HERITABILITY, STABILITY PARAMETERS AND PATHS OF INFLUENCE ON YIELD COMPONENTS OF SESAME (*Sesamum indicum* L.) BREEDING LINES

BY

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ABSTRACT

Field trials were conducted during the rainy season of 2012 to study the heritability, stability and contributions of some yield attributes to the seed yield of 9 sesame genotypes grown in two spacings at Naliendele, Nachingwea and Tunduru. The experiments were arranged in a split-split plot design in three replications at three sites. Observations were recorded on days to 50% flowering, total plant height, height to first branch, height to first capsule, number of primary branches, capsule on the main stem, number of capsules per plant, leaf spot score, date of harvesting, seed yield and 1000 seed weight. The genotypes varied considerably in the two spacings and GEI was highly significant. The traits, number of first branch, number of capsules per plant and seed yield showed high PCV and GCV estimates. There is scope for selection based on these characters, and the diverse genotypes can provide materials for a sound breeding programme. Most of the characters had low heritability along with low genetic advance; such situation may arise due to non-additive gene action indicating greater influence of environment in the expression of these characters. Seed yield per plant showed positive correlation with days to 50% flowering, total plant height, height to first branch, height to first capsules and capsule per plant. 1000 seed weight showed negative association with seed yield per plant. Genotype Nal. 06. Sc 31 was high yielding and found to suit in more favourable environmental conditions while Mtwara 09 showed to have good adaptability under more unfavourable conditions. According to this experiment, it was concluded that specific genotypes for specific environments are needed in order to maximize grain yield in sesame.

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DECLARATION

I, HAPPY MAKURU DAUDI do hereby declare to neither the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

.....
HAPPY M. DAUDI
(Msc. Candidate)

11/06/2014
Date

The above declaration is confirmed

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Prof. S.O.W. M. REUBEN
(Msc. Supervisor)

11/6/2014
Date

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DEDICATION

This dissertation is dedicated to my beloved father Daudi Makuru Siringo and mother Maria Washa Siringo who have enriched my life beyond any wealth I will ever dream.

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LIST OF ABREVIATIONS AND SYMBOLS

ANOVA	Analysis of variance
b1 (b)	regression coefficients
CV	Coefficient of Variation
DRD	Director of Research and Development
FAO	Food and Agricultural Organisation
Fig.	Figure
G x E	Genotype by Environment
GEI	Genotype by Environment Interaction
GEI	Genotype x Environment Interaction
kg	kilogram
km	kilometre
masl	metre above sea level
N	Nitrogen
NARI	Naliendele Agricultural Research Institute
P_2O_5	Phosphorus peroxide
pH	Hydrogen ion concentration
r	correlation
R^2	coefficients of determination
s^2d	variance of deviation
SD	Standard Deviation
SE	Standard Error

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Sesame (*Sesamum indicum* L.) is one of the world's oldest spice and oilseed crop grown mainly for its seeds that contain approximately 50% oil and 25% protein. The world production is estimated at 3.66 million tonnes with Asia and Africa producing 2.55 and 0.95 million tons respectively (Anon, 2008). In Africa, Sudan ranks first in production followed by Uganda and Nigeria (FAO, 2005). Tanzania is the world's 12th largest sesame producer and is the 6th in Africa. Sesame is considered to have both nutritional and medicinal values. The seeds are used either decorticated or whole in sweets such as sesame bars and halva, in baked products, or milled to get high grade edible oil or tahini, an oily paste (Morris, 2002; Bedigian, 2004). Sesame grows well in tropical to temperate climates and can yield well under fairly high temperatures. The continent of Africa is naturally endowed with favourable climatic and soil requirements that can support sesame production.

G x E interactions have assumed greater importance in plant breeding, as they affect the stability of varieties under diverse environments. Knowledge of GEI is advantageous to have a cultivar that gives consistently high yield in a broad range of environments and to increase efficiency of breeding program and selection of best genotypes (Zenebe *et al.*, 2009). The adaptability of a variety over diverse environments is usually tested by its degree of interaction with different growing environments. A variety or genotype is considered to be more adaptive or stable if it has a high mean yield but low degree of fluctuation in yielding ability when grown over diverse environments (Falconer, 1981). According to Eberhart and Russel (1966), a genotype considered as stable should meet criteria of high mean performance, with b equal to unity and s^2d approaching zero.

1.2 Statement of the problem and Justification

As sesame is a short day plant and sensitive to photo, thermo and moisture stress, the yield is not stable and varies widely (Velu and Shunmugavallic, 2005), in Tanzania the area grown sesame (Mtwara, Dodoma Tunduru) are also differ in temperature and moisture stress, these lead to affect the yield. The variability in environment namely location effect, seasonal fluctuations and their interactions highly influence the performance of genotypes in relation to yield potential (Kumaresan and Nadarajan. 2005). In sesame, seed yield, as in other crops, is a complex character which is dependent on a number of variables. In plant breeding the expression of phenotypic trait depends on the degree of the variety adaptation in the environment. This element arises from the interaction between a given genotype and an environmental condition (Vencovsky and Barriga, 1992 cited by Reginaldo *et al.*, 2000). If the interaction exists, the best genotype in one environment may not be the best in another. The adaptability of a variety over diverse environments is usually tested by its degree of interaction with different growing environments. A variety or genotype is considered to be more adaptive or stable if it has a high mean yield but low degree of fluctuation in yielding ability when grown over diverse environments (Falconer, 1981). Failure of genotypes to respond consistently to variable environmental conditions is attributed to Genotype x Environment Interaction (GEI). Knowledge of GEI is advantageous to have a cultivar that gives consistently high yield in a broad range of environments and to increase efficiency of breeding program and selection of best genotypes.

Despite the importance of sesame, unfortunately, average world yield of sesame is still low at 0.46 ton ha^{-1} (FAO, 2005). Low yields have been attributed to cultivation of low yielding dehiscent varieties with low harvest index values, significant yield losses occurring during threshing and inadequate agricultural inputs such as improved varieties, fertilizers and other agro-chemicals (Ashri, 1998; Weiss, 2000; Uzun and Cagirgam, 2006). In Tanzania the current national average yield is 0.4 tons ha^{-1}; whereas the potential average yield ranges between 1-1.2 tons ha^{-1} under improved management practices (e.g improved seeds, fertilizer application and timely planting) (Farm Africa, 2006).

The assessment of genotype x environment interaction is important in plant breeding since the expression of phenotypic trait depends on the degree of plant adaptation. Knowledge of GEI is advantageous to have a cultivar that gives consistently high yield in a broad range of environments and to increase efficiency of a breeding program and selection of best genotypes.

To increase yield of sesame the study of direct and indirect effects (path analysis) of yield and its components provide the basis for its successful breeding program. An increase of seed yield can be more effectively tackled on the basis of performance of yield components and selection of closely associated traits such as days to 50% flowering and number of capsules. For efficient breeding and crop improvement, it is of utmost importance in any crop plant to ascertain the contribution of yield related traits to yield and select components that maximize yield (Ashkan *et al.*, 2007; Chowdhury *et al.*, 2010).

Selection of stable genotypes that perform consistently across environments can reduce the magnitude of Genotype x Environment interaction. Besides, stability of sesame performance is of special importance under rain-fed conditions in developing countries where environmental conditions vary considerably and the technologies of modifying the environments are far from adequate (Adebisi and Moruf, 2010). Sesame was previously grown in Mtwara and Lindi regions that used to produce over 75% of National production. However, because there is high demand for sesame in international market producer prices have been on the increase since 1990's. These have prompted farmers to grow the crop for income generation and sesame is now grown in non-traditional growing areas such as Mbeya and Dodoma regions, this is the reason of finding the variety which will grow well in different environment and the one which will perform better in the specific location.

The variability in environment namely locations, seasonal fluctuations and their interaction highly influence the performance of genotypes in relation to yield potential. This justified and underlined the importance of identifying genotypes that are stable across a wide range of environments.

Besides, stability of sesame, performance is of special importance under rain-fed conditions in developing countries where environmental conditions varied considerably and the technologies of modifying the environments are far from adequate (Adebisi, 2004). Interest has been focused on the regression analysis, an approach originally proposed by Yates and Cochram (1938) and later modified by Eberhart and Russel (1966). In the place where this study conducted, there are a different in rainfall pattern, that means Naliendele differ with Nachingwea and Tunduru and Tunduru differ with Naliendele and Nachingwea, this applied the same to Nachingwea.

1.3 Objectives of the study

1.3.1 Overall Objective

To identify sesame genotypes that perform consistently well across different environments

1.3.2 Specific Objectives

(i) Determine genotypes x environment interaction effects on yield components

(ii) Estimate heritability and stability parameters and assess the relationships with mean performance of genotypes of the studied variables

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Effect of Environmental Conditions on yield

Sesame grows well in tropical to temperate climates and can yield well under fairly high temperatures. A temperature of about 30° C encourages rapid germination, initial growth and flower formation. Temperatures below 20° C delay germination and seedling growth whereas temperature below 10° C inhibits both. In India, Nath *et al.* (2003) indicated that sesame growth rate was negatively affected by low temperature and low effective photosynthetic rate. Temperature and variety affected seed yield variation by 69% and 39%, respectively. Seed yield of sesame significantly differed from one season to another during 1998-2000 as found by Sharma (2005). Initiation of flowering is sensitive to photoperiod and varies among varieties. The short day treatment shortened the duration to first flower and lowered the first flowering node.

Sesame is considered to be drought tolerant; however, good yields can be obtained when there is adequate rainfall. Established plants are capable of withstanding high moisture stress, but the seedling stage is extremely sensitive. Planting should be such that it coincides with adequate rains to enhance good emergence and crop establishment. Generally, 300 to 600 mm of evenly distributed rainfall is ideal during the growing season for good production of the crop. The crop is very sensitive to water logging, even for a relatively short duration.

Sesame thrives best on moderately fertile, well-drained soils with a pH ranging from 5.5 to 8.0. Very low pH values have a drastic negative effect on growth; however, some varieties can withstand a pH value up to 8. The crop is sensitive to salinity conditions.

Generally, sesame can successfully grow on a rather wide range of soils due to the diversity of cultivars well adapted to local conditions (Bedigian, 2004).

2.2 Heritability

The concept of heritability is used to examine the relative contributions of genes and environments to variation in a specific trait. One hundred fifty one sesame genotypes were evaluated in India for genetic diversity in respect of nine quantitative characters. High heritability was observed for seed yield. number of primary branches/plant, number of capsules/plant, number of seeds/capsule, plant height and days to 50% flowering (Parameshwarappa *et al.*, 2009). Similar findings were reported by Reddy *et al.* (2001), who showed that these characters were controlled by additive gene effects and phenotypic selection for these traits would likely be effective. At National Agricultural Research Center, Islamabad, the study conducted showed that, estimates of heritability in broad sense ranged from 55% for days to flower completion, to 96% for seed yield m^{-2}. It was high for days to flower initiation, days of completion flowering, days to maturity, number of branches $plant^{-1}$, number of capsules $plant^{-1}$, seed yield $plant^{-1}$ and seed yield m^{-2} with values of 67, 55, 79, 63, 78, 87, 84 and 96% respectively. Their higher estimates indicated that large proportion of the total variance was due to the high genotypic variance having less environmental influence hence possessing high heritable variation. From the results of that study it is concluded that seed yield m^{-2}, seed yield $plant^{-1}$, branches $plant^{-1}$ and capsules plant-1 provide a good selection base as they had high values of heritability.

2.3 Path Coefficient Analysis

Path coefficient is one of the effective techniques to reveal inter-relationships among yield characters and their direct and indirect effects on grain yield through a system of variable interrelations. Studies done in Nigeria (Muhamman, 2010) showed that, when the

correlation coefficients were partitioned into direct and indirect effects, number of branches per plant had the highest contribution followed by plant height. Leaf area per plant contributed the lowest. When the growth characters were quantified in terms of percentage, the percentage contribution of number of branches and plant height were higher (Muhamman, 2010) . Another study in Nigeria showed that, the strongest direct effect of seed yield per unit area was estimated for seed yield per plant followed by number of capsules per plant (Haruna *et al.*, 2011). The study was conducted in West Mediterranean Agricultural Research Institute's fields of Antalya at 2008-2009 to evaluate character associations using correlation coefficients showed that, the combined data over the two years for plant height, number of branches, number of capsule per plant and 1000 seed weight had the significant positive correlation with seed yield. With regard to positive correlation, similar results are in concurrence with the results of Uzun and Cagirgan (2001), Khan *et al.* (2001) and Sumathi *et al.* (2007). Similarly, number of branches/plant height showed strong positive indirect effect on seed yield. This situation indicated that although number of branches and number of capsule had no high direct effect on seed yield, these traits had powerful indirect effect over plant height and therefore they may be evaluated together in selection studies. The characters of stem height to the first capsule and number of seed per capsule indicated positive correlation with seed yield whereas in path analysis, negative direct effect was observed on seed yield for each of them.

Yield is a complex quantitative trait, which is greatly influenced by environmental fluctuations. Hence, selection based on yield performance alone may indicate a biased result and lead to ambiguity. A study of nature and degree of association of component characters with yield assumes greater importance for fixing up characters that play a decisive role in influencing yield. Selection would therefore be more effective, if it was

based on component characters rather than directly on yield. Working on the correlation and path analysis in Sesame, Gnanasekaran *et al.* (2008) and Kumar and Vivekanandan (2009) reported that positive and highly significant association between yield and yield attribute exists.

2.4 Stability Parameters

Stable varieties are the ones which perform the same regardless of the productivity level of the environments. The study done in Nigeria by using fourteen sesame genotypes showed that, seed germination of genotype 530-6-1 with regression coefficients of 1.03, s^2d approaching zero and with relatively high seed germination of 78.50% could be considered widely adapted and stable. The investigation of stability of sesame genotypes clearly showed that most of the test genotypes were sensitive to production environments (Adebisi and Moruf, 2010). Several other studies were carried out on GEI throughout the world by different researchers on various oil crops like Ethiopian mustard (Kassa, 2002) and Sunflower (Dijanovic *et al.*, 2004; Ghafoor *et al.*, 2005). They reported that the mean squares for genotypes, environments and GEI were highly significant; indicating the existence of a wide range of variation between the genotypes and between the seasons and that, the performance of genotypes differed over seasons. A study conducted in India by Kumaresan and Nadarajan (2005) showed that, the mean squares due to genotype x environment interaction as shown by the environment + [genotype x environment) showed significant values for all characters indicated that these characters were unstable and fluctuated in their expression with change in environment. The study on stability done in Nigeria by Adebisi and Moruf (2009) showed that most of the test genotypes were sensitive to production environments. Hence, their wider adaptability, stability and general performance to the fluctuating growing conditions within and across plant population environments were considerably lowered.

The study conducted at Naliendele Agricultural Research Institute during the season 2011/2012 in four sites, Naliendele, Nachingwea, Tunduru and Makutupora using ten varieties suggest that Nal. 95. Sc. 9.1 (956 kg/ha) followed by Nal. 06. Sc 91 with mean seed yields of 950 kg/ha performs better across sites (NARI annual report, 2011/2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

The nine selected genotypes evaluated in this study were (Nal.06.Sc.04, Nal.06.Sc.31, Nal.06.Sc.49, Nal.06.Sc.91, Nal.95.Sc.5.1, Nal.95.Sc.9.1, Mtwara 09, Lindi 02 and Ziada 94) from Naliendele Agricultural Research Institute (NARI). The sesame genotypes were advanced lines of F_5 generation selected from previous variety trials conducted by Oilseeds Research Program based at NARI that needed to be assessed for yield performance over a wide range of environments before adoption in Tanzania.

3.2 Methods

3.2.1 The Study Area

The southern zone, also known as south- Eastern Tanzania, comprises of Mtwara and Lindi regions, and Tunduru district in Ruvuma region. The zone covers 103,500 km^2 of which 17,750 km^2 is in Mtwara, 67,000 km^2 is in Lindi and remaining 18,750 km^2 is in Tunduru district. The zone is characterized by mixed farming system, whose elements change with variations in climate and environment. The elevation of this zone ranges between 135 to 710 masl. There are two main seasons: a humid and hotter wet season (November to May) and the cooler, less humid dry season (June to October). The mean annual rainfall ranges from 800 mm in inland and central areas to 1,200 mm in the hills and plateau near the coast. The rainfall pattern is usually monomodal from late November to end April. Soils are variable, ranging from the deep, well drained, but not very fertile sandy soils of the sedimentary zones, to the deep, well drained and somewhat more fertile red clay soils.

