k}
SSV 2009	7.03^{abc}	7.01^{b}	10.67^{a-d}	17.33^{a-g}	105.67^{fg}	230.00^{b}	230.00^{b}	11.67^{a-g}	37.67^{a-e}	1467.00^{a}	866.90^{a}	26.33^{e-h}
FARA BAUCHI 3	7.23^{ab}	7.01^{b}	10.00^{a-d}	16.67^{a-i}	97.67^{j}	151.70^{g-m}	151.70^{g-m}	11.00^{a-h}	33.33^{b-h}	766.70^{b-g}	366.70^{b-e}	26.67^{efg}
MACEDAKUYA	7.23^{ab}	7.01^{b}	10.00^{a-d}	14.03^{g-m}	112.67^{de}	198.30^{b-f}	198.30^{b-f}	14.00^{a-f}	32.37^{b-h}	966.70^{a-f}	500.00^{a-e}	25.33^{f-j}
JARDAWA	7.01^{abc}	7.01^{b}	11.23^{abc}	14.33^{f-m}	119.33^{ab}	223.30^{bc}	223.30^{bc}	10.33^{a-h}	16.70^{ij}	533.30^{d-g}	366.70^{b-e}	22.67^{klm}
GIZO-2	5.67^{bc}	7.01^{b}	10.67^{a-d}	13.33^{i-n}	102.67^{ghi}	205.00^{b-e}	205.00^{be}	8.67^{b-h}	43.67^{ab}	800.00^{a-g}	266.70^{cde}	25.67^{e-i}
GARAU-2	6.67^{abc}	7.01^{b}	10.33^{a-d}	14.03^{g-m}	104.00^{f-i}	188.30^{b-g}	188.30^{b-g}	12.67^{a-g}	34.01^{b-h}	933.30^{af}	633.30^{a-d}	28.33^{de}
KASTAL	6.67^{abc}	7.01^{b}	9.33^{cd}	15.33^{c-l}	102.67^{ghi}	231.70^{b}	231.70^{b}	18.33^{ab}	34.20^{b-h}	1067.00^{a-e}	666.70^{a-d}	28.03^{de}
YARDANGARKO	7.01^{abc}	7.01^{b}	8.33^{d}	14.33^{f-m}	76.67^{r}	150.00^{g-m}	150.00^{g-m}	14.01^{a-f}	26.67^{e-i}	733.30^{b-g}	400.00^{b-e}	31.33^{c}
NRL-3	6.67^{abc}	7.01^{b}	10.67^{a-d}	12.33^{mn}	102.67^{ghi}	136.70^{i-m}	136.70^{i-m}	15.67^{a-e}	28.03^{d-i}	1200.00^{a-d}	733.30^{abc}	27.33^{ef}
KSV 4	6.33^{abc}	7.01^{b}	8.33^{d}	16.67$^{a\ldots i}$	87.33^{n}	175.00^{e-j}	203.00^{cde}	20.33^{a}	29.53^{d-h}	666.70^{c-g}	266.70^{cde}	23.67^{ijk}
SRN 39	5.33^{c}	7.01^{b}	10.03^{a-d}	12.33^{mn}	79.33^{qr}	130.00^{klm}	130.00^{klm}	19.67^{a}	26.77^{e-i}	933.30^{a-f}	533.30^{a-e}	23.33^{ijk}
ICSR 94405	5.67^{bc}	7.01^{b}	9.67^{bcd}	14.33$^{f\ldots m}$	87.00^{n}	193.30^{b-g}	193.30^{b-g}	18.33^{ab}	23.77^{g-j}	1033.00^{a-e}	633.30^{a-d}	23.33^{ijk}
ICSR 94407	5.67^{bc}	7.01^{b}	10.33^{a-d}	14.03$^{g\ldots m}$	80.67^{pq}	145.00^{i-m}	145.00^{i-m}	17.67^{ab}	25.47^{e-i}	966.70^{a-f}	566.70^{a-d}	23.33^{ijk}
Mean	6.29	7.09	10.69	15.04	100.35	177.13	173.41	12.95	30.95	920.93	514.34	24.71

FD=Field data, SCR=Screen house data, 50% DH=Days taken 50% to head, NPH=Number of Panicles harvested per plot, PaL=Panicle length (cm), GrW=Grain weight (g), 1000GW=1000 grain weight (g),DAS=Days after sowing.

- 42 with height of 320.30cm and the shortest was Kaura Kaduna 2 with mean height of 111.70cm whereas SAMSORG-17,SAMSORG-44,RIBX 98-78,Kaura Borno, SSV 2006008X and SSV 20041-W were among the medium height genotypes both on the field and screen house.As for the screen house the tallest was also SAMSORG - 42 with mean height of 300.33cm and the shortest Kaura Kaduna 2 with mean of 111.70cm (Table 4.2b).

4.2.5 Number of panicle harvested per plot.

The overall mean value for number of panicle harvested per plot was 13.02 and it ranged from 19.33 for SAMSORG -14, which was not significantly different from the two susceptible checks (KSV 4 and SRN 39) to 2.00 for Kaura Kaduna 3.

4.2.6 Panicle length (PaL)

The overall average value for Panicle length was 31.20, the mean ranged from 47.43cm in Kashu Param to 13.40cm in Burulu Borno.

4.2.7 Panicle weight (PaW)

The panicle weight has an overall mean of 932.17g and it ranged from 1467g for SAMSORG – 14 which has long panicle based on it description to 233.33g for Kaura Kaduna 3 with robust but short panicle.

4.2.8 Grain weight (GrW)

The mean grain weight value ranged from 900g for SAMSORG -14 to 100.00g for Kaura Maiguduna.

4.2.9 1000 Grain weight

All the sorghum tested have the average mean of 24.70g while their individual 1000 grain weight ranged from 43.67g for Gwajamai which were bigger and heavier than the grains of the checks, to 10.33g for Yala Jigawa which according to it description it has a medium size seeds.(Table 4.2b).

4.3 Correlation

The phenotypic and genotypic correlations are presented in Table 4.3a. Days to 50% heading had a highly significant positive genetic correlation with number of leave per plant at 80 DAS and negative significant genetic correlation with Panicle weight, and number of Panicles harvested per plot (r= 0.63, –0.51, and – 0.64 respectively) and positive phenotypic correlation with Striga shoot count at 50 DAS(r=0.41). Significant positive genetic correlation was also found between Striga shoots count at 50DAS, 60DAS, 70DAS, 80DAS, number of leaves at 20DAS and SDS (r=0.95,1.00,0.71,0.61,0.65) but no significant phenotypic correlation between them. There were highly significant genetic correlation between Striga count at 60DAS with Striga shoots count at 70DAS,80DAS,Number of leaves at 28DAS,number of leaves at 80DAS,Panicle weight, Panicle length, Grain weight and Striga damage score (r= 1.00, 1.00, 1.00,1.00, 0.61,0.48,0.91 and 1.00, respectively). Striga shoot count at 60DAS also showed highly significant phenotypic correlation ($P \leq 0.01$) with Striga shoot count at 70DAS,Panicle weight and Plant height (r=0.89, 0.54, and 0.77)

Panicle weight had a significant genetic correlation with Plant height,number of panicles

harvested per plot and Grain weight (r= 0.55,0.60 and 0.76respectively.Striga shoots count at 50 DAS also showed a highly significant phenotypic correlation with Striga shoots count at 60 DAS, 70DAS, Panicle weight and Plant height (r=0.85,0.78, 0.56 and 0.84 respectively).

Table 4.3a; Correlation coefficients between Striga related traits and some sorghumagronomic traits studied in the field.

		50%DH	50DAS	60DAS	70DAS	80DAS	28NL	80NL	PaW	PH	PaL	NPH	GW	TGW	SDS
	P	1.00	0.04*	0.02	0.06	-0.01	-0.04	-0.15	-0.05	-0.09	0.12	-0.03	0.10	0.03	-0.02
50%DH	G		0.16	0.43	0.22	0.02	-0.26	0.63**	-0.51	0.08	-0.02	-0.64	-0.22	-0.22	-0.01
	P		1.00	0.85**	0.78**	0.25	0.00	0.13	0.56*	0.84**	0.28	0.15	0.19	0.03	0.17
50DAS	G			1.00**	0.84**	1.00**	1.00**	0.74**	0.32	0.31	0.26	-0.05	0.46*	0.01	0.95**
	P			1.00	0.89**	0.22	-0.04	0.17	0.54*	0.77**	0.14	0.30	0.34	0.18	-0.07
60DAS	G				1.00**	1.00**	1.00**	1.00**	0.61**	0.39	0.48*	-0.08	0.91**	0.03	1.00**
	P				1.00	0.19	0.12	0.34	0.32	0.22	0.14	0.26	0.47*	0.17	-0.07
70DAS	G					0.92**	0.76**	0.53*	0.17	0.22	0.07	-0.12	0.35	-0.01	0.71**
	P					1.00	0.15	0.16	0.52*	0.13	0.16	0.12	0.62**	0.09	-0.07
80DAS	G						0.05	0.56*	0.38	0.29	0.21	0.03	0.34	0.09	0.61**
	P						1.00	-0.04	0.28	0.52*	0.30	0.08	-0.01	-0.06	-0.10
28NL	G							-0.52	-0.67	0.87	0.23	0.21	0.07	0.39	0.65**
	P							1.00	0.34	0.12	0.02	0.13	0.29	0.16	0.00
80NL	G								-0.16	-0.14	0.30	-0.70	0.30	-0.03	0.28
	P								1.00	0.29	0.03	0.01	0.02	-0.02	-0.09
PaW	G									0.55*	0.09	0.60**	0.76**	0.04	-0.02
	P									1.00	0.02	0.26	0.33	0.16	0.10
PH	G										0.25	0.14	-0.14	0.08	0.08
	P										1.00	0.03	0.19	0.17	0.12
PaL	G											-0.13	0.09	0.15	0.13
	P											1.00	0.59*	-0.03	0.12
NPH	G												0.59**	-0.03	0.12
	P												1.00	0.37	0.02
GW	G													0.37	0.01
	P													1.00	0.01
TGW	G														-0.01
	P														1.00
SDS	G														

P =phenotypic correlation, G = genetic correlation,50DH=days taken 50% to head, 50DAS= Striga shootscount at 50 days after sowing60DAS=Striga shoots count at 60 days after sowing,70DAS=Striga shoots count at 70 days after sowing,80DAS=Striga shootscount at 80 days after sowing, 28NL=number of leaves at 28days after sowing, 80NL=number of leaves at 80 days after sowing, PaW=Panicle weight, PH=Plantheight, PL=Panicle length, NPH=Number of panicle harvested per plot,GW= Grain weight, TGW= 1000 grain weight, SDS= Striga damage scores. **significance $P \leq 0.01$,* $p \leq 0.05$

For the screen house experiment,Striga shoot count at 50DAS showed highly significant phenotypic correlation($p \leq 0.01$) with Striga shootscount at 60DAS,70DAS, the Striga subterranean count and number of leaves at 28DAS (r=0.87, 0.73, 0.82 and 0.53 respectively). There was also highly genetic significant correlation between Striga shoots count at 50 DAS,60DAS, 70DAS, 80DAS,Striga subterranean count and Plant height with Striga damage score (r=0.69,0.79,0.82,0.75and 0.86 respectively). Striga shoots count at 70 DAS showed a high genotypic significant correlation with Striga counts shoots at 80DAS,Striga subterranean count and Striga damage score (R=0.99,1.00 and 0.82).striga shoots count also showed significant phenotypic correlation with Striga subterranean count,number of leaves at 28DAS and number of leaves at 80DAS. Number of leaves at 28 DAS was also found to have highly significant phenotypic correlation with Striga shoots count at 50DAS,60DAS, 70DAS,and subterranean Striga count (r=0.53,0.51,0.44 and 0.63 respectively) but It (number of leaves at 28DAS) had significant genetic correlation with subterranean Striga count only(r=0.36) (Table 4.3b)

Table 4.3b;Correlation coefficients between Striga related traits and some sorghum agronomic traits in the screen house.

	P/G	50DAS	60DAS	70DAS	80DAS	SSC	28NL	80NL	PH	SDS
	P	1.00	0.87**	0.73**	0.34	0.82**	0.53**	-0.05	0.10	0.05
50DAS	G		1.00**	1.00**	1.00**	0.82**	0.14	0.16	0.15	0.69**
	P		1.00	0.81**	0.41	0.73**	0.51*	-0.06	0.10	0.06
60DAS	G			0.99**	0.99**	0.99**	0.05	0.11	0.06	0.79**
	P			1.00	0.19	0.60**	0.44*	0.41*	0.11	0.07
70DAS	G				0.99**	1.00**	0.15	0.11	0.09	0.82**
	P				1.00	0.27	0.26	-0.05	0.11	0.07
80DAS	G					1.00**	0.15	0.17	0.08	0.69**
	P					1.00	0.63**	0.81	0.09	0.04
SSC	G						0.36*	0.22	0.12	0.75**
	P						1.00	0.87**	0.12	0.11
28NL	G							0.24	-0.17	0.30
	P							1.00	-0.14	-0.09
80NL	G								0.31	-0.05
	P								1.00	0.86**
PH	G									-0.07
	P									1.00
SDS	G									

50DAS=Striga shoots count at 50 days after sowing, PH=Plant height

60DAS= Striga shoots count at 60 days after sowing, SDS = Striga damage score.

70DAS= Striga shoots count at 70 days after sowing , P=Phenotypic correlation

80DAS= Striga shoots count at 50 days after sowing , G=Genotypic correlation

SSC=Striga subterranean counts, 80NL=Number of leaves at 80 days after sowing

28NL=Number of leaves at 28 days, ** significance at $p \leq 0.01$, * $p \leq 0.05$

4.4 Genetic Distance

The estimated genetic interval of the genotypes tested in the field and screen are presented in Table 4.4a and 4.4b respectively. In the field, the pairwise genetic distance estimated for all the sorghums used in this study ranged from 4.80 for Gwajamai and SAMSORG- 43 to a maximum of 168.78 between BuruluBorno and Dalwanda with other 38 Genotypes (Fara 1 Bauchi, Fara 2 Bauchi, Fara 3 Bauchi, FaraBorno, Fara Kaduna, Fara Kano, Garau 2, Gizo 1, Gizo 2, ICSR 94407,IS 17562, Jardawa, KashuParam, Kastal, KauraBorno,Kaura Kaduna 1, Kaura Kaduna 2, Kaura Kaduna 3, KauraMaiguduna, KauraZunaInuwa, Macedakuya,, NRL – 1, NRL 3, RIBX 98 – 78, SAMSORG - 14, SAMSORG - 40, SAMSORG - 42, SAMSORG - 43, SAMSORG - 44, SawiyaInuwa, SSV20041-W, SSV2006008X, SSV2009, SRN 39, Twin seeded, YalaJigawa and Yandargako. On the other hand for the screen house experiment, the genetic distance ranges from 1.14 for Twin seeded and Fara 2 Bauchi to 22.15 for BuruluBorno and FaraBauchi 2 which included 12 other genotypes (FaraBorno, Fara Kaduna, Garau 2, Gizo 2, Gwajama, ICSR94405, Kastal, KauraMaiguduna, KauraZunaInuwa, SSV2009, Twin seeded and YalaJigawa). The highest distance (22.15) was found between Fara Kaduna and Fara Kano with twenty five other. In other words the highest distance was found within most of these genotypes, they are not genetically close.