3.2.2 Experimental Design and Treatment

A split-split plot [(a) Location (main plot/Factor A), (b) Spacing (sub plot/ Factor B) and (c) Genotype (sub-sub plot/factor C)] laid in a Randomized Complete Block was used with three replications at each of three locations. Two spacing were used at each location inoder to create six micro environments (3 locations x 2 spacing/location) for stability analysis. The plot sizes were 6 m x 2 m, each with four rows in which the spacing was 0.50 m between rows and 0.10 m within rows and 0.50 m between rows and 0.20 m within rows. The between plant spacing was achieved after thinning at 3-4 weeks following seedling emergence. Phosphorus fertilizer as P_2O_5 was applied at a rate of 40 kg/ha and Nitrogen fertilizer (urea) as a top dressing at a rate of 45 kg N per ha at four weeks after seedling emergence. Sesame flea beetle was controlled at seedling stage using karate insecticide at a rate of 5 mls/litre.

3.2.3 Data collected

Data was collected from net plot (5m) area for the following variables:

3.2.3.1 Days to 50% flowering

Days to 50% flowering was measured by counting the number of flowered plants at the time when 50% of the plot stand had reached flowering.

3.2.3.2 Disease severity and incidence

Disease scoring was done before harvesting by taking a random sample of five plants in each plot score for leaf spots(*Cercoseptoria sesame)* where 1= less disease and 5= more disease

3.2.3.3 Plant height (cm)

Total plant height was measured from ground level to plant apex (using meter stick) by taking ten randomly sampled plants in each net plot and averaged

3.2.3.4 Height to first branch (cm)

Height to first branch was measured from ground level to plant apex of the first branch (using meter stick) from above ground to first branch by taking ten random sampled plants in each net plot and averaged

3.2.3.5 Height to first capsule (cm)

Height to first capsule was measured from ground level to the tip of the first capsule (using meter stick) by taking ten random sampled plants in each net plot and averaged.

3.2.3.6 Number of capsules per plant

Number of capsules per plant was recorded by taking ten randomly sampled plants in each plot and counting all the number of capsules/plant then averaged to one decimal point

3.2.3.7 1000 seed weight (g)

1000 seed weight from each net plot was obtained from 2 weighed (g) samples of 1000 seeds and averaged to one decimal point

3.2.3.8 Seed yield (kg/ha)

Seed yield was measured by weighing total seed harvested from each net plot (using electronic balance) after sun drying to constant weight and measurements converted to kg/ha.

3.2.3.9 Meteorological data

Meteorological data such as average rainfall. minimum and maximum temperature and relative humidity were recorded from weather stations at each location.

3.2.4 Data Analysis

For each variable data was subjected to analysis of variance (ANOVA) using INDOSTAT version 8.5 computer software package; correlations among pairs of variables and genotypes stability were determined using linear regression analysis proposed by Eberhart and Russell (1966). Path coefficient analysis for the variables under investigation was done to discern paths of influence among components of yield following procedures of Dewey and Lu (1959).

Statistical Model for ANOVA

The statistical model for each location was: $Y_{ijkl} = \mu + r_i + \alpha_k + r\alpha_{ik} + \gamma_l + \alpha\gamma_{kl} + \varepsilon_{ijkl}$

For combined analysis was:

$$Y_{ijklm} = \mu + r_{i(j)} + \beta_j + r\beta ij(\varepsilon_a) + \alpha_k + \beta\alpha_{jk} + \gamma_l + \beta\gamma_{jl} + \alpha\gamma_{kl} + \alpha\beta\gamma_{ijk} + \varepsilon_{ijklm} \quad \text{.....(1)}$$

Where by:

Y_{ijklm} = measurement for l^{th} genotype of the j^{th} location and k^{th} spacing in i^{th} replication and m^{th} plot

μ = Overall mean,

$r_{i(j)}$= i^{th} replication within j^{th} location,

β_j = j^{th} location effect,

$r\beta_{ij}$ = interaction effect of i^{th} replication and j^{th} location,

α_k=k^{th} spacing effect,

$\beta\alpha_{jk}$=interaction effect of j^{th} location and k^{th} spacing, γ_l= l^{th} genotype effect,

$\beta\gamma_{jl}$ = interaction effect of j^{th} location and l^{th} genotype,

$\alpha\gamma_{kl}$=interaction effect of k^{th} spacing and l^{th} genotype,

$\alpha\beta\gamma_{kjl}$=interaction effect of k^{th} spacing, j^{th} location and l^{th} genotype,

ε_{ijklm}= random experimental error

The stability parameter model for each variable will be as shown below;

$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$, ... (2)

Where by:

Y_{ij} = observation of the i^{th} genotype at the j^{th} environment,

μ_i = mean of i^{th} genotype over all environments,

β_i = the regression coefficient that measures the response of the i^{th} genotype to varying environments,

δ_{ij}= the deviation from regression of the i^{th} genotype at the j^{th} environment,

I_j = the environmental index obtained as the mean of all genotypes at the j^{th} environments

Correlation Analysis

By using INDOSTAT version 8.5 software correlations among yield and yield components for each location and across locations as a combined analysis was done.

Estimation of components of variance

Variances pooled over locations and estimates of their components were calculated. The obtained mean squares from the combined analysis of variance was used to separate out the components of variance due to genotypes, spacing, environments and their interactions.

Table 1: Combined analysis of variance for evaluating genotypes at different locations

SV	DF	MS	EMS	F-VALUE
Locations (L)	l-1	MI	$\delta^2_e+r\delta^2_{GLS}+ s\delta^2_{GL}+ rgs\delta^2_{SL}+sg\ \delta^2_{R(L)L}+ sg\ \delta^2_{R(L)}+ sg\ \delta^2_L$	M1/M9
Replications within location(R)	l(r-1)	M2	$\delta^2_e+sg\ \delta^2_{R(L)L}+sg\ \delta^2_{R(L)}$	
R(L) x L	l(r-1) (l-1)	M3	$\delta^2_e+sg\delta^2_{R(L)L}$	
Spacing	s-1	M4	$\delta^2_e+r\delta^2_{GLS}+rg\delta^2_{SL}+rl\delta^2_{GS}+rlg\delta^2_S$	M4/M9
S x L	(s-1) (l-1)	M5	$\delta^2_e+r\delta^2_{GLS}+rg\delta^2_{SL}$	M5M9
Genotypes (G)	g-1	M6	$\delta^2_e+r\delta^2_{GLS}+rs\delta^2_{GL}+rl\delta^2_{GS}+rls\delta^2_G$	M6/M9
G x L	(g-1) (l-1)	M7	$\delta^2_e+r\delta^2_{GLS}+rs\delta^2_{GL}$	M7/M9
G x S	(g-1) (s-1)	M8	$\delta^2_e+r\delta^2_{GLS}+rl\delta^2_{GS}$	M8/M9
G x L x S	(g-1)(l-1)(s-1)	M9	$\delta^2_e+ r\delta^2_{GLS}$	M9/M10
Error	Difference	M10	δ^2_e	
Total	lrsg-1			

Assumptions all factors are random

Where:

δ^2_e =Component of variance due to the error term

δ^2_G = Component of variance due to genotypes

δ^2_L = Component of variance due to environments (location)

δ^2_S=component of variance due to spacing

$\delta^2_{R(L)}$= Component of variance due to replication within location

$\delta^2_{R(L)L}$= Component of variance due to replication within location x location interaction

δ^2_{GL} = Component of variance due to genotype x location interaction

δ^2_{GS}=Component of variance due to genotype x spacing interaction

δ^2_{GLS}= Component of variance due to genotype x location x spacing interaction

R =Replications

S=Spacing

E = Environments (locations)

G = Genotypes

Computation of phenotypic variance and heritability (broad sense)

The component of phenotypic variance (δ^2_{ph}) tested in r replications and l locations were computed by using the following formula:

$$\delta^2_{ph} = \delta^2_e + \delta^2_{GLS} + \delta^2_{GS} + \delta^2_{GL} + \delta^2_G + \delta^2_{SL} + \delta^2_S + \delta^2_{R(L)L} + \delta^2_{R(L)} + \delta^2_L$$

Heritability estimates was computed by using the estimates of phenotypic and genotypic variances, a formula after Hanson *et al.* (1956), as follows;

$h^2_b = (\delta^2 g/\delta^2 ph) \times 100$

Where;

h^2_b is heritability in the broad sense,

$\delta^2 g$ is the component of variance due to genotypes and

$\delta^2 ph$ is the phenotypic component of variance.

Path Coefficient Analysis

Path coefficient analysis was used to determine direct and indirect effects of days to 50% flowering, plant height, height to first branch. height to first capsule, number of capsules per plant and 1000 seed weight. This was performed following the method outlined by Dewey and Lu (1959). The method involves solving unknowns (path coefficients) from a series of simultaneous equations. Computation was done using the formula arranged in matrix (Appendix 1).

$$r_{17}=P_{17}+r_{12}P_{27}+r_{13}P_{37}+r_{14}P_{47}+r_{15}P_{57}+r_{16}P_{67}$$

$$r_{27}=r_{12}P_{17}+P_{27}+r_{23}P_{37}+r_{24}P_{47}+r_{25}P_{57}+r_{26}P_{67}$$

$$r_{37}=r_{13}P_{17}+r_{23}P_{27}+P_{37}+r_{34}P_{47}+r_{35}P_{57}+r_{36}P_{67}$$

$$r_{47}=r_{14}P_{17}+r_{24}P_{27}+r_{34}P_{37}+P_{47}+r_{45}P_{57}+r_{46}P_{67}$$

$$r_{57}=r_{15}P_{17}+r_{25}P_{27}+r_{35}P_{37}+r_{45}P_{47}+P_{57}+r_{56}P_{67}$$

$$r_{67}=r_{16}P_{17}+r_{26}P_{27}+r_{36}P_{37}+r_{46}P_{47}+r_{56}P_{57}+P_{67}$$

The residual factor (P_{X7}) was computed as follows:

$$1=P^2_{X5}+P^2_{17}+P^2_{27}+P^2_{37}+P^2_{47}+P^2_{57}+P^2_{67}+2P_{17}r_{12}P_{27}+2P_{17}r_{13}P_{37}+2P_{17}r_{14}P_{47}+2P_{17}r_{15}P_{57}+2P_{17}r_{16}P_{67}+2P_{27}r_{23}P_{37}+2P_{27}r_{24}P_{47}+2P_{27}r_{25}P_{57}+2P_{27}r_{26}P_{67}+2P_{37}r_{34}P_{47}+2P_{37}r_{35}P_{57}+2P_{37}r_{36}P_{67}+2P_{47}r_{45}P_{57}+2P_{47}r_{46}P_{67}+2P_{57}r_{56}P_{67}$$

In the path model:

rij = simple correlation coefficients for measuring the mutual association of two variables

Pij = path coefficient for measuring direct influence between variables to yield

RijPij = indirect effects of variables upon another through the other variable

Px = the residual effect in the path analysis model

i and j = (1, 2, 3, . . . 6)

CHAPTER FOUR

4.0 RESULTS

4.1. Results of analysis of variance for different variables studied

The combined analysis of variance (ANOVA) and analysis for each location for different variables studied is as shown in tables 2, 3. 4 and 5. In case of results from Naliendele site, significant spacing effects were observed for height to first branch and seed yield. Also significant genotypic differences were observed for days to 50% flowering, height to first branch, height to first capsule, total plant height, capsules on the main stem and date of harvesting (Table 2). For Nachingwea, significant spacing effects were observed for days to 50% flowering, total plant height, capsules on the main stem and seed yield. On the genotypes, significant differences were observed for days to 50%flowering, height to first branch, height to first capsule, total plant height and number of primary branches. Also the significant effects were observed for the spacing x genotype interaction for seed yield (Table 3). At Tunduru, for spacings the significant differences were observed on height to first capsule, capsules on the main stem, capsules per plant and seed yield. Significant genotypic differences were observed for height to first branch, height to first capsule, total plant height, number of primary branch, capsules on the main stem and seed yield (Table 4).

Results from combined analysis of variance indicated significant differences on the sites for all variables except days to 50% flowering, leaf spot score and 1000 seed weight. For spacing significant differences were observed only for days to 50% flowering and for the interaction (location x spacing) significant differences were observed for all variables except leaf spot score and 1000 seed weight. Significant genotypic differences were observed for all variables except number of capsule per plant and 1000 seed weight. For interaction on sites and genotypes (locations x genotype) significant differences were

observed for days to 50% flowering, height to first branch, height to first capsule, number of primary branch, date of harvesting and seed yield. The significant effects were observed only for seed yield for the interaction of population and genotypes. In the interaction of spacing x location x genotypes significant effects were observed for days to 50% flowering, height to first capsule, number of primary branches, capsules on the main stem, date of harvesting and seed yield (Table 5).

Table 2: ANOVA summary for different variables studied at NALIENDELE

SV	DF	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Replicates	2	2.1	12.1	16.7	218.0	0.0	4.7	27.2	0.1	0.0	8.9	0.3
SPACING	1	8.2	204.6**	393.7	976.2	0.4	16.4	0.0	0.0	0.0	4482.7***	0.0
Error (A)	2	2.2	23.6	212.7	377.0	0.9	53.4	107.1	0.7	0.0	257.2	0.1
GENOTYPE	8	99.1***	570.2***	1281.2***	1037.5***	0.3	37.7**	32.4	0.5	32.5***	233.9	0.0
SPAC x GEN	8	1.2	165.3	81.3	133.7	0.2	12.4	82.8	0.5	0.0	319.0	0.0
Error (B)	32	1.7	90.8	36.9	172.1	0.4	11.4	60.6	0.6	0.0	217.4	0.1
Total	53	16.5	171.0	244.0	321.5	0.4	17.0	59.0	0.5	4.9	309.3	0.1

*=probability significant level at 0.05; **=probability significant level at 0.01 and ***=probability significant level at 0.001

Key:

SV= Source of variation, DF= Degree of freedom, DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g), SPAC= Spacing and GEN= Genotype

Table 3: ANOVA summary for different variables studied at NACHINGWEA

SV	DF	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Replicates	2	13.7	278.1*	105.1**	183.0	5.3 **	60.9	1167.6 *	0.1	68.1	182362.2 *	0.1
SPACING	1	137.0*	85.6	43.7	1637.9***	1.1	153.4 *	461.1	0.0	130.7	372338.1 **	0.0
Error (A)	2	31.5	72.5	19.4	90.7	0.6	24.8	295.0	0.7	76.2	41308.8	0.2
GENOTYPE	8	86.8**	684.8***	2136.3***	1138.7 ***	6.3 ***	30.5	129.3	0.4	12.8	49488.9	0.1
SPAC x GEN	8	48.0	45.0	37.5	47.0	0.2	11.3	33.1	0.3	26.5	106592.0 **	0.0
Error (B)	32	20.8	79.4	45.0	70.1	0.4	28.6	146.2	0.3	16.3	24427.8	0.1
Total	53	37.2	173.0	360.8	262.5	1.4	29.7	176.7	0.3	23.7	53773.9	0.1

*=probability significant level at 0.05; **=probability significant level at 0.01 and ***=probability significant level at 0.001

Key:

SV= Source of variation, DF= Degree of freedom, DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g). SPAC= Spacing and GEN= Genotype

Table 4: ANOVA summary for different variables studied at TUNDURU

SV	DF	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Replicates	2	9.2	10.7	193.1 ***	327.0	0.4	10.5	126.1	0.1	0.0	24508.7 ***	0.3**
SPACING	1	2.7	11.6	54.0 *	160.2	0.0	66.7*	654.5**	0.1	0.0	45472.0 ***	0.0
Error (A)	2	36.2	3.4	7.7	162.2	0.4	13.7	62.4	0.1	0.0	1947.2	0.0
GENOTYPE	8	6.7	400.4 ***	782.6***	557.7***	2.3 **	17.6 *	146.9	0.7	54.0	67783.2 ***	0.1
SPAC x GEN	8	10.9	49.5	71.5	147.9	0.9	11.6	118.3	0.2	0.0	14604.8	0.1
Error (B)	32	7.6	35.9	62.6	110.6	0.7	7.1	75.5	0.5	0.0	13406.7	0.1
Total	53	9.0	90.3	175.3	194.8	0.9	10.9	105.1	0.4	8.2	22386.8	0.1