4.5 Cluster analysis

The clustering analysis for field and screen house experiments were recorded in Table 4.3b and Table 4.3a respectively. All the genotypes were clustered into three based on their mean performances in the field and the screen house.

Table 4.4a; Genetic distance (cm) of the 43 genotypes used in the field experiment

	100	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	1100	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	2100	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	3100	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	4100	42.00
2.00	168.78																																										
3.00	168.78	123.55																																									
4.00	168.78	42.01	123.55																																								
5.00	168.78	123.55	78.57	123.55																																								
6.00	168.78	79.96	123.55	79.96	123.55																																						
7.00	168.78	50.62	123.55	50.62	123.55	79.96																																					
8.00	168.78	123.55	109.09	123.55	109.09	123.55	123.55																																				
9.00	168.78	123.55	44.93	123.55	78.57	123.55	123.55	109.09																																			
10.00	168.78	79.96	123.55	79.96	123.55	19.80	79.96	123.55	123.55																																		
11.00	168.78	50.62	123.55	50.62	123.55	79.96	17.39	123.55	123.55	79.96																																	
12.00	168.78	123.55	78.57	123.55	54.91	123.55	123.55	109.09	78.57	123.55	123.55																																
13.00	168.78	123.55	36.01	123.55	78.57	123.55	123.55	109.09	44.93	123.55	123.55	78.57																															
14.00	168.78	123.55	78.57	123.55	45.14	123.55	123.55	109.09	78.57	123.55	123.55	54.91	78.57																														
15.00	91.62	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78																													
16.00	168.78	21.91	123.55	42.01	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78																												
17.00	168.78	50.62	123.55	50.62	123.55	79.96	33.90	123.55	123.55	79.96	33.90	123.55	123.55	123.55	168.78	50.62																											
18.00	168.78	42.01	123.55	23.63	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78	42.01	50.62																										
19.00	168.78	123.55	109.09	123.55	109.09	123.55	123.55	37.49	109.09	123.55	123.55	109.09	109.09	109.09	168.78	123.55	123.55	123.55																									
20.00	168.78	21.91	123.55	42.01	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78	16.75	50.62	42.01	123.55																								
21.00	168.78	72.12	123.55	72.12	123.55	79.96	72.12	123.55	123.55	79.96	72.12	123.55	123.55	123.55	168.78	72.12	72.12	72.12	123.55	72.12																							
22.00	168.78	123.55	78.57	123.55	24.80	123.55	123.55	109.09	78.57	123.55	123.55	54.91	78.57	45.14	168.78	123.55	123.55	123.55	109.09	123.55	123.55																						
23.00	168.78	79.96	123.55	79.96	123.55	40.18	79.96	123.55	123.55	40.18	79.96	123.55	123.55	123.55	168.78	79.96	79.96	79.96	123.55	79.96	79.96	123.55																					
24.00	168.78	123.55	78.57	123.55	54.91	123.55	123.55	109.09	78.57	123.55	123.55	24.42	78.57	54.91	168.78	123.55	123.55	123.55	109.09	123.55	123.55	54.91	123.55																				
25.00	45.96	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	91.62	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78																			
26.00	168.78	123.55	78.57	123.55	33.15	123.55	123.55	109.09	78.57	123.55	123.55	54.91	78.57	45.14	168.78	123.55	123.55	123.55	109.09	123.55	123.55	33.15	123.55	54.91	168.78																		
27.00	168.78	50.62	123.55	50.62	123.55	79.96	15.53	123.55	123.55	79.96	17.39	123.55	123.55	123.55	168.78	50.62	33.90	50.62	123.55	50.62	72.12	123.55	79.96	123.55	168.78	123.55																	
28.00	168.78	123.55	78.57	123.55	54.91	123.55	123.55	109.09	78.57	123.55	123.55	29.23	78.57	54.91	168.78	123.55	123.55	123.55	109.09	123.55	123.55	54.91	123.55	29.23	168.78	54.91	123.55																
29.00	168.78	50.62	123.55	50.62	123.55	79.96	33.90	123.55	123.55	79.96	33.90	123.55	123.55	123.55	168.78	50.62	19.63	50.62	123.55	50.62	72.12	123.55	79.96	123.55	168.78	123.55	33.90	123.55															
30.00	168.78	72.12	123.55	72.12	123.55	79.96	72.12	123.55	123.55	79.96	72.12	123.55	123.55	123.55	168.78	72.12	72.12	72.12	123.55	72.12	40.44	123.55	79.96	123.55	168.78	123.55	72.12	123.55	72.12														
31.00	91.62	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	42.54	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	168.78	91.62	168.78	168.78	168.78	168.78	168.78												
32.00	168.78	123.55	78.57	123.55	33.15	123.55	123.55	109.09	78.57	123.55	123.55	54.91	78.57	45.14	168.78	123.55	123.55	123.55	109.09	123.55	123.55	33.15	123.55	54.91	168.78	18.66	123.55	54.91	123.55	123.55	168.78											
33.00	168.78	14.29	123.55	42.01	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78	21.91	50.62	42.01	123.55	21.91	72.12	123.55	79.96	123.55	168.78	123.55	50.62	123.55	50.62	72.12	168.78	123.55										
34.00	168.78	123.55	78.57	123.55	54.91	123.55	123.55	109.09	78.57	123.55	123.55	4.80	78.57	54.91	168.78	123.55	123.55	123.55	109.09	123.55	123.55	54.91	123.55	24.42	168.78	54.91	123.55	29.23	123.55	123.55	168.78	54.91	123.55									
35.00	168.78	123.55	21.55	123.55	78.57	123.55	123.55	109.09	44.93	123.55	123.55	78.57	36.01	78.57	168.78	123.55	123.55	123.55	109.09	123.55	123.55	78.57	123.55	78.57	168.78	78.57	123.55	78.57	123.55	123.55	168.78	78.57	123.55	78.57								
36.00	168.78	50.62	123.55	50.62	123.55	79.96	33.90	123.55	123.55	79.96	33.90	123.55	123.55	123.55	168.78	50.62	13.23	50.62	123.55	50.62	72.12	123.55	79.96	123.55	168.78	123.55	33.90	123.55	19.63	72.12	168.78	123.55	50.62	123.55	123.55							
37.00	168.78	50.62	123.55	50.62	123.55	79.96	20.94	123.55	123.55	79.96	20.94	123.55	123.55	123.55	168.78	50.62	33.90	50.62	123.55	50.62	72.12	123.55	79.96	123.55	168.78	123.55	20.94	123.55	33.90	72.12	168.78	123.55	50.62	123.55	123.55	33.90						
38.00	168.78	123.55	78.57	123.55	33.15	123.55	123.55	109.09	78.57	123.55	123.55	54.91	78.57	45.14	168.78	123.55	123.55	123.55	109.09	123.55	123.55	33.15	123.55	54.91	168.78	18.66	123.55	54.91	123.55	123.55	168.78	12.74	123.55	54.91	78.57	123.55	123.55					
39.00	168.78	79.96	123.55	79.96	123.55	26.99	79.96	123.55	123.55	26.99	79.96	123.55	123.55	123.55	168.78	79.96	79.96	79.96	123.55	79.96	79.96	123.55	40.18	123.55	168.78	123.55	79.96	123.55	79.96	79.96	168.78	123.55	79.96	123.55	123.55	79.96	79.96	123.55				
40.00	168.78	23.67	123.55	42.01	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78	23.67	50.62	42.01	123.55	23.67	72.12	123.55	79.96	123.55	168.78	123.55	50.62	123.55	50.62	72.12	168.78	123.55	23.67	123.55	123.55	50.62	50.62	123.55	79.96			
41.00	168.78	23.67	123.55	42.01	123.55	79.96	50.62	123.55	123.55	79.96	50.62	123.55	123.55	123.55	168.78	23.67	50.62	42.01	123.55	23.67	72.12	123.55	79.96	123.55	168.78	123.55	50.62	123.55	50.62	72.12	168.78	123.55	23.67	123.55	123.55	50.62	50.62	123.55	79.96	12.04		
42.00	168.78	50.62	123.55	50.62	123.55	79.96	10.64	123.55	123.55	79.96	17.39	123.55	123.55	123.55	168.78	50.62	33.90	50.62	123.55	50.62	72.12	123.55	79.96	123.55	168.78	123.55	15.53	123.55	33.90	72.12	168.78	123.55	50.62	123.55	123.55	33.90	20.94	123.55	79.96	50.62	50.62	
43.00	168.78	79.96	123.55	79.96	123.55	40.18	79.96	123.55	123.55	40.18	79.96	123.55	123.55	123.55	168.78	79.96	79.96	79.96	123.55	79.96	79.96	123.55	23.50	123.55	168.78	123.55	79.96	123.55	79.96	79.96	168.78	123.55	79.96	123.55	123.55	79.96	79.96	123.55	40.18	79.96	79.96	79.96