*=probability significant level at 0.05; **=probability significant level at 0.01 and ***=probability significant level at 0.001

Key:

SV= Source of variation, DF= Degree of freedom, DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g). SPAC= Spacing and GEN= Genotype

Table 5: Analysis of variance in combined analysis

SV	DF	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Replicates	2	8.3	69.1	29.8	192.5	2.1	24.2	432.0	0.3	22.7	26731.9	0.1
Location	2	116.6	1997.3 ***	1858.7 ***	6080.8 ***	15.7 ***	334.7 **	2536.3 **	0.0	956.1 ***	155126.1**	0.0
Error (A)	4	41.2	43.7	78.9	110.9	1.1	61.6	372.4	0.5	24.7	23191.2	0.1
SPACING	1	36.6 ***	0.9	380.9	1162.7	0.0	22.8	5.7	0.1	43.5	36300.2	0.0
LOC x SPAC	2	275.6 ***	4026.7 ***	3890.5 ***	7203.6 ***	39.4 ***	198.3 ***	1773.7 ***	0.1	2847.8 ***	1212911.0 ***	0.1
Error (B)	6	1.3	81.3	122.4	314.5	1.1	6.9	202.9	0.2	24.1	59092.8	0.1
GENOTYPE	8	114.9 ***	1317.9 ***	3760.1 ***	2263.0 ***	4.9 ***	39.3 *	184.0	1.2 *	51.0 ***	54355.6 ***	0.0
LOC x GEN	16	38.6 ***	193.8 ***	167.0 ***	165.2	1.2 **	9.4	100.1	0.3	11.1 *	35874.3** *	0.1
SPAC x GEN	8	15.2	35.1	50.6	65.7	0.5	6.3	43.1	0.5	8.9	39807.2**	0.0
LOC x SPAC x GEN	16	22.6 **	87.3	122.9 **	201.8	1.2 **	28.4 *	57.8	0.2	21.9 ** *	36555.1 ***	0.1
Error (C)	96	10.1	68.7	48.2	117.6	0.5	15.7	94.1	0.4	5.4	12684.0	0.1
Total	161	24.8	215.9	327.6	411.4	1.6	24.2	158.8	0.4	58.8	39770.2	0.1

*=probability significant level at 0.05; **=probability significant level at 0.01 and ***=probability significant level at 0.001

Key:

SV= Source of variation, DF= Degree of freedom, DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g), SPAC= Spacing, LOC = Location and GEN= Genotype

4.2 Yield and yield components

4.2.1 Seed yield (kg/ha) performance at Naliendele

The highest yielding genotype at Naliendele was Nal.06.Sc 31 (205 kg/ha) followed by 201.667 kg/ha and 200.167 kg/ha for Nal. 06. Sc 49 and Mtwara 09 respectively (Table 6 and Fig.1). However, the lowest yielding genotype was Lindi 02 (187.333 kg/ha). Spacing 1(50x10 cm) yielded more compared to spacing 2 (50x20 cm) (Table 7 and Fig. 1).

Table 6: Main effects of genotypes for yield and yield components at Naliendele

Genotypes	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Ziada 94	64.3a	50.2a	95.9a	132.9a	1.6a	17.5a	27.6a	1.8b	12.5a	190.7ab	3.0a
Nal.06.Sc 04	52.3de	18.9b	54.5b	107.8b	1.2a	15.7abcd	22.3a	2.5ab	5.5b	195.3ab	2.9a
Nal. 06.Sc 91	55.2b	19.9b	53.7b	103.6b	1.4a	16.0abc	25.1a	2.2ab	5.5b	192.7ab	3.1a
Nal. 06.Sc 31	52.3de	24.8b	54.9b	106.7b	1.4a	16.4ab	22.9a	2.2ab	5.5b	205.0a	3.2a
Nal.95.Sc.9.1	54.3bc	20.1b	50.0b	94.6bc	1.9a	12.9bcdc	22.9a	2.0ab	5.5b	197.7ab	3.1a
Nal.95.Sc.5.1	53.0cde	21.0b	48.0b	86.7bc	1.5a	12.2cdc	20.9a	2.8a	5.5b	187.7ab	3.1a
Lindi 02	53.7bcd	21.3b	52.3b	99.8bc	1.5a	11.8dc	20.9a	2.2ab	5.5b	187.3b	2.9a
Mtwara 09	50.3f	25.6b	52.9b	93.7bc	1.7a	10.9c	20.1a	2.2ab	5.5b	200.2ab	3.0a
Nal. 06.Sc 49	52.0e	21.9b	55.1b	107.8b	1.5a	16.9a	23.2a	2.3ab	5.5b	201.7ab	3.0a
Mean	54.2	24.8	57.5	103.7	1.5	14.5	22.9	2.2	6.3	195.3	3.0
CV (%)	7.495	52.7	27.2	17.3	41.0	28.5	33.6	32.4	35.3	9.0	8.6
SD	4.060	13.1	15.6	17.9	0.6	4.1	7.7	0.7	2.2	17.6	0.3
SE±	0.552	1.8	2.1	2.4	0.1	0.6	1.0	0.1	0.3	2.4	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S.D. Comparisons at 5% level.

Key;

DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem. CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

Table 7: Means for plant populations/effect of spacing on different variables at Naliendele

Populations	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
SPACING 1	54.6a	26.8a	60.2a	10780a	1.4a	15.0a	22.9a	2.2a	6.3a	17.6	0.3
SPACING 2	53.8a	22.9b	54.8a	99.5a	1.6a	13.9a	22.9a	2.3a	6.3a	186.2b	3.0a
CV (%)	7.50	52.7	27.2	17.3	41.0	28.5	33.6	32.4	35.3	9.0	8.6
SD	4.06	13.1	15.6	17.9	0.6	4.1	7.7	0.7	2.2	17.6	0.3
SE±	0.55	1.8	2.1	2.4	0.1	0.6	1.0	0.1	0.3	2.4	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L S.D Comparisons at 5% level

Key:
DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

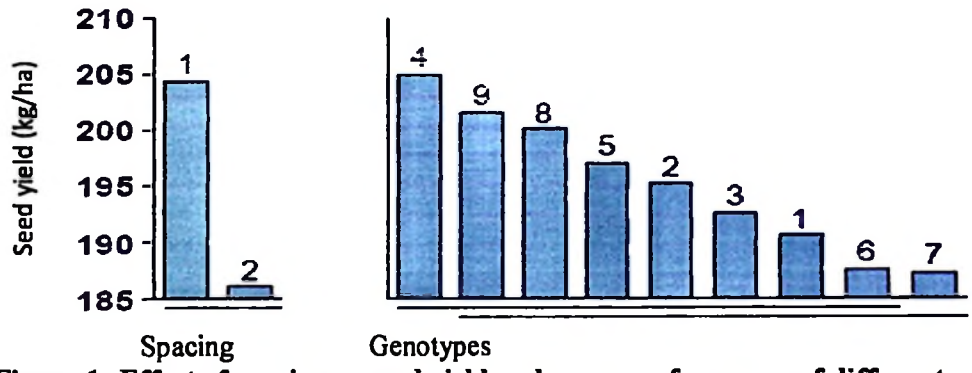


Figure 1: Effect of spacing on seed yield and mean performance of different genotypes at Naliendele

4.2.2 Seed yield (kg/ha) performance at Nachingwea

The highest mean yield performance at Nachingwea was 662.0 kg/ha for Nal. 06. Sc 31(Table 8) followed by Nal.95.Sc.9.1 (582.0 kg/ha) and Mtwara 09 (531.2 kg/ha) while Lindi 02 (371.5 kg/ha) gave the lowest mean yield at this location (Fig.2).Plant spacing 1(50x10 cm) yielded more compared to plant spacing 2 (50x20 cm) (Table 9 and Fig.2).

Table 8: Main effects of genotypes for yield and yield components at Nachingwea

Genotypes	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Ziada 94	67.7a	72.8a	125.7a	167.7a	6.2a	19.4ab	47.9a	2.0b	19.1a	511.0abc	2.9a
Nal.06.Sc 04	57.0bc	39.8b	68.6b	124.6bc	3.3bc	18.7ab	38.6a	2.5ab	20.1a	453.0bc	2.9a
Nal. 06.Sc 91	59.2bc	37.8b	65.8b	126.7bc	3.4bc	20.4ab	42.7a	2.7a	20.1a	446.7bc	3.1a
Nal. 06.Sc 31	60.3bc	44.3b	71.3b	130.4bc	3.1bc	22.8a	37.2a	2.5ab	18.4a	662.0a	3.0a
Nal.95.Sc.9 .1	55.7c	42.8b	72.2b	130.8bc	3.3bc	20.9ab	44.2a	2.3ab	21.7a	582.0ab	3.1a
Nal.95.Sc.5 .1	55.7c	38.3b	66.1b	126.3bc	2.9bc	21.3ab	38.6a	2.2ab	21.7a	428.0bc	2.8a
Lindi 02	59.2bc	42.6b	70.9b	128.3bc	3.2bc	18.3ab	34.1a	2.0b	21.7a	371.5c	2.9a
Mtwara 09	61.2b	42.1b	72.0b	121.4c	3.5b	15.5b	34.6a	2.0b	18.4a	531.2abc	3.0a
Nal. 06.Sc 49	56.2bc	44.7b	69.4b	131.9b	2.7c	22.2a	36.5a	2.5ab	21.7a	421.7bc	3.1a
Mean	59.1	45.0	75.8	132.0	3.5	19.9	39.4	2.3	20.3	489.7	3.0
CV (%)	10.3	29.2	25.1	12.3	34.4	27.3	33.8	23.4	23.9	47.4	9.6
SD	6.1	13.2	13.2	16.2	1.2	5.5	13.3	0.5	4.9	231.9	0.3
SE±	0.8	1.8	2.6	2.2	0.2	0.7	1.8	0.1	0.7	31.6	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S.D. Comparisons at 5% level

Key:

DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

Table 9: Means for plant populations/effect of spacing on different variables at Nachingwea

Populations	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
SPACING 1	60.7a	46.3a	74.9a	126.5a	3.3a	18.3a	36.5a	2.3a	18.8a	572.7a	3.0a
SPACING 2	57.5b	43.8a	76.7a	137.5b	3.6a	21.6b	42.3a	2.3a	21.9a	406.6b	3.0a
CV (%)	10.3	29.2	25.1	12.3	34.4	27.3	33.8	23.4	23.9	47.4	3.0
SD	6.1	13.2	13.2	16.2	1.2	5.5	13.3	0.5	4.9	231.9	0.3
SE±	0.8	1.8	2.6	2.2	0.2	0.7	1.8	0.1	0.7	31.6	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S.D. Comparisons at 5% level
Key;
DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

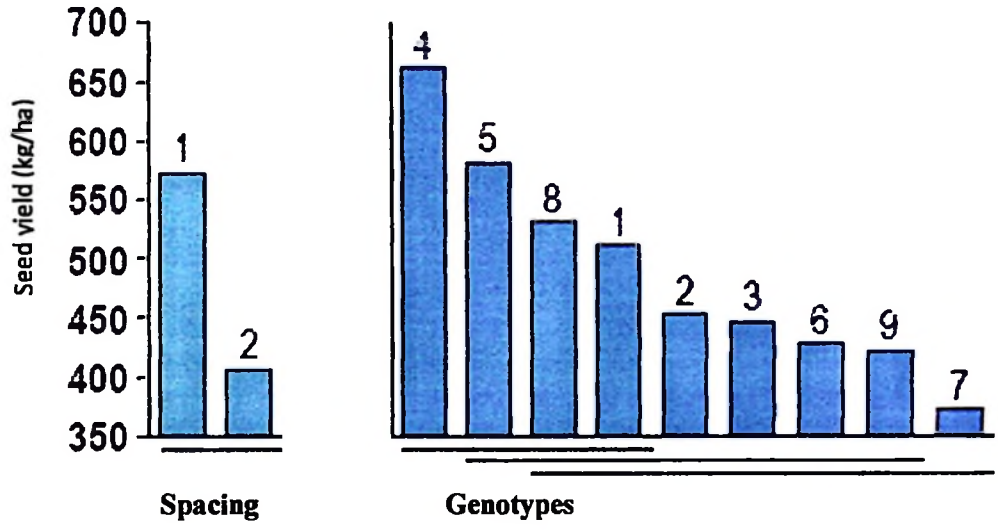


Figure 2: Effect of spacing on the seed yield and mean performance of different genotypes at Nachingwea

4.2.3 Seed yield (kg/ha) performance at Tunduru

Highest performance at Tunduru was given by Mtwara 09 (610.167 kg/ha) followed by Ziada 94 (398 kg/ha) and Na.06. Sc 91 (380.3 kg/ha) (Table 10). The trial lowest yielder genotype was Nal.06.Sc 04 which gave only 265.3 kg/ha followed by yield mean of 269.3 kg/ha for Lindi 02 (Fig.3). Plant spacing 1(50x10 cm) yielded more compared to plant spacing 2 (50x20 cm) (Table 11 and Fig.3).

Table 10: Main effects of genotypes for yield and yield components at Tunduru

Genotypes	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Ziada 94	56.7a	39.7a	83.2a	129.0a	3.7a	15.7ab	36.2ab	2.0a	13.5a	398.3a	3.2a
Nal.06.Sc 04	56.0a	31.8b	54.7cd	103.3c	3.5ab	16.7ab	38.5a	2.5a	4.5b	265.3b	2.9ab
Nal. 06.Sc 91	55.5a	21.5c	53.5d	102.5c	2.5cde	16.7ab	35.2ab	2.5a	4.5b	380.3b	3.0ab
Nal. 06.Sc 31	56.5a	42.0a	63.8bc	108.0bc	2.3de	12.5c	24.7c	2.5a	4.5b	318.7b	2.7b
Nal.95.Sc.9.1	54.5a	25.8bc	48.7d	98.8c	2.8abcd	17.3ab	35.3ab	1.8a	4.5b	379.7b	2.9b
Nal.95.Sc.5.1	56.5a	23.2c	50.3d	102.8c	2.7bcde	17.7ab	33.0abc	2.5a	4.5b	329.0b	3.0ab
Lindi 02	57.2a	22.8c	51.2d	101.8c	2.3de	14.7bc	26.5bc	1.8a	4.5b	269.3b	3.0ab
Mtwara 09	54.3a	39.8a	69.2b	118.0ab	3.3abc	15.8ab	38.3a	1.8a	4.5b	610.2b	2.8b
Nal. 06.Sc 49	57.2a	26.8bc	52.5d	109.5bc	1.8de	18.0a	35.2abc	2.5a	4.5b	284.7b	2.9b
Mean	56.0	30.4	58.6	108.2	2.8	16.1	33.1	2.2	5.5	359.5	2.9
CV (%)	5.4	31.3	22.6	12.9	34.0	20.5	30.9	29.9	51.9	41.6	9.4
SD	3.0	9.5	13.2	14.0	0.9	3.3	10.3	0.7	2.9	149.6	8.7
SE±	0.4	1.3	1.8	1.9	0.1	0.4	1.4	0.1	0.4	20.4	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L S.D. Comparisons at 5% level.
Key;
DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

Table 11: Means for plant populations/effect of spacing on different variables at Tunduru