1=BURULU BORNO, 2=DALWANDA, 3.=FARA 1 BAUCHI, 4=FARA3BAUCHI, 5.=FARA BAUCHI2,6=FARA BORNO, 7.=FARA KADUNA,8=FARA KANO, 9=GARAU 2, 10.=GIZO 1; 11=GIZO 2; 12=GWAJAMAI 13=ICSR94407; 14=IS17562; 15=ICSR94405; 16=JARDAWA; 17=KASHUPARAM; 18=KASTAL 19=KAURABORNO; 20=KAURA KADUNA 1; 21=KAURA KADUNA 2; 22=KAURAKADUNA3; 23=KAURA MAIGUDUNA; 24 =KAURA ZUNAINUWA; 25 =KSV 4; 26=MACEDAKUYA; 27=NRL-1; 28=NRL-3; 29 =RIBX 98-78; 30=SAMSORG -14; 31=SAMSORG -17; 32.=SAMSORG -40; 33=SAMSORG-42; 34=SAMSORG -43; 35=SAMSORG- 44; 36=SAWIYA INUWA; 37=SRN 39; 38=SSV 20041-W; 39=SSV2006008X 40=SSV 2009; 41=TWIN SEEDED; 42=YALA JIGAWA; 43=YARDANGARKO.

Table 4.4b; Genetic distance (cm) of the 43 sorghum genotypes used in the screen house experiment

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00
2.00	5.18																																										
3.00	3.04	5.18																																									
4.00	14.24	14.24	14.24																																								
5.00	22.15	22.15	22.15	22.15																																								
6.00	22.15	22.15	22.15	22.15	9.11																																						
7.00	22.15	22.15	22.15	22.15	5.81	9.11																																					
8.00	5.14	5.18	5.14	14.24	22.15	22.15	22.15																																				
9.00	22.15	22.15	22.15	22.15	9.11	3.90	9.11	22.15																																			
10.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15																																		
11.00	22.15	22.15	22.15	22.15	9.11	4.15	9.11	22.15	4.15	22.15																																	
12.00	22.15	22.15	22.15	22.15	5.81	9.11	1.28	22.15	9.11	22.15	9.11																																
13.00	5.18	2.69	5.18	14.24	22.15	22.15	22.15	5.18	22.15	6.99	22.15	22.15																															
14.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24																														
15.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	2.55	22.15	22.15	6.99	14.24																														
16.00	22.15	22.15	22.15	22.15	9.11	2.37	9.11	22.15	3.90	22.15	4.15	9.11	22.15	22.15	22.15																														
17.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	2.55	22.15	22.15	6.99	14.24	1.97	22.15																													
18.00	22.15	22.15	22.15	22.15	3.52	9.11	5.81	22.15	9.11	22.15	9.11	5.81	22.15	22.15	22.15	9.11	22.15																												
19.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15																											
20.00	14.24	14.24	14.24	6.33	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	9.90	14.24	22.15	14.24	22.15	9.90																									
21.00	5.14	5.18	5.14	14.24	22.15	22.15	22.15	2.50	22.15	6.99	22.15	22.15	5.18	14.24	6.99	22.15	6.99	22.15	14.24	14.24																								
22.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	3.43	22.15	22.15	6.99	14.24	3.43	22.15	3.43	22.15	14.24	14.24	6.99																						
23.00	22.15	22.15	22.15	22.15	3.33	9.11	5.81	22.15	9.11	22.15	9.11	5.81	22.15	22.15	22.15	9.11	22.15	3.52	22.15	22.15	22.15	22.15																					
24.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	3.87	9.90	14.24	14.24	22.15																				
25.00	22.15	22.15	22.15	22.15	9.11	3.90	9.11	22.15	2.14	22.15	4.15	9.11	22.15	22.15	22.15	3.90	22.15	9.11	22.15	22.15	22.15	22.15	9.11	22.15																			
26.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	1.21	14.24	22.15	14.24	22.15	5.34	9.90	14.24	14.24	22.15	5.34	22.15																		
27.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	2.38	9.90	14.24	14.24	22.15	3.87	22.15	5.34																	
28.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	3.43	22.15	22.15	6.99	14.24	3.43	22.15	3.43	22.15	14.24	14.24	6.99	1.73	22.15	14.24	22.15	14.24	14.24																
29.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	3.87	9.90	14.24	14.24	22.15	2.44	22.15	5.34	3.87	14.24															
30.00	5.18	2.69	5.18	14.24	22.15	22.15	22.15	5.18	22.15	6.99	22.15	22.15	2.08	14.24	6.99	22.15	6.99	22.15	14.24	14.24	5.18	6.99	22.15	14.24	22.15	14.24	14.24	6.99	14.24														
31.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	2.38	9.90	14.24	14.24	22.15	3.87	22.15	5.34	1.76	14.24	3.87	14.24													
32.00	5.18	1.95	5.18	14.24	22.15	22.15	22.15	5.18	22.15	6.99	22.15	22.15	2.69	14.24	6.99	22.15	6.99	22.15	14.24	14.24	5.18	6.99	22.15	14.24	22.15	14.24	14.24	6.99	14.24	2.69	14.24												
33.00	5.18	2.69	5.18	14.24	22.15	22.15	22.15	5.18	22.15	6.99	22.15	22.15	0.99	14.24	6.99	22.15	6.99	22.15	14.24	14.24	5.18	6.99	22.15	14.24	22.15	14.24	14.24	6.99	14.24	2.08	14.24	2.69											
34.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	2.55	22.15	22.15	6.99	14.24	1.42	22.15	1.97	22.15	14.24	14.24	6.99	3.43	22.15	14.24	22.15	14.24	14.24	3.43	14.24	6.99	14.24	6.99	6.99										
35.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	3.43	22.15	22.15	6.99	14.24	3.43	22.15	3.43	22.15	14.24	14.24	6.99	1.19	22.15	14.24	22.15	14.24	14.24	1.73	14.24	6.99	14.24	6.99	6.99	3.43									
36.00	14.24	14.24	14.24	4.06	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	9.90	14.24	22.15	14.24	22.15	9.90	6.33	14.24	14.24	22.15	9.90	22.15	9.90	9.90	14.24	9.90	14.24	9.90	14.24	14.24	14.24	14.24								
37.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	3.78	14.24	22.15	14.24	22.15	5.34	9.90	14.24	14.24	22.15	5.34	22.15	3.78	5.34	14.24	5.34	14.24	5.34	14.24	14.24	14.24	14.24	9.90						
38.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	3.87	9.90	14.24	14.24	22.15	1.01	22.15	5.34	3.87	14.24	2.44	14.24	3.87	14.24	14.24	14.24	14.24	9.90	5.34					
39.00	6.99	6.99	6.99	14.24	22.15	22.15	22.15	6.99	22.15	2.55	22.15	22.15	6.99	14.24	1.97	22.15	1.90	22.15	14.24	14.24	6.99	3.43	22.15	14.24	22.15	14.24	14.24	3.43	14.24	6.99	14.24	6.99	6.99	1.97	3.43	14.24	14.24	14.24				
40.00	22.15	22.15	22.15	22.15	3.33	9.11	5.81	22.15	9.11	22.15	9.11	5.81	22.15	22.15	22.15	9.11	22.15	3.52	22.15	22.15	22.15	22.15	1.60	22.15	9.11	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15				
41.00	22.15	22.15	22.15	22.15	1.14	9.11	5.81	22.15	9.11	22.15	9.11	5.81	22.15	22.15	22.15	9.11	22.15	3.52	22.15	22.15	22.15	22.15	3.33	22.15	9.11	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	3.33		
42.00	22.15	22.15	22.15	22.15	9.11	4.15	9.11	22.15	4.15	22.15	1.30	9.11	22.15	22.15	22.15	4.15	22.15	9.11	22.15	22.15	22.15	22.15	9.11	22.15	4.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	22.15	9.11	9.11	
43.00	14.24	14.24	14.24	9.90	22.15	22.15	22.15	14.24	22.15	14.24	22.15	22.15	14.24	5.34	14.24	22.15	14.24	22.15	1.83	9.90	14.24	14.24	22.15	3.87	22.15	5.34	2.38	14.24	3.87	14.24	2.38	14.24	14.24	14.24	14.24	9.90	5.34	3.87	14.24	22.15	22.15	22.15