Populations	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
SPACING 1	55.8a	29.9a	59.6a	106.5a	2.8a	15.0a	29.7a	2.2a	6.3a	388.5a	2.9a
SPACING 2	56.3a	30.9a	57.6b	109.9a	2.8a	15.0b	36.6b	2.3a	18.8a	330.5b	2.9a
CV (%)	5.4	31.3	22.6	12.9	34.0	20.5	30.9	29.9	51.9	41.6	9.4
SD	3.0	9.5	13.2	14.0	0.9	3.3	10.3	0.7	2.9	149.6.7	8.7
SE±	0.4	1.3	1.8	1.9	0.1	0.4	1.4	0.1	0.4	20.4	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S.D. Comparisons at 5% level.
Key;
DFL= days to 50% flowering, HFB= height to first branch (cm). HFC= height to first capsule (cm). TPH= total plant height (cm). NPB= number of primary branch. CMS= capsule on the main stem, CPP= number of capsule per plant. LSC= leaf spot score. DH= date of harvesting. SY= seed yield (kg/ha). TSW= 1000 seed weight (g)

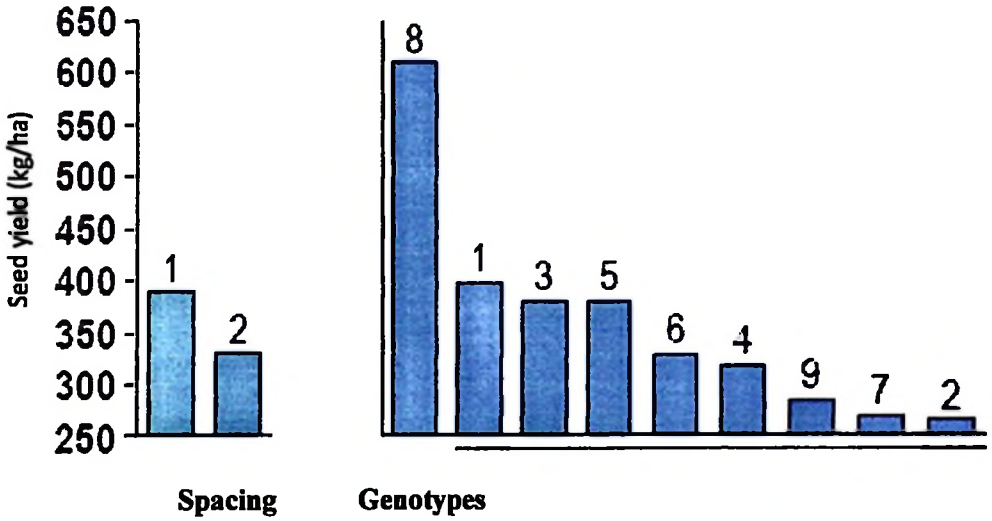


Figure 3: Effect of spacing on seed yield and mean performance of different genotypes at Tundura

4.2.4 Seed yield (kg/ha) performance in combined analysis

Results of combined analysis revealed that highest seed yield genotype across locations was Mtwara 09 (447.167 kg/ha), followed by Nal. 06. Sc 31 and Nal.95.Sc.9.1 which gave 395.222 kg/ha and 386.278 kg/ha respectively (Table 12 and Fig. 4). The lowest mean yield across trials was Lindi 02 (276.056 kg/ha).

Plant spacing 1 (10 cm x 50 cm) yielded significantly higher than plant spacing 2.Genotype 8 outperformed the rest which were not significantly different (Table 12 and Fig 4). Genotypes 2, 9 and 7 (Fig 4) yielded significant lower than genotypes the rest.

Table 12: Main effects of genotypes for yield and yield components in combined analysis

Genotypes	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
Ziada 94	62.9a	54.2a	101.6a	143.2a	3.8a	17.5ab	37.2a	1.9d	15.0a	366.7bcd	3.0a
Nal.06.Sc 04	55.1b	30.2d	59.2cd	111.9bcd	2.6bc	17.0ab	33.1abc	2.5a	10.0b	304.6de	2.9a
Nal. 06.Sc 91	56.6b	26.4d	57.7d	110.9bcd	2.4bcd	17.7a	34.3ab	2.4ab	10.0b	339.9bcde	3.0a
Nal. 06.Sc 31	56.4b	37.0b	63.4bc	115.0bc	2.3d	17.2ab	28.3bc	2.4abc	9.5b	395.2ab	2.9a
Nal.95.Sc.9.1	54.8b	29.6d	56.9d	108.1cd	2.7bc	17.0ab	34.2ab	2.1bcd	10.6b	386.3abc	3.0a
Nal.95.Sc.5.1	55.1b	27.5d	54.8d	105.3d	2.4cd	17.1ab	30.8abc	2.5a	10.6b	314.9cde	3.0a
Lindi 02	56.7b	28.9d	58.1d	110.0bcd	2.3cd	14.9bc	27.1c	2.0cd	10.6b	276.1e	2.9a
Mtwara 09	55.3b	35.8bc	64.7b	111.0bcd	2.8b	14.1c	31.0abc	2.0cd	9.5b	447.2a	3.0a
Nal. 06.Sc 49	55.1b	31.1cd	59.0cd	116.4b	2.0d	19.0a	30.1bc	2.4ab	10.6b	302.7de	3.0a
Mean	56.4	33.4	63.9	114.6	2.6	16.8	31.8	2.3	10.7	348.2	3.0
CV (%)	8.8	44.0	28.3	17.7	48.3	29.2	39.6	28.6	71.7	57.3	9.2
SD	5.0	5.0	18.1	20.3	1.3	4.9	12.6	0.6	7.7	199.4	0.3
SE±	0.4	1.2	1.4	1.6	0.1	0.4	1.0	0.1	0.6	15.7	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S D. Comparisons at 5% level.

Key;

DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

Table 13: Means for effect of spacing on different variables in combined analysis

Populations	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
SPACING 1	56.0a	33.5a	65.5a	117.3a	2.6a	17.2a	31.6a	2.2a	11.2a	333.2a	3.0a
SPACING 2	56.9b	33.3a	62.4a	112.0a	2.6a	16.5a	32.0a	2.3a	10.2a	363.1a	3.0a
CV (%)	8.8	44.0	28.3	17.7	48.3	29.2	39.6	28.6	77.7	57.3	9.2
SD	5.0	5.0	18.1	20.3	1.3	4.9	12.6	0.6	7.7	199.4	0.3
SE±	0.4	1.2	1.4	1.6	0.1	0.4	1.0	0.1	0.6	15.7	0.0

Means within column followed with the same latter (s) are not significantly different from each other according to L.S.D. Comparisons at 5% level.
Key;
DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

Table 14: Means for sites (Locations) on different variables in combined analysis

Sites	DFL	HFB	HFC	TPH	NPB	CMS	CPP	LSC	DH	SY	TSW
S1	57.6a	36.5a	67.5a	117.2b	2.4b	16.5a	29.7ab	2.3a	12.5a	388.6a	3.0a
S2	54.8a	26.4b	57.2b	103.0c	2.2b	14.5b	26.3b	2.2a	5.9b	287.4b	2.9a
S3	56.9a	37.3a	67.1a	123.7a	3.2a	19.4a	39.5a	2.3a	13.7a	368.6ab	3.0a
CV (%)	8.8	44.0	28.3	17.7	48.3	29.2	39.6	28.6	71.7	57.3	9.2
SD	5.0	5.0	18.1	20.3	1.3	4.9	12.6	0.6	7.7	199.4	0.3
SE±	0.4	1.2	1.4	1.6	0.1	0.4	1.0	0.1	0.6	15.7	0.0

Key;
DFL= days to 50% flowering, HFB= height to first branch (cm), HFC= height to first capsule (cm), TPH= total plant height (cm), NPB= number of primary branch, CMS= capsule on the main stem, CPP= number of capsule per plant, LSC= leaf spot score, DH= date of harvesting, SY= seed yield (kg/ha), TSW= 1000 seed weight (g)

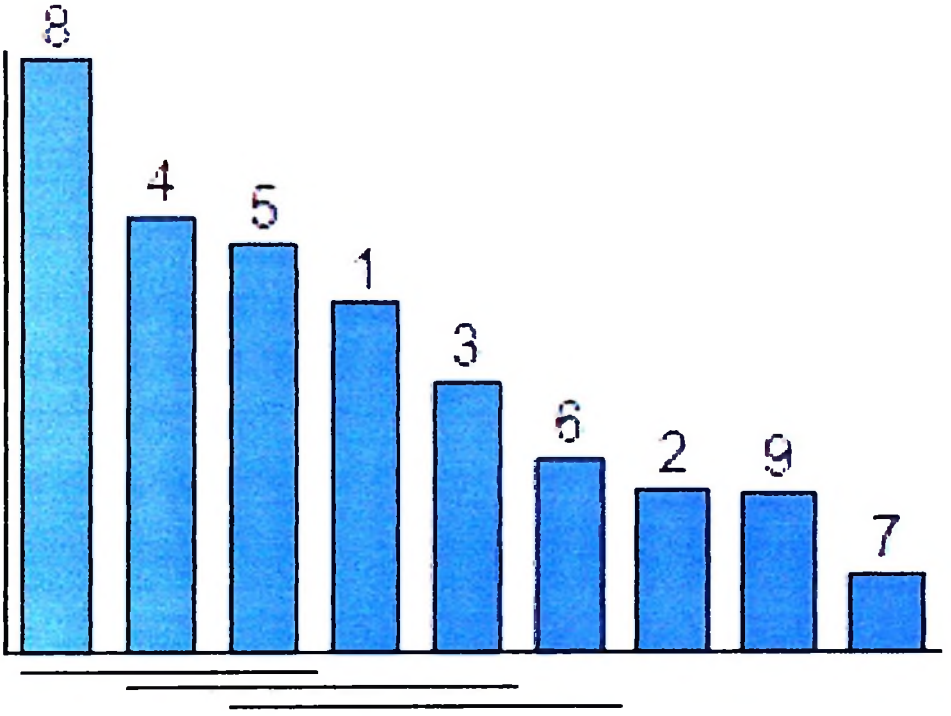


Figure 4: Mean performance of different genotypes in combined analysis

4.3 Performance of genotypes for yield components at each site

4.3.1 Mean effects of genotypes for different variables at Naliendele

Mtwara 09, Nal. 06. Sc 49, Nal.06.Sc 04 and Nal. 06. Sc 31 genotypes took relatively short duration of days to 50% flowering as compared to other genotypes (Table 6), which ranged from 50 to 52 days respectively. Genotype 9 (Ziada 94) was tallest (132.9 cm) and the shortest one was Nal.95.Sc.5.1 (86.7 cm). Also genotype 1 (Ziada 94) had relatively highest height to first branch and to first capsule (50.15 and 95.93 cm) respectively. Height to first branch was shortest (18.92 cm) for Nal.06.Sc 04 and for first capsule Nal.95.Sc.5.1 was shortest (48 cm). Number of capsules per plant was highest for Ziada 94 followed by Nal. 06. Sc 91, the capsules were 27.57 and 25.10 respectively. The one with lowest number of capsules per plant was Mtwara 09 (20.10). Genotype 4 (Nal. 06.

Sc 31) and Nal.95.Sc.5.1 was highest in 1000 seed weight (3.1 g). The one which had lowest 1000 seed weight were Lindi 02 and Nal.06.Sc 04 (2.9 g). However, genotypes were statistically similar on thousand seed weight. For all these variables there were no significant differences in spacing however, there was a significant effect only for the interaction between spacing and genotype in total plant height.

4.3.2 Mean effects of genotypes for various variables at Nachingwea

All genotypes at Nachingwea site were observed with days to 50% flowering that go beyond 50 days (Table 8). However, genotypes viz: Nal. 06. Sc. 9.1 and Nal.95.Sc.5.1 took shortest duration for days to 50% flowering (56 days) compared to other genotypes. Ziada 94 took longest days to 50% flowering 68 days, also there was a significant differences in spacing where spacing 1 (50x10 cm) taking longest days to 50% flowering compared to spacing 2 (50x20 cm) (Table 9). Ziada 94 showed highest total plant height, height to first branch and height to first capsule (167.67, 72.75 and 125.70 cm) respectively. For total plant height the shortest was Mtwara 09 (121.40 cm). Nal. 06. Sc 91 showed shortest for both heights to first branch and height to first capsule at 37.833 and 65.833 cm respectively. Also there was a significant difference in spacing, 50x10 cm had the lower total plant height compared to 50x20 cm. Ziada 94 showed highest number of capsules per plant and the one which showed the lowest was Lindi 02 (47.92 and 34.08 respectively). Nal. 06. Sc 49, Nal. 95. Sc. 9.1 and Nal. 06. Sc 91 genotypes recorded highest 1000 seed weight (3.1 g) and the least was Nal.95.Sc.5.1 (2.8 g). However, genotypes did not differ significantly on thousands seed weight.

4.3.3 Mean effects of genotypes for various variables at Tunduru

Genotypes viz: Mtwara 09 and Nal.95.Sc.9.1 took relatively short duration to days to 50% flowering compared to other genotypes (Table 10). Of these, Mtwara 09 took shortest

duration of 54.333 days and Lindi 02 and Nal. 06. Sc 49 took longest duration of 57.167 days each. For total plant height and height to first capsule the tallest one was Ziada 94 (129.000 and 83.167 cm respectively). Nal. 06. Sc 31 and Mtwara 09 showed the highest first branch compared to others and Nal. 06. Sc 91 showed the shortest first branch (21.5 cm). For capsules per plant, Nal.06.Sc 04 genotype showed highest number of capsules per plant followed by Mtwara 09 while Nal. 06. Sc 31 showed the lowest number of capsule per plant followed by Lindi 02. The one which had lowest 1000 seed weight was Nal. 06. Sc 31 (2.7 g) and the one which had highest 1000 seed weight was Ziada 94 (3.2g) followed by Nal. 06. Sc 91 (3.0 g).

4.3.4 Combined mean effects of genotypes for the various variables

Results obtained from combined analysis indicated that Nal.95.Sc.9.1 and Nal.95.Sc.5.1 took fewest days to 50% flowering compared to others (Table 12). However, of these, Ziada 94 took most days to 50% flowering and differs significantly from the rest which did not differ. Ziada 94 showed highest total plant height, height to first branch and height to first capsule compared to others and Nal.95.Sc.5.1 showed shortest total plant height and height to first capsule. Nal. 06. Sc 91 showed the shortest height to first branch followed by Nal.95.Sc.5.1. For number of capsules per plant Ziada 94 showed highest number of capsules per plant (37.2) while Lindi 02 showed the lowest number of capsules per plant (27.1). Results showed that Nal. 06. Sc 91, Ziada 94, Nal. 95. Sc. 9.1, Nal. 95. Sc. 5.1 and Mtwara 09 had highest 1000 seed weight (3.0 g) followed by Ziada 94 (3.0 g) and the lowest one was Lindi 02 (2.9 g) followed by Nal. 06. Sc 31 (2.9 g) (Table 12). However 1000 seed weight did not differ significantly between genotypes.

4.4 Combined means of GxE interactions for different growth variables that have showed significant interaction

4.4.1 Combined means of GxE interactions for seed yield variable

Nal. 06. Sc 31 gave highest seed yield (662.0 kg/ha) at Nachingwea followed by Mtwara 09 at Tunduru (610.2 kg/ha). The least seed yield mean was 187.3 kg/ha for Lindi 02 followed by 187.7 kg/ha for Nal.95.Sc.5.1 and 190.7 kg/ha for Ziada 94. For Naliendele varieties behaved highly different compared to the other two sites and also showed low yield.

Table 15: Combined means of GxE interaction for seed yield (kg/ha)

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±15.67
Ziada 94	190.7	7	511.0	4	398.3	2	366.67
Nal.06.Sc 04	195.3	5	453.0	5	265.3	9	304.56
Nal. 06.Sc 91	192.7	6	446.7	6	380.3	3	339.89
Nal. 06.Sc 31	205.0	1	662.0	1	318.7	6	395.22
Nal.95.Sc.9.1	197.2	4	582.0	2	379.7	4	386.28
Nal.95.Sc.5.1	187.7	8	428.0	7	329.0	5	314.89
Lindi 02	187.3	9	371.5	9	269.3	8	276.06
Mtwara 09	200.2	3	531.2	3	610.2	1	447.17
Nal. 06.Sc 49	201.7	2	421.7	8	284.7	7	302.67
Mean	195.3		489.7		359.5		
SE±	2.39		31.56		20.36		
$LSD_{0.05}$	143.46						

4.4.2 Combined means of GxE interactions for days to 50% flowering variable

Combined data for days to 50% flowering are shown in Table 16. The earliest flowering was obtained with Mtwara 09 (50 days) followed by Nal. 06.Sc 49 (52 days) both at Naliendele while the latest flowering was with Ziada 94 (67 days and 64 days) at Nachingwea and Naliendele respectively.

Table 16: Combined means of GxE interaction for days to 50% flowering

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±0.39
Ziada 94	64.33	1	67.67	1	56.67	3	62.89
Nal.06.Sc 04	52.33	6	57.00	6	56.00	6	55.11
Nal. 06.Sc 91	55.17	2	59.17	4	55.50	7	56.61
Nal. 06.Sc 31	52.33	7	60.33	3	56.50	4	56.39
Nal.95.Sc.9.1	54.33	3	55.67	9	54.50	8	54.83
Nal.95.Sc.5.1	53.00	5	55.67	8	56.50	5	55.06
Lindi 02	53.67	4	59.17	5	57.17	1	56.67
Mtwara 09	50.33	9	61.17	2	54.33	9	55.29
Nal. 06.Sc 49	52.00	8	56.17	7	57.17	2	55.11
Mean	54.17		59.11		56.04		
SE±	0.55		0.83		0.41		
$LSD_{0.05}$	3.75						

4.4.3 Combined means of GxE interactions for plant height variable

The tallest plant height (167.67 cm) was recorded at Nachingwea followed by 132.93 cm at Naliendele for Ziada 94. The shortest genotype was recorded at Naliendele (86.72 cm) for Nal.95.Sc.5.1 followed by Nal.95.Sc.9.1 (98.65 cm) at Tunduru (Table 17).

Table 17: Combined means of GxE interaction for Plant Height (cm)

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±1.59
Ziada 94	132.93	1	167.67	1	128.90	1	143.20
Nal.06.Sc 04	107.80	2	124.58	8	103.28	5	111.91
Nal. 06.Sc 91	103.57	5	126.67	6	102.45	7	110.91
Nal. 06.Sc 31	106.65	4	130.42	4	108.18	4	115.02
Nal.95.Sc.9.1	94.60	7	130.83	3	98.65	9	108.09
Nal.95.Sc.5.1	86.72	9	126.25	7	103.00	6	105.27
Lindi 02	99.78	6	128.33	5	101.98	8	109.98
Mtwara 09	93.70	8	121.40	9	117.87	2	111.03
Nal. 06.Sc 49	107.78	3	131.92	2	109.65	3	116.40
Mean	103.73		132.01		108.22		
SE±	2.44		2.20		1.90		
$LSD_{0.05}$	12.99						

4.4.4 Combined means of GxE interactions for height to first branch variable

The tallest one to first branch was Ziada 94 at Nachingwea followed by the same genotype at Naliendele (Table 18). The shortest one was 18.92 cm for Nal.06.Sc 04 at Naliendele.

Table 18: Combined means of GXE interaction for Height to first branch (cm)

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±1.16
Ziada 94	50.15	1	72.75	1	39.52	3	54.19
Nal.06.Sc 04	18.92	9	39.75	7	31.45	4	30.17
Nal. 06.Sc 91	19.85	8	37.83	9	21.58	9	26.39
Nal. 06.Sc 31	24.77	3	44.33	3	41.83	1	37.03
Nal.95.Sc.9.1	20.07	7	42.83	4	25.87	6	29.58
Nal.95.Sc.5.1	20.97	6	38.33	8	23.23	7	27.49
Lindi 02	21.32	5	42.58	5	22.88	8	28.91
Mtwara 09	25.57	2	42.08	6	39.92	2	35.83
Nal. 06.Sc 49	21.85	4	44.67	2	26.95	5	31.12
Mean	24.83		45.02		30.36		
SE±	1.78		1.79		1.29		
$LSD_{0.05}$	9.47						

4.4.5 Combined means of GxE interactions for Height to first capsule variable

Ziada 94 showed the highest height to first capsule at all sites; however Nachingwea recorded the tallest one (125.70 cm) followed by Naliendele (95.93 cm). The shortest one was recorded at Naliendele (48.00 cm) for Nal.95.Sc.5.1. However, Nal.95.Sc.9.1 showed consistently fairly similar height for both Naliendele and Tunduru (Table 19).

Table 19: Combined means of GxE interaction for height to first capsule (cm)

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±1.42
Ziada 94	95.93	1	125.70	1	83.23	1	101.60
Nal.06.Sc 04	54.45	4	68.58	7	54.72	4	59.23
Nal. 06.Sc 91	53.73	5	65.83	9	53.50	5	57.69
Nal. 06.Sc 31	54.45	3	71.33	4	63.83	3	63.36
Nal.95.Sc.9.1	49.95	8	72.17	2	48.75	9	56.93
Nal.95.Sc.5.1	48.00	9	66.08	8	50.23	8	54.81
Lindi 02	52.32	7	70.92	5	51.02	7	58.13
Mtwara 09	52.90	6	72.00	3	69.27	2	64.69
Nal. 06.Sc 49	55.12	2	69.38	6	52.57	6	59.00
Mean	57.48		75.78		58.57		
SE±	2.13		2.59		1.80		
$LSD_{0.05}$	8.37						

4.4.6 Combination means of GXE interactions for capsules per plant variable

The one which had highest number of capsules per plant was Ziada 94 (48) followed by 43 for Nal. 06. Sc 91 both at Nachingwea. The least one for number of capsules per plant was Mtwara 09 (20) at Naliendele.

Table 20: Combined means of GxE interaction for capsules per plant

Genotypes	Naliendele	Rank	Nachingwea	Rank	Tunduru	Rank	Mean ±1.00
Ziada 94	27.57	1	47.92	1	36.22	3	37.22
Nal.06.Sc 04	22.33	6	38.60	4	38.50	1	33.14
Nal. 06.Sc 91	25.10	2	42.68	3	35.28	5	34.32
Nal. 06.Sc 31	22.93	4	37.23	6	24.68	9	28.28
Nal.95.Sc.9.1	22.88	5	44.23	2	35.12	4	34.15
Nal.95.Sc.5.1	20.93	7	38.57	5	33.08	6	30.83
Lindi 02	20.78	8	34.08	9	26.10	8	27.12
Mtwara 09	20.10	9	34.63	8	38.22	2	31.02
Nal. 06.Sc 49	23.15	3	36.45	7	30.55	7	30.09
Mean	22.86		39.38		33.08		
SE±	1.05		1.81		1.40		
$LSD_{0.05}$	12.05						

4.4.7 Combined means of GxE interactions for 1000 seed weight variable

For 1000 seed weight, the heaviest seed was recorded for Ziada 94 at Tunduru (3.150 g) followed by 3.133 g for Nal. 06. Sc 49 at Nachingwea and the lightest was recorded at Tunduru (2.717 g) for Nal. 06. Sc 31 followed by Nal.95.Sc.5.1 (2.833 g) at Nachingwea (Table 21).

4.6 Effects of yield components on seed yield

Yield is a very complex entity and is influenced by its various components, directly as well as indirectly through other variables (Fig. 5). Results for path coefficient and correlation analysis are shown in Table 23. Days to 50% flowering had direct positive effect (0.219) on seed yield and positive correlated (0.357***) with yield. Total plant height was positively correlated with seed yield (r = 0.370***) mainly due to its positive indirect effect (0.395) through height to first branch resulting to a significant positive correlation with yield. Height to first branch showed positive correlation with seed yield (r = 0.447***) that resulted from its positive direct effect (0.51) and positive indirect effect through days to 50% flowering (0.112). However, the negative indirect effect (-0.298) through height to first capsule reduced the total correlation to lower level (0.447***) though significant. The positive correlation (r = 0.341***) between height to first capsule and seed yield was predominantly due to its indirect effect (0.438) through height to first branch. However, the direct effect of height to first capsule on yield was negative and high (-0.348). Number of capsules per plant was positively correlated with yield (0.297**), this was predominantly due to its positive direct effect (0.12) and positive indirect effect (0.203) through height to first branch. However, the indirect effect through height to first capsule was negative (-0.130). The residual effect was quite high probably due to sampling error in the experiment and other variables which were not included in the model.

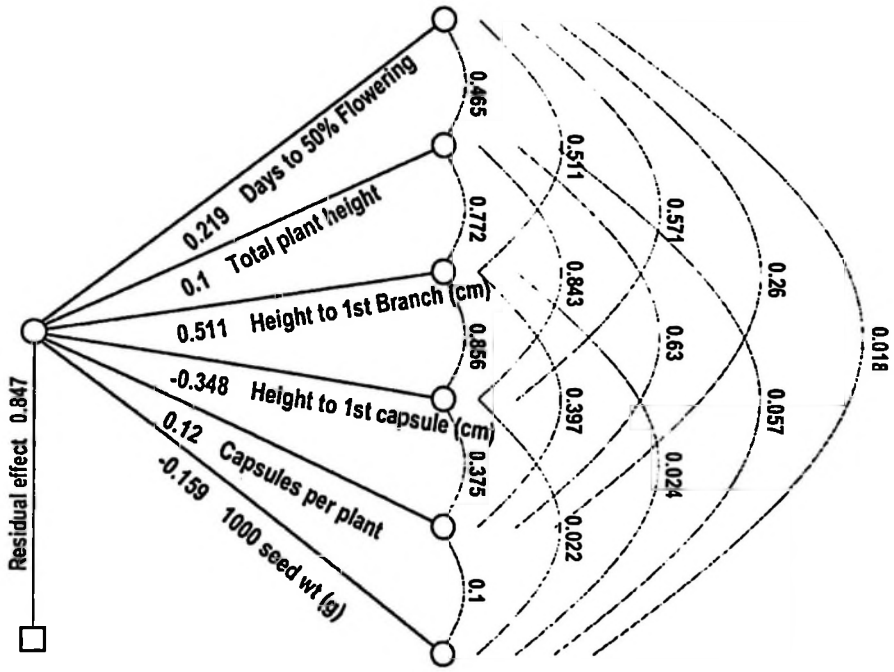


Figure 5: Path diagram showing causal relationships among growth and yield traits

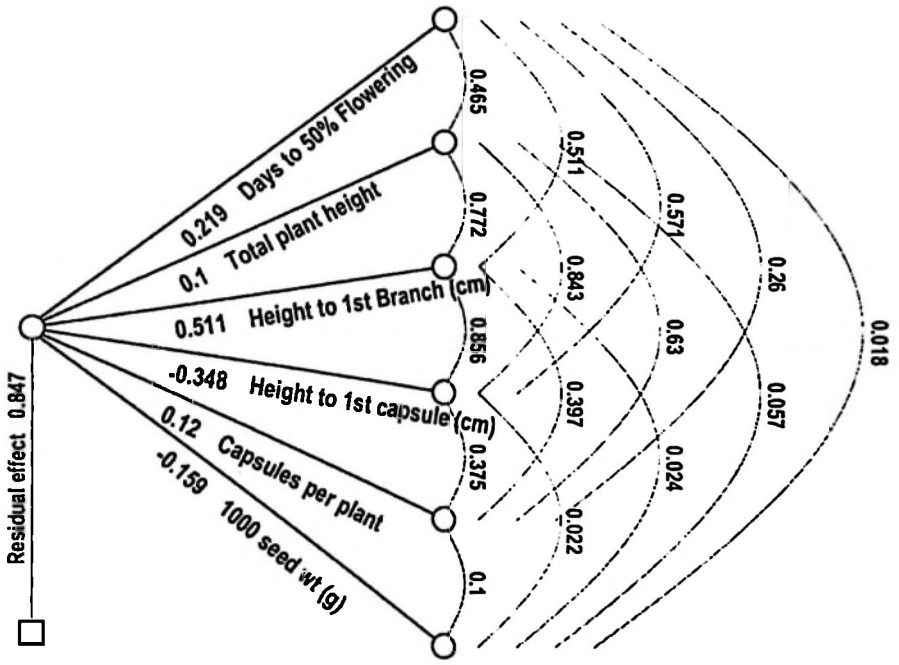


Figure 5: Path diagram showing causal relationships among growth and yield traits

Table 23: Path-coefficients analysis showing direct and indirect effects of six variables on yield (along diagonal are the direct effects)

Variables		1	2	3	4	5	6
1	Days to 50% Flower	**0.219**	0.102	0.112	0.125	0.057	0.004
2	Total plant height	0.047	**0.100**	0.078	0.085	0.063	0.006
3	Height to 1st Bran	0.261	0.395	**0.512**	0.438	0.203	0.012
4	Height to 1st caps	-0.199	-0.293	-0.298	**-0.348**	-0.130	-0.008
5	Capsules per plant	0.031	0.076	0.048	0.045	**0.120**	0.012
6	1000 sced wt (g)	-0.003	-0.009	-0.004	-0.004	-0.016	**-0.159**
	Genotypic Correlation	0.357***	0.370***	0.447***	0.341***	0.297**	-0.133
	Residual effect (P_{X7})						**0.847**

4.7 Estimates of variance components, coefficient of variation, heritability (broad sense) and expected genetic advance for sesame traits studied

Estimates of variance components and heritability of tested genotypes combined over three locations are presented in Table 24. The estimates of genetic variance (δ^2g) were relatively small for most of the variables as compared to their corresponding phenotypic variances (δ^2ph). It is however, important to note that absolute values of location variances (δ^2l) are low for most of variables except for 1000 seed weight as compared to their corresponding phenotypic variances. Genotypic coefficient of variation (GCV) was small for all variables as compared to their phenotypic coefficient of variation (PCV). The expected genetic advance (EGA) was relatively medium for seed yield followed by capsules per plant and height to first branch. Days to 50% flowering showed low genetic variance (2%), followed by height to first capsule and total plant height. The heritability (h^2) was moderate for total plant height (38%) followed by capsule per plant (29%); while it was low for days to 50% flowering (12%) followed by height to first capsule (21%) (Table 24).

Table 24: Estimates of parameters of variability for yield and its components for sesame genotypes tested at three locations in Southern zone during 2011/2012 season

Variable	Mean	$\delta^2 g$	$\delta^2 ph$	$\delta^2 l$	GCV (%)	PCV (%)	$h^2(b)$	EGA (%)
Seed yield	348.15	10607.86	42107.67	31499.80	29.58	58.94	0.25	30.59
Days to 50% flowering	56.44	2.86	23.44	20.58	2.10	8.58	0.12	2.16
Total Plant height	114.65	154.59	401.68	247.10	10.85	17.48	0.39	13.86
Height to first branch	33.41	55.52	205.61	150.09	22.30	42.92	0.27	23.87
Height to first capsule	63.94	63.60	297.85	234.25	12.47	26.99	0.21	11.87
Capsule per plant	31.80	47.28	164.11	116.83	21.63	40.29	0.29	23.91
1000 seed weight	2.96	-0.00	0.076	0.08	1.87	9.28		

Key: $\delta^2 g$ =Component of variance due to genotypes, $\delta^2 ph$ =Component of variance due to phenotypes, $\delta^2 l$ =Component of variance due to environments, $h^2(b)$ =heritability (broad sense), GCV (%) =Genotypic coefficient of variation, PCV (%) =Phenotypic coefficient of variation, EGA (%)=Expected genetic advance

4.8 Stability parameters for studied variables

4.8.1 Seed yield stability parameters

Results from stability analysis on seed yield variables are shown in Table 25. Lind 02 showed significant response (b) with changing of environments. The variances of deviation from regression were generally high ranging from -1080.6 (Nal. 06. Sc 49) to 26230.1 (Mtwara 09). Most of the genotypes had high coefficients of determination (R^2), ranging from 61% (Nal.95.Sc.5.1) to 94% Lindi 02 while Mtwara 09 had lowest values (42%).