1.=BURULU BORNO, 2.=DALWANDA, 3.=FARA 1 BAUCHI, 4=FARA3BAUCHI, 5.=FARABAUCHI2,6=FARABORNO, 7.=FARA KADUNA,8.=FARA KANO, 9.=GARAU 2, 10.=GIZO 1; 11=GIZO- 2; 12.=GWAJAMAI**,**13=ICSR94407; 14.=IS17562; 15=ICSR94405; 16.=JARDAWA; 17.=KASHU PARAM; 18=KASTAL19=KAURA BORNO; 20=KAURAKADUNA1; 21=KAURAKADUNA2; 22.=KAURAKADUNA3; 23=KAURAMAIGUDUNA; 24.00=KAURA ZUNAINUWA; 25 =KSV4; 26=MACEDAKUYA; 27=NRL-1;28=NRL-3; 29=RIBX98-78; 30=SAMSORG 14; 31=SAMSORG 17; 32.=SAMSORG 40; 33=SAMSORG-42;34=SAMSORG43; 35=SAMSORG- 44; 36.00=SAWIYAINUWA; 37=SRN39; 38=SSV20041-W; 39.00=SSV200600840.=SSV 2009; 41=TWIN SEEDED; 42.=YALA JIGAWA; 43=YARDANGARKO.

Table 4.5a;Genotypes for the screen house experiment grouped into clusters

Clusters	Genotypes
1	SSV20041-W, Kaurazunainuwa, RIBX98, Yardangako, KauraBorno, SAMSORG-17, NRL-1, Macedakuya, IS17562, SRN39, Sawiya Inuwa, Fara3Bauchi, KauraKaduna1, SAMSORG- 42, ICSR94407
2	SAMSORG-14,SAMSORG-40,Dalwanda, Fara 1 Bauchi, BuruluBorno, KauraKaduna 2, FaraKano, SSV2006008X,Kashuparam,SAMSORG-43,ICSR94405,Gizo1,SAMSORG-44, Kaura Kaduna3,NRL3,SSV2009,Kaura Maiguduna,Twinseeded,Fara Bauchi2,Kastal,Gwajamai,Fara Kaduna,Jardawa
3	Kaura Borno, KSV4, YalaJigawa,Gizo 2,Fara Borno,KSV 4,Garau,YalaJigawa,

Each cluster has a distinct feature and characteristics from other genotypes in the characteristics under consideration (figure 1)