Table 25: Regression of seed yield for each genotype across locations

Genotypes	Mean(kg/ha)	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	366.7	1.5	8	1.2	16874.5 **	8	0.5	0.72
Nal.06.Sc 04	304.6	0.8	3	0.5	91.3	1	-0.2*	0.73
Nal. 06.Sc 91	339.9	0.9	2	0.6	-1980.7	4	-0.1**	0.87
Nal. 06.Sc 31	395.2	1.5	7	1.2	2031.4	5	0.5	0.88
Nal.95.Sc.9.1	386.3	1.5	9	1.2	4907.4	7	0.5	0.86
Nal.95.Sc.5.1	314.9	0.6	5	0.3	1097.3	3	-0.4	0.61
Lindi 02	276.1	0.7*	4	0.4	-4668.9	6	-0.3*	0.95
Mtwara 09	447.2	1.0	1	0.7	26230.1 ***	9	0.005	0.42
Nal. 06.Sc 49	302.7	0.6	6	0.3	-1080.6	2	-0.4	0.67

Table 26: Means for seed yield (kg/ha)

Code	Variety	Env. 1	Env. 2	Env. 3	Env. 4	Env. 5	Env. 6
A	1 Variety	192.00	825.33	465.33	189.33	196.67	331.33
B	2 Variety	200.67	492.00	208.67	190.00	414.00	322.00
C	3 Variety	204.00	570.67	353.33	181.33	322.67	407.33
D	4 Variety	216.00	754.00	382.00	194.00	570.00	255.33
E	5 Variety	195.33	840.00	429.33	199.00	324.00	330.00
F	6 Variety	193.33	374.67	355.33	182.00	481.33	302.67
G	7 Variety	200.00	442.33	313.33	174.67	300.67	225.33
H	8 Variety	222.33	462.00	707.67	178.00	600.33	512.67
I	9 Variety	216.00	393.33	281.67	187.33	450.00	287.67
Environmental	**Index**	**-143.75**	**224.55**	**40.36**	**-161.97**	**58.48**	**-17.67**

4.8.2 Days to 50% flowering

Most of genotypes studied on average responded with changing environments except for Nal.95.Sc.9.1 which responded below average with changing environments (Table 27). The variances of deviation were generally low except for Ziada 94 which was high and

significant with changing environments, this was reflected in the low coefficient of determination value (30%). For coefficients of determination, Nal. 06.Sc 31 showed highest value (88%) followed by 81% (Mtwara 09) and Ziada 94 recorded lowest coefficient of determination (30%) followed by Nal.95.Sc.9.1 (36%).

Table 27: Regression of days to 50% flowering for each genotype across locations

Genotypes	Code	Mean	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	A	62.89	1.63	7	1.1	43.64 ***	9	0.6*	0.30
Nal.06.Sc 04	B	55.11	0.81	3	0.3	-1.11	2	-0.2	0.67
Nal. 06.Sc 91	C	56.61	1.13	2	0.6	-0.12	1	0.1	0.74
Nal. 06.Sc 31	D	56.39	1.38	5	0.9	-1.68	5	0.4	0.88
Nal.95.Sc.9.1	E	54.83	0.22*	8	-0.3	-2.93	8	-0.8**	0.36
Nal.95.Sc.5.1	F	55.06	0.41	6	-0.1	-1.28	4	-0.5	0.36
Lindi 02	G	56.67	0.88	1	0.4	1.28	3	-0.1**	0.55
Mtwara 09	H	55.28	1.81	9	1.3	2.10	6	0.8*	0.81
Nal. 06.Sc 49	I	55.11	0.74	4	0.2	2.36	7	-0.2	0.41

4.8.3 Total plant height

Stability parameters of total plant height of 9 sesame genotypes evaluated at three environments are presented in Table 28. Regression co-efficients ranged from 1.018 (Lindi 02) to 1.391 (Ziada 94). Three genotypes (Ziada 94, Nal.95.Sc.9.1 and Nal.95.Sc.5.1) had regression coefficients greater than 1.0. However, five genotypes viz; (Nal.06.Sc 04, Nal. 06. Sc 91, Nal. 06. Sc 31, Mtwara 09 and Nal. 06. Sc 49) had regression coefficients of less than 1.0. Genotype Lindi 02 had regression coefficients close to unit (b = 1.02). Most of genotypes recorded high coefficients of determination above 55%.

Table 28: Regression of total plant height for each genotype across locations

Genotypes	Code	Mean	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	A	143.2	1.39	9	1.2	40.1	8	0.4	0.86
Nal.06.Sc 04	B	111.9	0.74	8	0.5	-18.3	2	-0.3	0.85
Nal. 06.Sc 91	C	110.9	0.92	3	0.7	-33.0	6	-0.1*	0.95
Nal. 06.Sc 31	D	115.0	0.88	4	0.7	-24.5	3	-0.1*	0.91
Nal.95.Sc.9 .1	E	108.1	1.19	6	1.0	-14.6	1	0.2	0.93
Nal.95.Sc.5 .1	F	105.3	1.13	5	0.9	30.4	5	0.1	0.82
Lindi 02	G	110.0	1.02	1	0.8	-38.2	7	0.02	0.99
Mtwara 09	H	111.0	0.78	7	0.6	85.2 *	9	-0.2	0.55
Nal. 06.Sc 49	I	116.4	0.95	2	0.8	27.6	4	-0.1	0.77

4.8.4 Height to first branch

For height to first branch regression coefficients ranged from 0.698 to 1.495. The one which showed regression coefficients less than the average was Mtwara 09 (0.698) and Ziada 94 showed higher regression coefficients than the average. Nal. 06. Sc 91 had regression coefficients close to unity (0.907) (see Table 29). The variance of deviation recorded highly significant value for Ziada 94 while high coefficients of determination for most genotypes ranged from 57% to 95%.

Table 29: Regression of height to first branch for each genotype across locations

Genotypes	Code	Mean	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	A	54.19	1.50	9	1.2	162.79 ***	9	0.5*	0.57
Nal.06.Sc 04	B	30.17	0.89	5	0.6	3.58	1	-0.1	0.77
Nal. 06.Sc 91	C	26.40	0.91	1	0.7	-10.87	2	-0.1**	0.88
Nal. 06.Sc 31	D	37.03	0.78	7	0.5	28.59	8	-0.2	0.57
Nal.95.Sc. 9.1	E	29.58	1.10	2	0.8	-12.62	5	0.1	0.93
Nal.95.Sc. 5.1	F	27.49	0.89	4	0.6	-11.53	3	-0.1**	0.89
Lindi 02	G	28.91	1.10	3	0.8	-14.67	6	0.1	0.94
Mtwara 09	H	35.83	0.70	8	0.4	11.94	4	-0.3	0.61
Nal. 06.Sc 49	I	31.12	1.15	6	0.9	-15.62	7	0.2	0.95

4.8.5 Height to first capsule

Stability parameters of height to first capsule of 9 sesame genotypes evaluated in three environments are presented in Table 30. Nal.06. Sc 91 and Nal.95.Sc.9.1 showed high and significant value of regression coefficient with changing environments. Lindi 02 had regression coefficient close to unit (1.047). Ziada 94 and Mtwara 09 recorded significant variances of deviation. Most genotypes recorded high coefficients of determination except for Mtwara 09 which recorded 43%.

Table 30: Regression of height to first capsule for each genotype across locations

Genotypes	Code	Mean	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	A	101.60	2.04	9	1.7	81.85 ***	9	1.0	0.82
Nal.06.Sc 04	B	59.23	0.83	3	0.5	-6.95	3	-0.2	0.87
Nal. 06.Sc 91	C	57.69	0.66*	8	0.4	-12.07	4	-0.3*	0.89
Nal. 06.Sc 31	D	63.36	0.72	6	0.4	13.14	6	-0.3	0.65
Nal.95.Sc.9.1	E	56.93	1.27*	5	1.0	-15.00	7	0.3*	0.99
Nal.95.Sc.5.1	F	54.81	0.93	2	0.6	-3.97	2	-0.1*	0.87
Lindi 02	G	58.13	1.05	1	0.7	-12.78	5	0.1**	0.96
Mtwara 09	H	64.69	0.69	7	0.4	52.23**	8	-0.3	0.43
Nal. 06.Sc 49	I	59.00	0.82	4	0.5	-2.47	1	-0.2	0.83

4.8.6 Number of capsules per plant

Nal.06.Sc 04 recorded regression coefficient close to the unit (1.02) followed with Nal. 06. Sc 49 (0.97) and Mtwara 09 (1.09). The one which showed the lowest value of variance of deviation was Mtwara 09 followed by Nal. 06. Sc 31 and Ziada 94 (Table 31). Most genotypes recorded high values of coefficient of determination except Nal. 06. Sc 31 (49%).

Table 31: Regression of capsules per plant for each genotype across locations

Genotypes	Code	Mean	b-value	Rank	SE_b	S^2d	Rank	b-1	R^2
Ziada 94	A	37.23	1.11	5	0.8	14.11	3	0.1	0.65
Nal.06.Sc 04	B	33.14	1.03	1	0.8	-21.18	6	0.02	0.83
Nal. 06.Sc 91	C	34.32	1.17	6	0.9	-31.20	9	0.2	0.93
Nal. 06.Sc 31	D	28.28	0.67	9	0.4	-2.05	2	-0.3	0.49
Nal.95.Sc.9.1	E	34.15	1.29	8	1.0	-29.62	7	0.3	0.93
Nal.95.Sc.5.1	F	30.83	0.90	4	0.6	-16.00	4	-0.1	0.74
Lindi 02	G	27.12	0.78	7	0.5	-30.97	8	-0.2	0.86
Mtwara 09	H	31.02	1.09	3	0.8	1.58	1	0.1	0.70
Nal. 06.Sc 49	I	30.09	0.97	2	0.7	-19.51	5	-0.03	0.80

4.9 Relationships among stability parameters for seed yield and yield components

4.9.1 Relationship between b-value and seed yield mean

Genotypes H (Mtwara 09) and G (Lindi 02) responded on average with yield above and below average respectively. On the other hand, H (Mtwara 09) had high yield mean and regression coefficient approaching 1 and C (Nal. 06. Sc 91) had regression coefficient approaching unit and intermediate yield (Fig. 6).

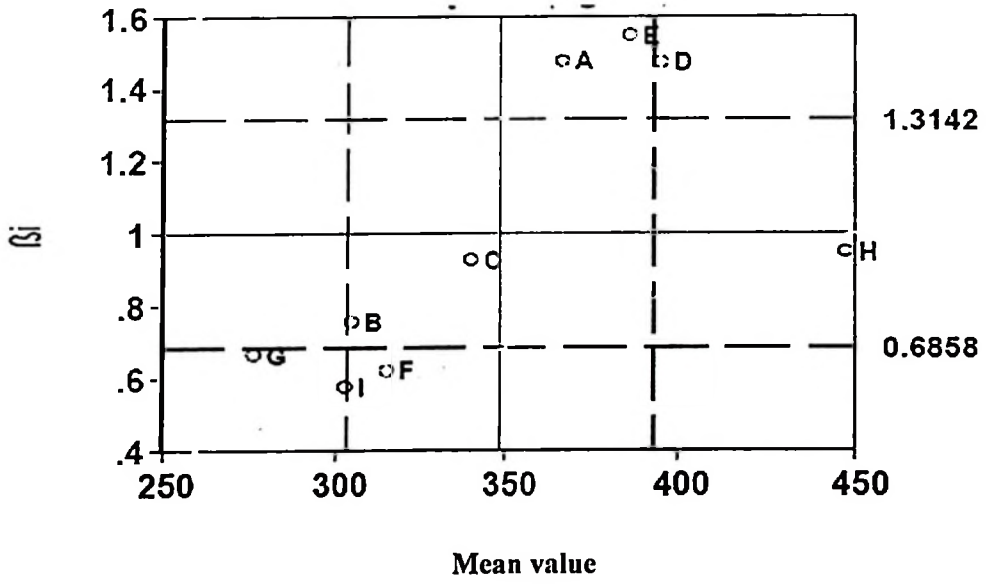


Figure 6: Diagram of b-value versus seed yield (kg/ha) mean

4.9.2 Relationship between variance of deviation (s^2d) and b-value for seed yield variable

Diagram of s^2d against b-value on seed yield (Fig. 7) indicates that 2 (Nal.06.Sc 04) had low variance of deviation and b value approaching one (0.758) and 3(Nal. 06. Sc 91) had low variance of deviation and b value approaching unit (0.929), therefore these genotypes showed high stability. Genotype viz; 8 (Mtwara 09) had b value close unity (0.950) but low stability due to high value of variance of deviation.

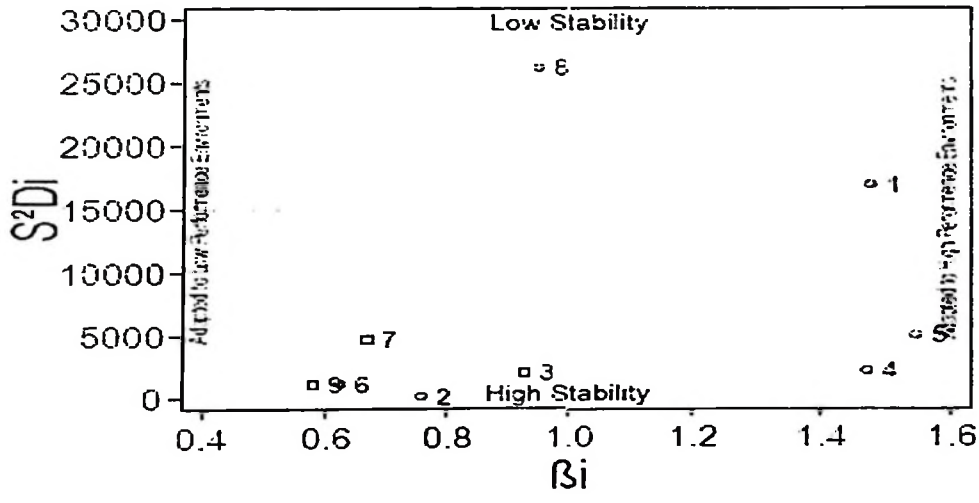
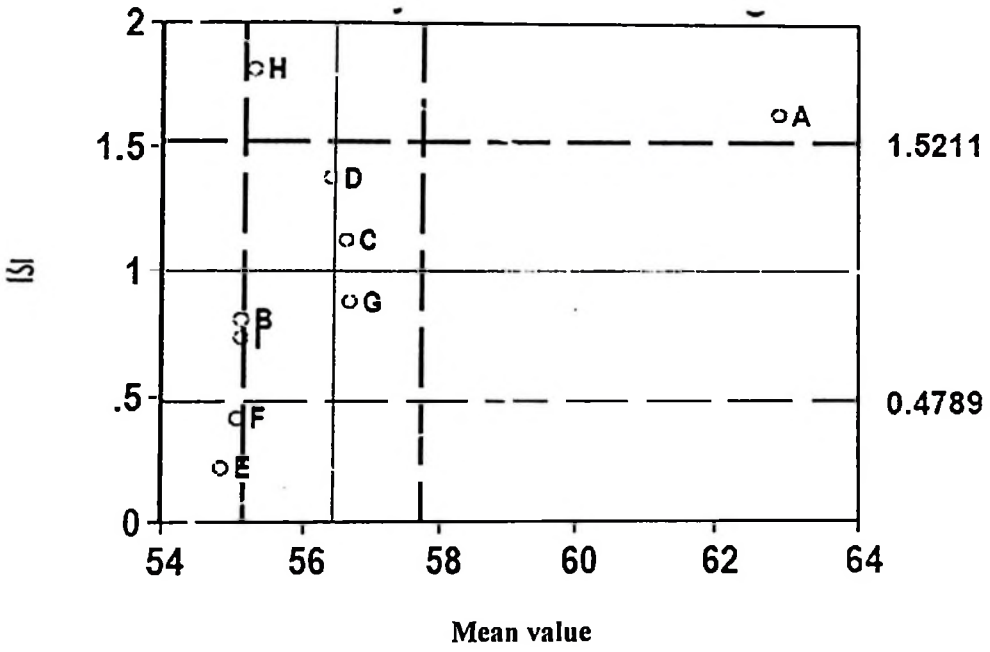


Figure 7: Diagram of s^2d against b-value for seed yield

4.9.3 Relationship between b-value and days to 50% flowering

Diagram showing relationship between regression coefficients and mean days to 50% flowering showed that A (Ziada 94) was a late maturing genotype, on the other hand G (Lindi 02) was early maturing and had regression coefficient approaching 1(Fig.8). Other earliest genotypes are H (Mtwara 09), B (Nal. 06. Sc 04), F (Nal. 95. Sc. 5.1) and E (Nal. 95. Sc. 9.1).