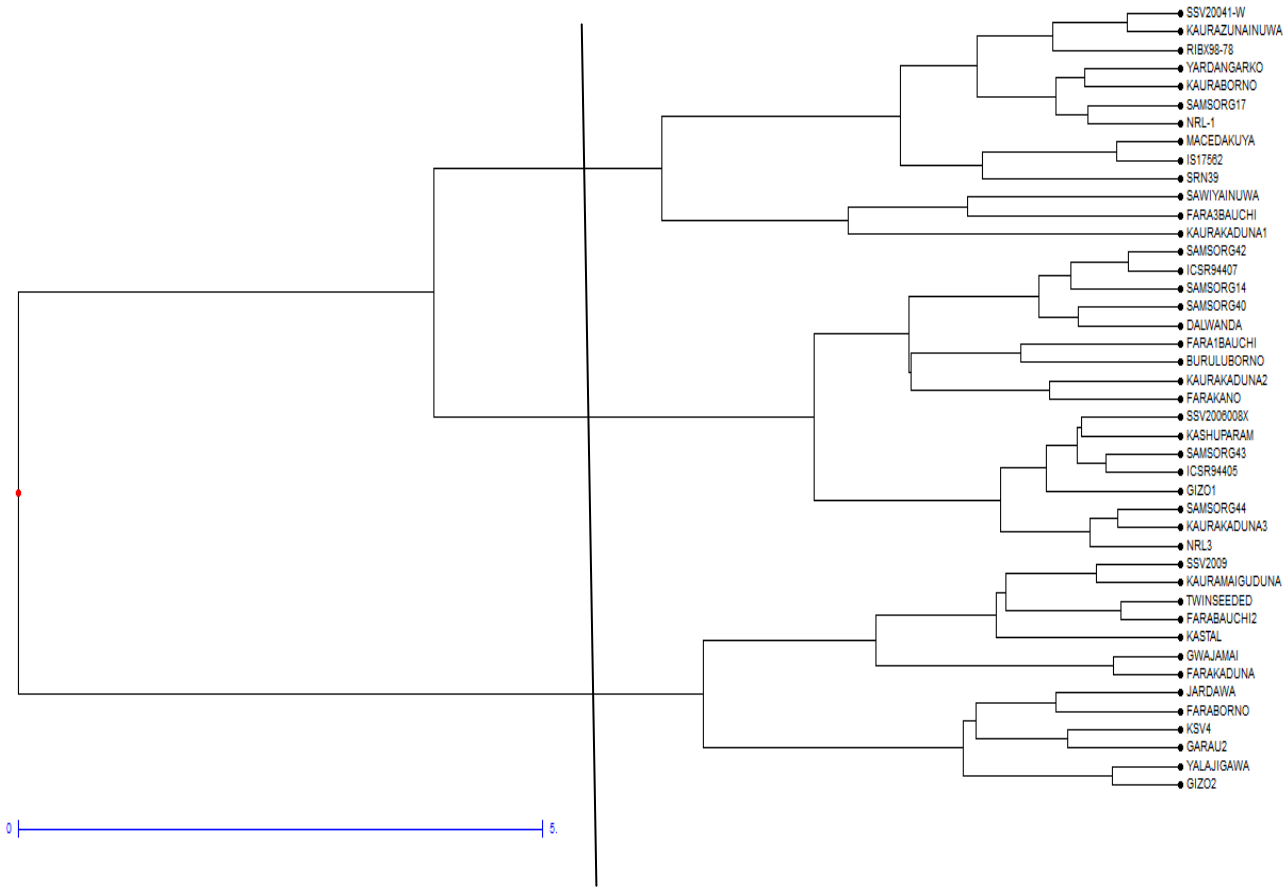


Figure 1: Dendrogram of the sorghum Genotypes clusters based on their mean performance in the screen house

Table 4.5b; Genotypes for the field experiment grouped into clusters

Cluster	Genotypes
1	Yala Jigawa, FaraKaduna,NRL1, Gizo2, SRN39, SawiyaInuwa, Kashu Param, RIBX,KauraKaduna1, Jardawa, SAMSORG-42, Dalwanda, Twinseeded, SSV2009, Kastal,Fara Bauchi 3, SAMSORG-14, Kaura Kaduna2, GIZO1, Fara Borno, SSV 2006008X, Yardagarko, Kaura Maiguduna, SSV 20041-W,Macedakuya, Kaura Kaduna3,Fara Bauchi 2,.
2	SAMSORG43, IS17562, Dalwada, Gwajamai, Kaurazunainuwa, NRL3, SAMSORG-44, Fara 1 Bauchi, ICSR94407,Garau2, Kaura Borno, Fara Kano,KSV 4, Burulu Borno,SAMSORG- 17
3	ICSR94405

Each cluster has a distinct feature and characteristics from other genotypes in the characteristics under consideration (figure 2)

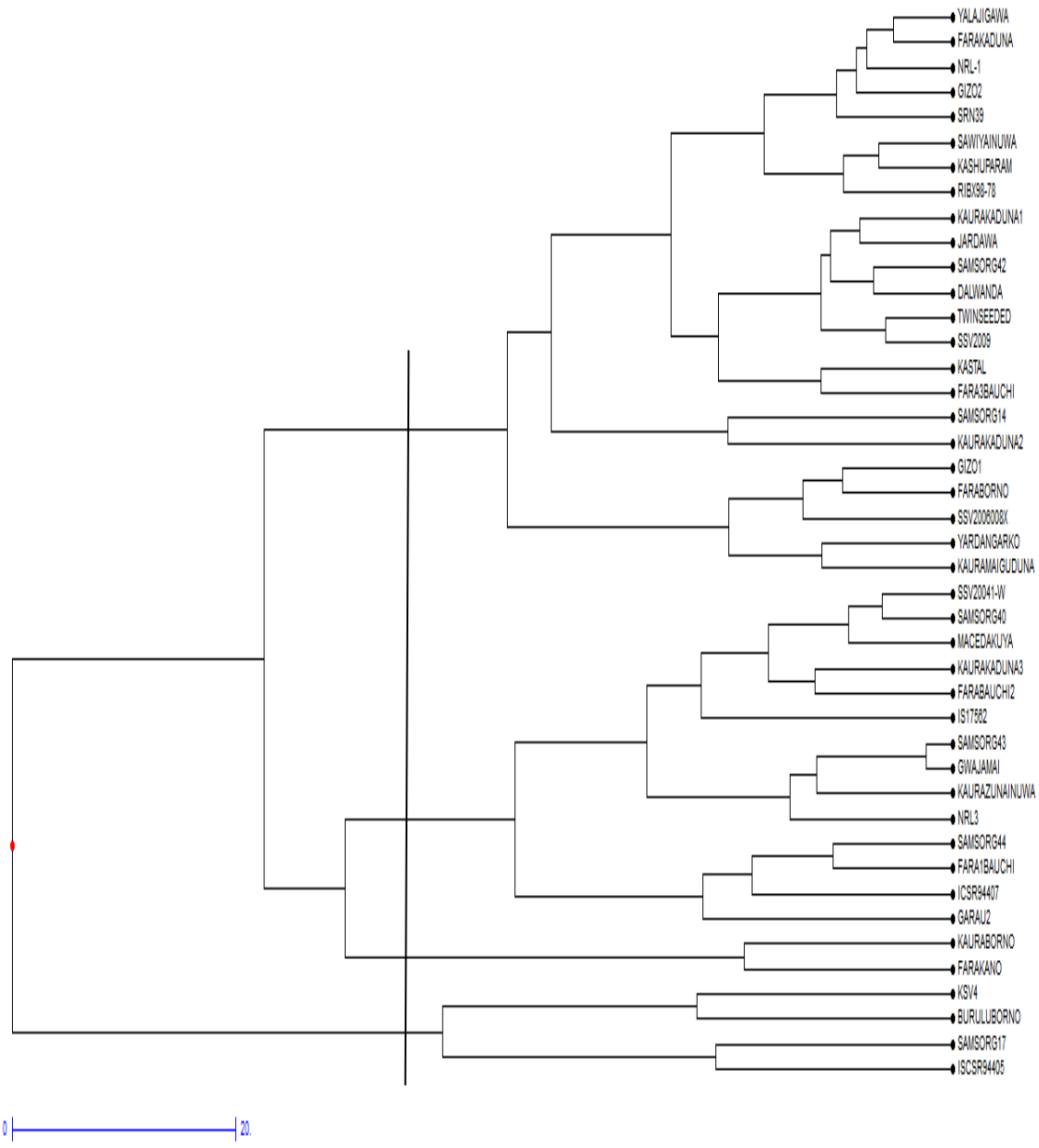


Figure 2: Dendrogram of the sorghum Genotype clusters based on their mean performance in the field

4.6 Striga damage score mean and rating

Table 4.6a showed Striga damage score means, and rating for all the genotypes used in this study. Plants with scores of 0 to 4 were considered resistant, while plants with 5 to 9 were considered susceptible (Sinebo and Drennan 2001). Kaura Maiguduna, NRL1, Gizo1, Gizo 2,Garau,Kastal and Yandargako had mean damage scores of 3.04, 4.01, 3.23, 3.33, 4.33,4.33 and 4.03 respectively for the field experiment with 3.67, 4.03, 4.03,4.33,4 03,3.33 and 4.03 for the screen house experiment. All their means were lower than that of the susceptible check KSV4 (6.01 and 6.67) and lower than SRN39 (6.67 and 8.67), so they were regarded as resistant while other genotypes had their means greater than 4.33, they were regarded as susceptible genotypes. Eight of the sorghum genotypeswere regarded as unstable probably because of the Striga virulence level in the field which could be higher than that in the screen house or the strain of the Striga had undergone mutation in the screen house.

Table 4.6;Striga Damage score mean and rating of the sorghum Genotypes

Genotypes	Damage score		Rating		Identity
	FD	SCR	FD	SCR	
SAMSORG-14	6.00	5.67	S	S	susceptible
SAMSORG-17	5.33	5.67	S	S	susceptible
SAMSORG-40	5.67	6.33	S	S	susceptible
SAMSORG-42	5.67	6.33	S	S	susceptible
SAMSORG-43	4.67	6.33	S	S	susceptible
SAMSORG-44	5.67	5.33	S	S	susceptible
FARAKANO	3.67	5.33	R	S	unstable
KAURAKADUNA3	4.67	4.67	S	S	susceptible
YALAJIGAWA	5.33	6.33	S	S	susceptible
FARABORNO	5.00	6.33	S	S	susceptible
KAURAZUNAINUWA	4.67	5.03	S	S	susceptible
BURULUBORNO	4.71	5.67	S	S	susceptible
KAURAMAIGUDUNA	3.04	3.67	R	R	resistant
RIBX98-78	3.33	5.03	R	S	unstable
KAURABORNO	4.03	5.67	R	S	unstable
SSV2006008X	5.33	4.67	S	S	susceptible
SAWIYAINUWA	4.33	6.33	S	S	susceptible
KASHUPARAM	5.00	6.33	S	S	susceptible
KAURAKADUNA1	5.67	4.67	S	S	susceptible
IS17562	6.33	3.67	S	R	unstable
FARAKADUNA	6.01	7.03	S	S	susceptible
FARABAUCHI2	6.33	7.33	S	S	susceptible
NRL-1	4.01	4.03	R	R	resistant
SSV20041-W	6.33	6.33	S	S	susceptible
FARA1BAUCHI	5.67	6.33	S	S	susceptible
KAURAKADUNA2	4.67	5.67	S	S	susceptible
DALWANDA	4.43	4.67	S	S	susceptible
GWAJAMAI	3.04	4.67	R	S	unstable
GIZO-1	3.23	4.03	R	R	resistant
TWINSEEDED	3.33	5.03	R	S	unstable
SSV2009	6.33	5.03	S	S	susceptible
FARA BAUCHI 3	4.67	4.67	S	S	susceptible
MACEDAKUYA	3.67	5.67	R	S	unstable
JARDAWA	4.67	5.33	S	S	susceptible
GIZO-2	3.33	4.33	R	R	resistant
GARAU-2	4.33	4.03	R	R	resistant
KASTAL	4.33	3.33	R	R	resistant
YARDANGARKO	4.03	4.03	R	R	resistant
NRL3	3.33	7.67	R	S	unstable
KSV 4	6.01	6.67	S	S	susceptible
SRN 39	6.67	8.67	S	S	susceptible
ICSR 94405	1.67	1.33	R	R	resistant
ICSR 94407	2.23	1.03	R	R	resistant

FD= Field data, SCR= Screen house data, R= resistant, S= susceptible

CHAPTER FIVE

5 Discussion

5.1 Analysis of variance

Highly significant mean squares were observed in all the trait tested (50% Days to Heading, Striga shoot count at 50DAS, Striga shoots count at 70DAS,Striga shoots count 80DAS, Plant height, Panicle weight, number of leaves at 80 DAS, number of panicles harvested per plot, Panicle length, grain weight, 1000grain weight and Striga damage score),indicated that there were variations among the genotypes for these traits. Simplifying variations among the genotypes this could be due to the fact that they were gotten from different locationswhich might have been affected by natural selection. This indicates that significant improvement could be achieved through selection for the traits of interest. This is in agreement with Callaham (1962) who expressed that diverse environmental condition throughout the range of any widely distributed species lead to a species with a great degree of genetic variability. These observed variations therefore; present us with a viable selection alternative at a very early stage (germplasm collection) from base seed material that could be of used in improvement programs. Jean-Baptiste*et al*., 2012) also observed the presence of genetic variability among sorghum germplasm in their response to *S. hermonthica* parasitism in pot and field experiments.

5.2 Mean performance of Agronomic traits and Yield trait

All the sorghum varieties including the checks used in this study took an average of 100 days to germinate.KauraBorno being the earliest took approximately 87 days which had no significant difference with days taken by two of the checks (KSV4 and ICSR94405). It was observed that those that had long duration of germination supported more *Striga* shoot

emergence this result agreed with Ezeaku and Gupta2004.

As at 40days after sowing both at the screen house and on the field, there was no Striga shoot emergence but by the 50days after sowing some of the genotypes had Striga shoot attached to them with SRN 39 having the highest number of Striga shoot (8). SRN 39 was known to be Striga resistant but this result showed otherwise which was also observed by Innocent (2000) which could be due to loss of SRN 39 resistance to *Striga hermonthica*, or its durable resistance on the field, or outcross contamination coupled with its undesirable traits such as low grain yield, short stature and small grain. Although Hausmann *et al.*, (2000) considered entries as resistant when they support significantly fever Striga plants but SRN 39 had more Striga plants than all other genotypes used in this study. There was a delay in Striga emergence in some of the host plant like Fara 3 Bauchi, SSV2009, Twin seeded, Gizo 1, Dalwanda, Kaura Kaduna, KSV4, Fara Kaduna Kauramaiguduna, Garau 2, Yandargako, Samsorg 17 and Samsorg 40 aside the two resistance checks (ICSR94405 and ICSR 94407).The delay could be due to reduced germination of Striga seeds, reduced haustorium initiation and attachment, which was also observed by Jean-Baptiste*et al*., (2012).

Ezeaku and Gupta (2004) pointed out that the genetic differences between Sorghum cultivars affect time of parasite attachment with tolerant varieties showing later attachment and later parasite emergence than sensitive cultivars. But as time went on by 80 days after sowing Striga plants emerged in all the susceptible genotypes. At 90DAS, the sorghum in the pots at the screen house were uprooted to count the Striga plant that were yet to shoot out but had attached themselves to the host root (subterranean Striga count) and this was

observed to be significantly correlated with the aboveground Striga shoot count at 70days after sowing which supported earlier observation by Rodenburg*et al.,* (2006). The number of Striga plants per host and their pattern of emergence differ by an order of magnitude in sorghum cultivars. These findings corroborate earlier reports on the genetics of resistance to *S.hermonthica* (Ezeaku and Gupta, 2004). Many researchers had also reported that resistance could depend on differences in virulence in Striga strains (Hess *et.al*, 1992). Several mechanisms including low germination stimulant production like sorgolactone, sorgolcone and strigol (Olivier *et.al*, 1991), reduction in successful establishment of parasitic plants on roots and reduced capacity to elicit haustorical induction of Striga, have been implicated in lowering the number of emerged striga plants. Showemimo*et al.*,(2002) as cited by Jean-Baptiste *et al* 2012 andMarley *et al.,* (2*004*) had also summarized other potential post germination mechanism of resistance that impede attachment and emergence of Striga in crops. El-Hiweris (1998) mentioned that roots of some sorghum cultivars that are tolerant to Striga have great total phenolic than those of sensitive genotypes.

At maturity most of the sorghum had stagnant growth, some were stunted, the worst was SRN 39, SawiyaInuwa, Kaura Kaduna 3, but SAMSORG -17 was better than other susceptible one even in the presence of Striga plants.This finding agreed with the earlier discovery by Showemimo and Kimbeng(2005) and Chukwu (2014) that SAMSORG-17 is a promising genotype. Makoko and Sibuga, (2003) observed shoot biomass of sorghum genotype IS6723 to be highly tolerant to *Strigaasiatica* under high infestation. They also observed that crop height as an indicator of varietal response to Striga attack did not correspond with Striga count. For instance some genotypes had very low Striga shoot count but were severely stunted (SAMSORG-42, FaraBorno, Ribx98-78, Fara Kaduna 3,

compared to others that had high Striga shoot count. SAMSORG -14 and SSV-2009, which were susceptible, had the highest panicle weight followed by Fara 1 Bauchi while KauraKaduna 3 had the smallest weight mean 233.33. Ironically none of the checks had neither the highest grain weight, nor panicle weight but SAMSORG - 14 had the highest grain weight of 900g followed by SSV2009. The least weight was found with Kauramaiguduna.This result showed that yield (grain) weight is not enough to prove a variety resistance or susceptible but other traits should be looked into, this was also observed by Rodenburg*et al.*,(2006).