'igure 8: Diagram of b-value against days to 50% flowering mean

.9.4 Relationship between variance of deviation (s^2d) and b-value for days to 50% flowering variable

ienotypes viz; Lindi 02 (7), Nal.06.Sc 04 (2) and Nal. 06. Sc 91(3) showed low variance f deviation and regression coefficient approaching unit value. Ziada 94 (1) showed low ability (Fig. 9).

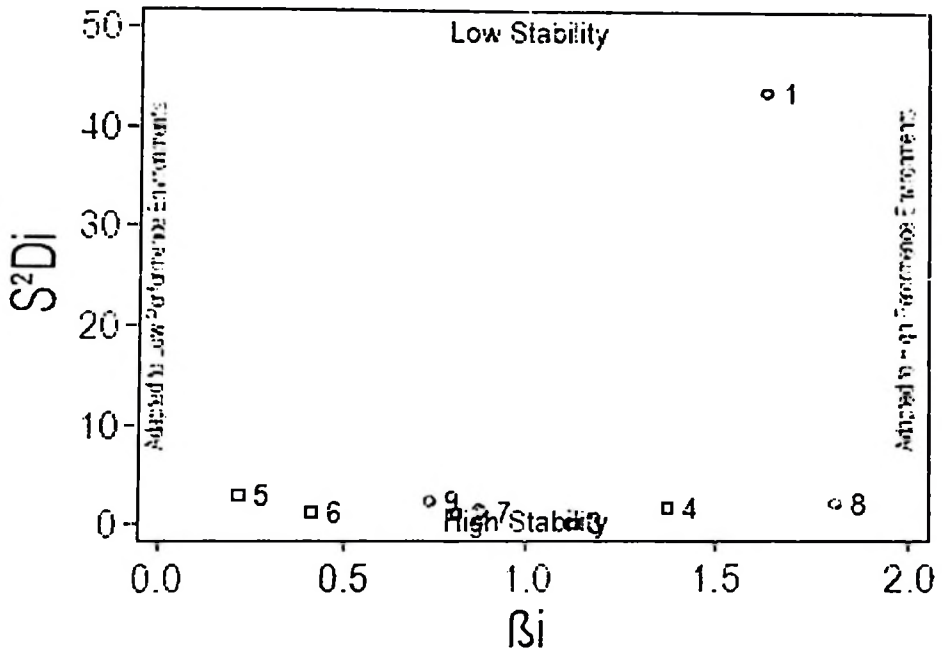


Figure 9: Diagram of s^2d against b-value for days to 50% flowering

4.9.5 Relationship between b-value and total plant height

Diagram (Fig. 10) indicates that G (Lindi 02) had relatively b- value close to unit value and had low mean for total plant height (short genotype) and the one with highest plant height was A (Ziada 94). F (Nal.95.Sc.5.1) was the shortest one (Fig. 10).

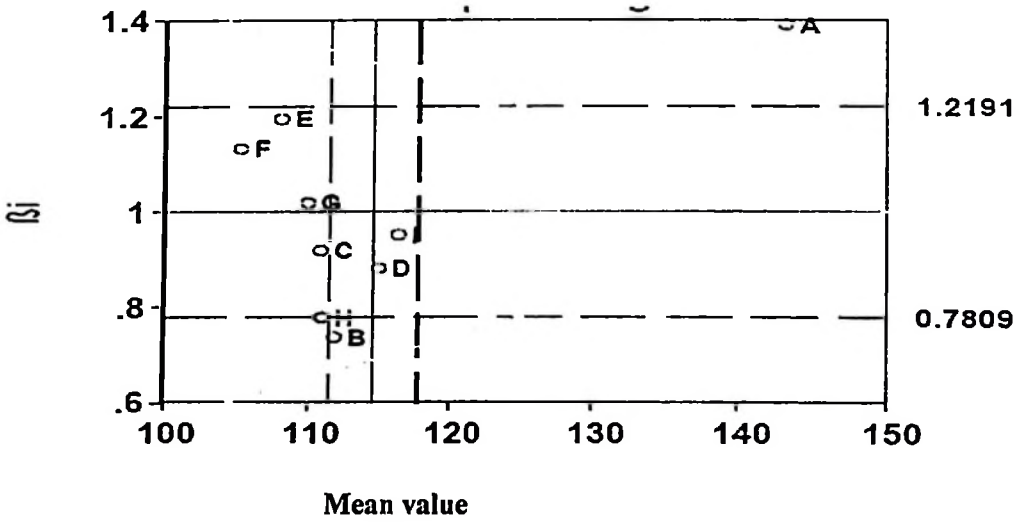


Figure 10: Diagram of b-value against total plant height mean

4.9.6 Relationship between variance of deviation (s^2d) and b-value for total plant height

Genotypes viz: 5 (Nal.95.Sc.9.1) and 2 (Nal.06.Sc 04) showed low variances of deviation. 7 (Lindi 02) had regression coefficient close to 1 (Fig 11).

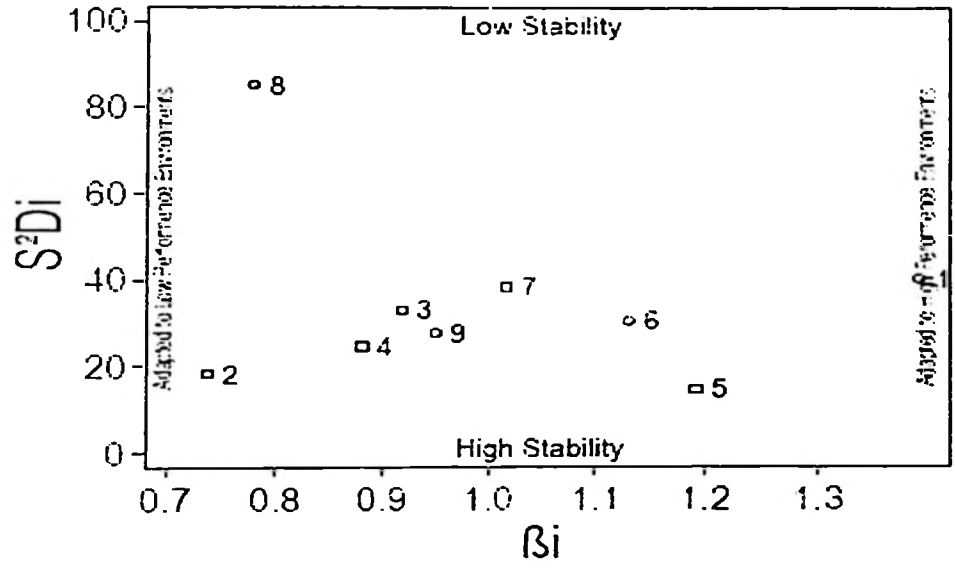


Figure 11: Diagram of s^2d against b-value for total plant height

4.9.7 Relationship between b-value and height to first branch

C (Nal. 06. Sc 91) had comparable regression coefficients value closer to 1 and shortest height to first branch. A (Ziada 94) was tallest to first branch (Fig. 12).

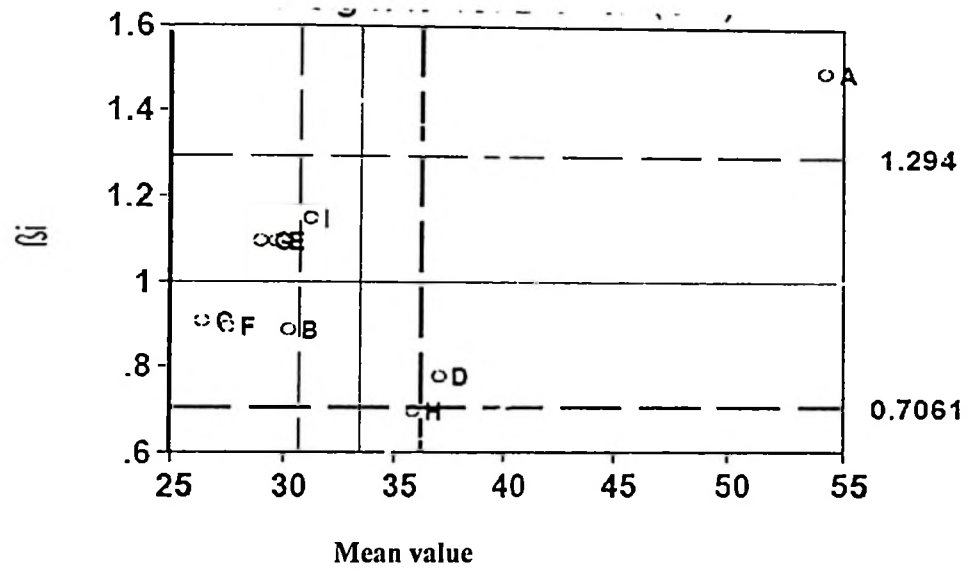


Figure 12: Diagram of b-value against height to first branch mean

4.9.8 Relationship between variance of deviation (s^2d) and b-value for height to first branch

2 (Nal.06.Sc 04) had low variance of deviation and its b value closer to 1 (0.89). Genotype viz; 9 (Ziada 94) had regression coefficient more than unit (Fig. 13).

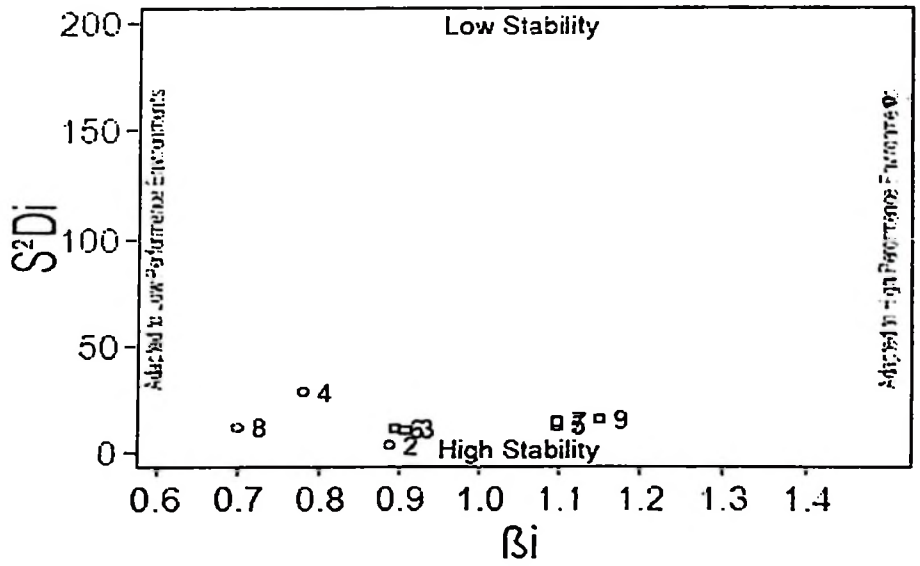
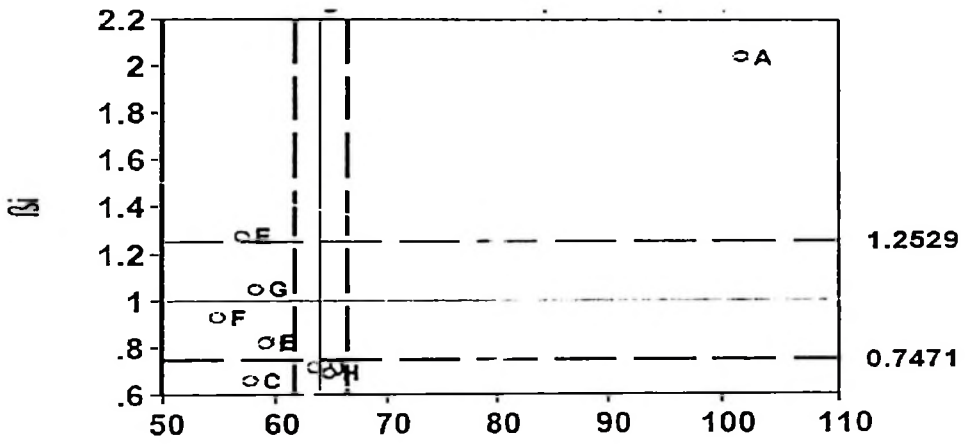


Figure 13: Diagram of s^2d against b-value for height to first branch

4.9.9 Relationship between b-value and height to first capsule

F (Nal.95.Sc.5.1) and G (Lindi 02) had regression coefficient close to unit and small height to first capsule(short) and A (Ziada 94) was taller with regression coefficient (Fig.14).



Mean value

Figure 14: Diagram of b-value against height to first capsule mean

4.9.10 Relationship between variance of deviation (s^2d) and b-value for height to first capsule

6 (Nal.95.Sc.5.1) and 7 (Lindi 02) had regression coefficient close to unit and low variance of deviation (Fig.15).

4.9.9 Relationship between b-value and height to first capsule

F (Nal.95.Sc.5.1) and G (Lindi 02) had regression coefficient close to unit and small height to first capsule(short) and A (Ziada 94) was taller with regression coefficient (Fig.14).

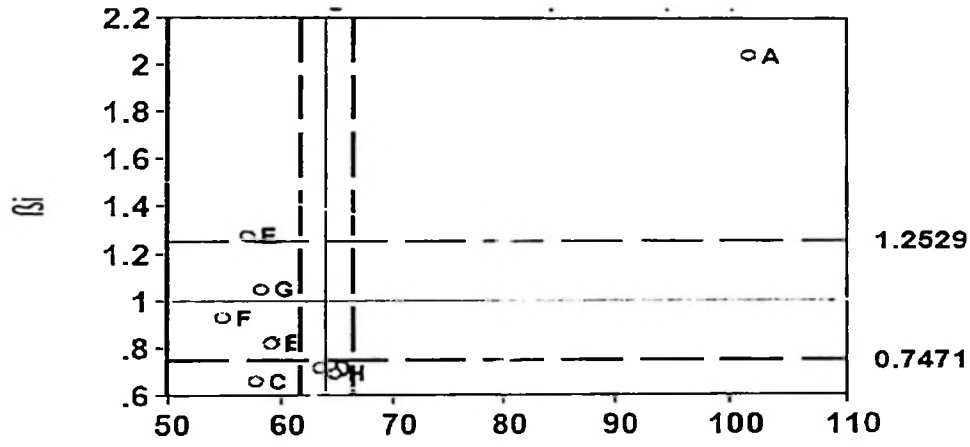


Figure 14: Diagram of b-value against height to first capsule mean

4.9.10 Relationship between variance of deviation (s^2d) and b-value for height to first capsule

6 (Nal.95.Sc.5.1) and 7 (Lindi 02) had regression coefficient close to unit and low variance of deviation (Fig.15).

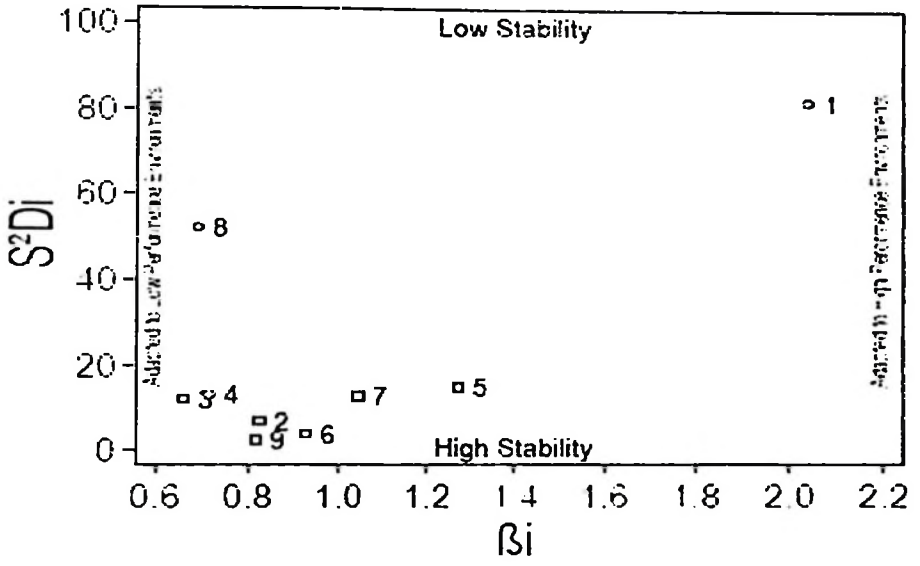


Figure 15: Diagram of s^2d against b-value for height to first capsule

4.9.11 Relationship between b-value and capsules per plant

Most genotypes had number of capsules per plant above the average mean value except for D (Nal. 06. Sc 31) and G (Lindi 02) which were below average for number of capsules per plant. B (Nal.06.Sc 04) had regression coefficient close to unit and number of capsules per plant above average. Genotypes E (Nal.95.Sc.9.1), C (Nal.06.Sc 91) and A (Ziada 94) had high means but regression coefficients deviate from unit (Fig. 16).