*A*lthough *S. hermonthica* has devastating effect on grain yield of susceptible sorghum by robbing its host of carbon, nitrogen and inorganic salt (Hassan *et al.,* 2009) which at the same time diminish the growth and photosynthetic capacity of the cereal (Marley *et.al,* 2004).. Infected sorghum plants are prone to water stress, carbon partitioning to the parasite and reduced Co_2 flux (Jean-Baptiste *et al*., 2012).As at 28 days after sowing all the sorghums used in this study have almost equal number of leaves (7 to 8) by 80 DAS, all showed no difference in the number of their leaves. This result agrees with that of Osman *et al.*,(2013). This result indicated that generally Striga infestation has no significant effect on sorghum number of leaves. Gebremedhin*et al.*,(2000) as quoted by Jean-Baptiste *et a*l., 2012 noted that under the competition for water and nutrients with Striga, the sorghum plants may strategically divert their dry matter to roots and leaves so that the morphological changes due to parasite were best observed on stem and panicle.

5.2.1 Striga Damage Score and Rating

In this study visual evaluation of Striga damage symptoms varied approximately (normal

growth to visible damage) Sinebo and Drennan (2001). Based on this plant with score 0-4 were considered resistant while plant with score 5-9 were considered susceptible. Although Striga plant emerged on all roots of all the genotypes used in this study indicating that none exhibited true resistance mechanism but ICSR94405 and ICSR94407 were confirmed resistant having the least number of Striga which is in accordance with Hausmann *et al*.,(2000) that entries are to be considered resistant when they support significantly fewer Striga plants. However Gizo 1, Gizo 2 Garau 2, Kastal, NRL 1,Kaura Maiguduna and Yandargako sustained lower Striga emergence and no significant decrease in host biomass so they were also regarded as resistant genotypes.

Whereas RIBX 98-78, IS17562, Fara Kano, Twinseeded, Macedakuya, Gwajamai, KauraBorno and NRL 3 were found unstable being resistant in the field and susceptible in the screen house which could be a case of level of the *Striga hermonthical* (Del) Benth virulence in the field and escape in the screen house. Others were confirmed susceptible both in the screen house and on the field. Out of the susceptible ones SAMSORG- 17 had a mean yield that was not significantly different from the resistant checks yield.

5.2.2 The association between striga damage score, striga count and other agronomic traits

The degree of phenotypic and genotypic correlations between characters is very important. According to Aghughu (2001), significant positive phenotypic correlation between characters indicates that they can be predicted from each other and that genotypic correlation between them will determine whether this relationship will be passed on to the offspring or not. Hence, this will determine whether or not genetic improvement of one

will lead to a corresponding change in the other).Striga shoot count at all the given days were highly significantly correlated genetically with Striga damage score this implies that as Striga shoot count increases the damage to the host plant increase (virulence) which could lead to death of the host plant, this result agrees with that of Makoko*et al.*,(2003). Agronomic traits like panicle weight had significant phenotypic correlation with all Striga shoot counts indicating that as Striga shoot increased panicle weight will be significantly affected. Plant height, panicle length, panicle weight and grain weight, were not genetically correlated to Striga shoot counts.50% days to heading was also observed to be significantly correlated to Striga count at 60days after sowing and number of leaves at 80 days after sowing which was also recorded by Ezeakuand Gupta(2004). This result implies that only agronomic traits like Plant height, Panicle length and grain weight will not be sufficient enough to be used to ascertain resistance/tolerance.

5.2.3 Genetic distance and cluster analysis of sorghum germplasms used in this study.

The closest genotypes are Gwajamai and SAMSORG 43 having mean genetic distance of 4.80 (as the smallest distance).Whereas Burulu Borno and Dalwanda with other 38 genotypes exhibited the greatest genetic distance(168.78).According to Ghaderi *et al.,* (1984), increasing parental distance implies a great number of contrasting alleles at the desired loci, and to the extent that these loci recombine in the F2 and F3 generation following a cross of distantly related parents, the greater will be the opportunities for the effective selection for yield factors. Thus, crossing of genotypes from these ones with others may produce higher amount of hetrotic expression in the first filial generations (F1's) and wide range of variability in subsequent segregating (F2) populations. Based on

this the more uniform two genotypes are the better for them to be used together in breeding improvement, and vice versa.Whereas for the screen house experiment, Twin seeded and Fara 2 Bauchi had the shortest distance with genetic distance of 1.14.Screening for tolerance based on the yield response of a genotype is difficult when the selection pool contain genotype with largely different and unknown levels of resistance, so as the need for unraveling resistance and tolerance is evident, the result of the study showed that screening should be properly done before embarking on crop improvement programs.

CHAPTER SIX

6 Summary, Conclusion and Recommendation

6.1 Summary

The current study was carried out in Plant Science screen house IAR, ABU, Zaria between March and June 2013 and IAR Samaru research field within June to December 2013. Three resistant sorghum varieties: ICSR94405, ICSR94407 and SRN 39 with susceptible variety KSV4 were used as the checks. However, SRN 39 was found susceptible. Other 39 sorghum germplasm used comprised of 32 local collection from different locations within Nigeria, six IAR improved genotypes. All were initially planted at the screen house and later by July on Striga sick plot of IAR research field. Effect of Striga on Plant height, 50% heading days, Panicle weight, grain weight were observed.So plant height, grain yield, panicle weight, panicle length, 1000 grain weight, Striga damage score and Striga shoots count were the resistance criteria used. The results obtained for the field experiment showed that all except number of leaves at 28 days after sowing were significantly different among the genotypes.

6.2 Conclusion

It was confirmed that two of the resistant checks ICSR94405 and ICSR95507 were truly resistant,. though their mean grain yield, Panicle weight, Panicle length and 1000 grain weight were not the highest when compare to othesr but the Striga shoots count and Striga damage score which were major resistance criteria proved them to be resistant to *Striga Hermonthica*. KSV4 was also confirmed as susceptible. From the experiment SAMSORG-17 had grain weight that was not significantly different from the other two resistant checks; visually it was healthier than other susceptible genotypes. Gizo 1, Gizo 2 Garau 2, Kastal,

NRL 1,Kaura Maiguduna and Yandargako were also found to be resistant from this experiment both on the field and the screen house. RIBX 98.5b-f3-78, IS17562, FaraKano, Twin seeded, Macedakuya, Gwajamai, KauraBorno and NRL 3 were considered unstable. They are therefore suggested for multi-location evaluation to ascertain their resistance level.

In conclusion, based on this study SRN39 a proven resistant variety was found susceptible hence the need for continuous screening before any selection is being made.

6.3 Recommendations

Based on this study, it can then be recommended that

- Striga resistance with appropriate complementary agronomic practices as ideal control package should be inculcated.
- All the resistant genotypes Gizo 1, Gizo 2 Garau 2, Kastal, NRL 1,Kaura maiguduna and Yandargako should be improved on and be subjected to further screening to ascertain the durability on the field.
- Future research efforts should be directed towards understanding host resistance mechanisms, improvement of field screening with infestation techniques.

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