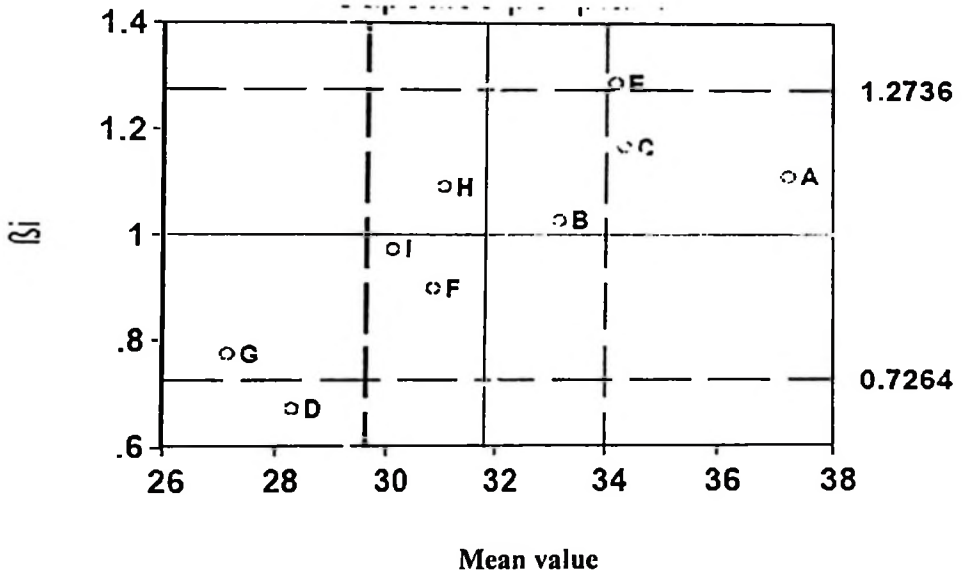


Figure 16: Diagram of b-value against capsule per plant mean

4.9.12 Relationship between variance of deviation (s^2d) and b-value for capsules per plant

Nal 06.Sc 31 had low variance of deviation and b value approaching unit. However, genotypes viz; 2 (Nal.06.Sc 04) had b value close to unit and genotypes viz; 8 (Mtwara 09) and 4 (Nal. 06. Sc 31) showed low variances of deviation (Fig. 17).

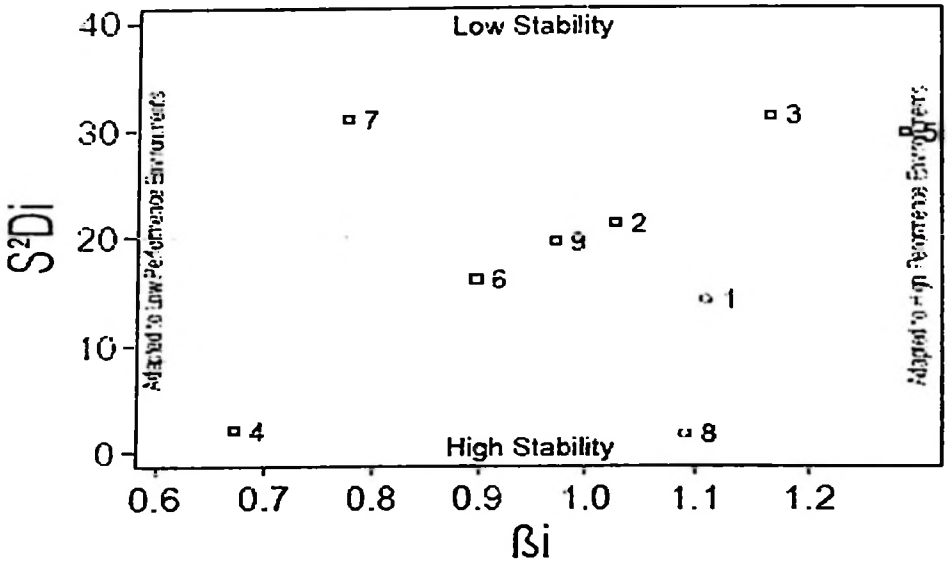


Figure 17: Diagram of s^2d against b-value for capsule per plant

CHAPTER FIVE

5.0 DISCUSSION

The study showed significant difference on yield potential and some yield components within and across locations, this indicating that there was genetic constitution disparity between genotypes, hence high scope for genetic improvement through selection of better varieties as source of genes. This study showed that Nachingwea is a good location for seed yield and Naliendele and Tunduru are not suitable area for sesame seed yield.

Performance of yield and yield components differed among genotypes and between locations due to existence of GXE interaction. The existence of G X E indicated that yield and some characters were unstable and fluctuated in their expression with change in environment and give a chance to evaluate the genotypes in several different production environments before recommending for farmers use (Abera *et al.*, 2004). However, from literature, plant populations that are grown in the same environmental condition are assumed to share similar environmental influences, and variation in performance that might occur would largely be due to genetic differences (Brown *et al.*, 1990). Based on this concept, a conclusive remark would be made from this study that variations in seed yield performance within locations were merely due to genetic disparity found between them; there were no significant differences in yield for spacing except when there were interactions with genotypes. This observed genetic diversity reflects potential of selection for genetic improvement and enhanced crop production (Fehr, 1987). The highly significant genotype x location x population interactions for yield observed, indicates that genotypes of sesame showed differential responses at different environments. Thus evaluation of genotypes should be done in specific combinations of the microenvironments.

For seed yield, Nal. 06.Sc 31 (395.22 kg/ha) and Mtwara 09 (447.17 kg/ha) were identified as superior yielding genotypes in combined analysis, they also showed reasonable good average yield performance at individual sites. These results conform to what has been reported by NARI technical report (2008/2009) which observed genotypic differences in sesame seed yield at Naliendele, Nachingwea and Ilonga. At Nachingwea (50x10 cm) had the largest environmental index of 224.549 and therefore the most suitable environment for realizing yield potential of genotypes. On the other hand Naliendele (50x 20 cm) recorded the least environmental index of-161.969 and hence the poorest environment. The variation of performance between locations was also reported by Zenebe *et al.* (2010).

For days to 50% flowering there were significant differences among genotypes indicating presence of variation among genotypes tested. The time taken to 50% flowering was shortest at Naliendele due to high temperatures while cool temperatures delayed the time to flowering. This explains as to why flowering days were longer at Nachingwea where temperature regimes were lower which were associated with high altitude (Appendix 2).

Genetic and environmental differences are essentially the key factors for phenotypic variability in plants performance and the manifestation of traits of agronomic importance is also a matter of concern (Benner and Miller, 2002). Seed yield levels were low, with an overall mean yield range of (195.296 kg/ha) at Naliendele (low altitude) while relatively high (359.500 kg/ha) at Tunduru (high altitude) and highest (489.667 kg/ha) at Nachingwea (medium altitude) due to differences in agro-climatic conditions as reflected by differences in altitude (Appendix 2). Also high seed yield at Nachingwea influenced by soil characteristics. Nachingwea soil has a characteristic to retain water compared to the soil of Naliendele which is sandy soil.

The phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all the characters studied, indicating that the environment had more important role in the expression of relationships in these characters. The traits, number of first branch, number of capsules per plant and seed yield per plant showed high PCV and GCV estimates. There is enough scope for selection based on these characters, and the diverse genotypes can provide materials for a sound breeding programme. Saravanan and Nadarajan (2003) and Solanki and Deepak (2003) reported high coefficient of variation for the number of capsules per plant. High coefficient of variation for number of capsules per plant was also reported by Vasline *et al.* (2000). Plant height and height to first capsule showed moderate PCV and GCV and the other traits recorded low PCV and GCV. Sudhakar et al. (2007) and Shadakshari *et al.* (1995) reported low phenotypic and genotypic coefficients of variation for the characters days to fifty per cent flowering, while Low co efficient of variation for 1000 seed weight was reported by Thangavel *et al.* (2000).

Estimates of variance components showed that the genetic variances (δ^2g) were relatively small for each of the variables as compared to the corresponding phenotypic variances (δ^2ph) indicating that the variables are highly influenced by environmental factors (δ^2l) than genetic differences among them.The estimates of PCV and GCV values give only the extent of variability existing for various traits, but does not give any information about the heritable portion of it. Therefore, estimates of heritability and genetic advance would give better idea about the possible gains from selection. A comparison of the data presented indicate that most of the characters had low heritability along with low genetic advance, such situation may arise due to non-additive gene action indicating greater influence of environments in the expression of these characters . Therefore, direct selection for improvement of these characters would be futile.

Correlation coefficient analysis measures the mutual relationship between various characters and is used to determine the component character on which selection can be done for improvement in yield. Most characters were positively significant and related to each other. The trait total plant height showed significantly positive correlation with the traits height to first branch, height to first capsule, number of capsules per plant, days to 50% flowering, these positive correlations showed possibility for simultaneous improvement of genotypes. Earlier reports of Kumar and Sundaram (2002) and Sankar and Kumar (2003) revealed the positive association of plant height with number of capsules per plant. Most traits recorded positive correlation with yield but 1000 seed weight showed negative association with yield and this was sacrificial association.

A perusal of results obtained in path analysis revealed that seed yield directly influenced by height to first branch (0.511) and height to first capsule (-0.348). Thus, if other variables are held constant increased height to first branch would increase yield while reduced height to first capsule would also increase yield. The positive relationships and contributions of days to 50% flowering, capsule per plant and total plant height influences seed yield. Results suggest that lateness and taller plant genotypes with height to first branch and shortest height to first capsule would be important for increased seed yield. However, short and earlier genotypes are more favourable for the Tanzania environment; due to unreliable rainfall patterns in the areas growing sesame. It is therefore important to compromise agronomic requirements of height and yield. According to Uzun and Cagirgan (2001; 2006) Total plant height is the most contributing character for seed yield in sesame because it has indeterminate growth habit. Although this wildish character prevents mechanized harvesting and the expansion of its cultivation, plant height provides permanent branching and capsule production. In the current results, total plant height showed positive direct effect on yield and the former was positively correlated with

Mtwara 09, Nal.06.Sc 91, Nal.06.Sc 04, Lindi 02, Nal.95.Sc.5.1 and Nal.06.Sc 49.These genotypes are adapted to low pereformance environments. The genotypes, Ziada 94, Nal. 06.Sc 31 and Nal.95.Sc.9.1 showed low means, regression coefficients more than unity thus are suitable for high performance environments. According to criteria of stability all genotypes don't meet those criteria because of high S^2d, therefore no stable genotype was identified for seed yield.

In this study, the coefficients of determination (R^2) ranged from 42% to 94% since the environmental sum of squares contributed to the regression sum of squares.

Osman (1991) showed serious concern in the interpretation of R^2, Reported that linear regressions accounted for 76-99% of the variation in sesame seed yield. Similarly, Adebisi and Ajala (2006) observed that linear regression accounted for 65%-125% of the variation in seed yield of Nigerian sesame genotypes. Also Adebisi and Moruf (2010) observed that linear regression contributed as much as between 07 and 91% of the variation in seed germination and between 01 and 89% in field emergence. In this study, linear regressions contributed as much as between 42% and 94% of the variation in seed yield.

In case of days to 50% flowering, B (Nal.06.Sc 04), G (Lindi 02) and I (Nal. 06. Sc 49) registered regression coefficient close to unity and non significant mean square deviation with shorter days to 50% flowering. The genotypes which showed regression coefficients of lower than unit value and non significant mean square deviation were E (Nal.95.Sc.9.1), F (Nal.95.Sc.5.1) and I (Nal.06.Sc 49). These genotypes are specifically adaptable to poor environments. Genotypes; C (Nal. 06. Sc 91), D (Nal. 06. Sc 31) and H (Mtwara 09) had regression coefficients more than unit value and non significant mean square deviation with short days to 50% flowering. These genotypes are specifically

adaptable to favourable environments. A (Ziada 94) had regression coefficient of more than unit value with longer days to 50% flowering and showed high and significant mean square deviation and it was adapted to more favourable environments. According to Eberhart and Russel (1966), a genotype considered as stable should meet criteria of optimum mean performance, with b equal to unity and S^2d approaching zero. Using these criteria, days to 50% flowering of genotype C (Nal. 06. Sc 91) with regression coefficients of 1.126, S^2d approaching zero (-0.1209) and with relatively short days to 50% to flowering of 57 could be considered widely adapted and stable

With respect to total plant height, B (Nal.06.Sc 04), C (Nal. 06. Sc 91), D (Nal. 06. Sc 31), H (Mtwara 09) and I (Nal. 06. Sc 49) had low regression coefficient with non significant variances of deviation. These genotypes are specifically adapted to low performance environments and all these are shorter genotypes. Genotypes A (Ziada 94), E (Nal.06.Sc 04), F (Nal.95.Sc.5.1) and G (Lindi 02) are suitable for high performance environments. But A (Ziada 94) had high mean value than average (tallest one) and G (Lindi 02) showed significant mean square deviation. All genotypes don't meet the criteria of S^2d approaching zero, therefore less stable. Genotypes, Lindi 02 and Nal. 06. Sc 49 have regression coefficient approaching one and genotypes Nal.06.Sc 04 and Nal.95.Sc 9.1 have low s^2d, intercrossing of these will give better combinations; therefore can get stable and short variety for these traits.

For results of stability for height to first branch, C (Nal. 06. Sc 91), B (Nal. 06. Sc 91), F (Nal.95.Sc.5.1) D (Nal. 06. Sc 31) and H (Mtwara 09) had low mean values with regression coefficients less than unit value and non-significant mean square deviation, therefore perform well under unfavourable environments. Ziada 94 had mean value above average with regression coefficient of more than unit value and genotypes: E

(Nal.95.Sc.9.1) and G (Lindi 02) had low mean values with regression coefficients of more than unit value. This genotype performs better under favourable environments. This study suggests that genotypes viz: 6 (Nal.95.Sc.5.1), 2 (Nal. 06. Sc 91), 7 (Lindi 02) and 3 (Nal. 06. Sc 91) could be crossed with 1 (Ziada 94) to get segregates that have short height to first branch, stable and having average response with changing environments. This is due to high positive correlation shown by height to first branch with seed yield. Short variety with high yield is more important because of shortage rainfall to the area grown.

With respect to height to first capsule, 6 (Nal.95.Sc.5.1), 2 (Nal. 06. Sc 91), 7 (Lindi 02) and 9 (Nal. 06. Sc 49) had regression coefficients close to unit value and had variances of deviation more than zero, therefore perform better under poor environments. Also 3 (Nal. 06. Sc 91), 4 (Nal. 06. Sc 31) and 8 (Mtwara 09) showed the adaptation to low performance environments as they had regression coefficient less than unit. Ziada 94 and 5(Nal.95.Sc.9.1) had regression coefficient above unit value, therefore perform better under favourable environments. Most of these genotypes had mean values below avarage except for D (Nal. 06. Sc 31), A (Ziada 94) and H (Mtwara 09) which had mean values above average.

With respect to number of capsules per plant, genotypes 2 (Nal. 06. Sc 91) and 9 (Nal. 06. Sc 49) showed mean values below average and had regression coefficients close to unit. 4 (Nal. 06. Sc 31), (Nal.95.Sc.5.1) and (Lindi 02) had regression coefficient below unit with mean value above average; therefore perform better under low performance environments. Genotypes viz; 1 (Ziada 94), 3 (Nal. 06. Sc 91), 5 (Nal.95.Sc.9.1) and 8 (Mtwara 09) had mean values above avarage and regression coefficienst more than unit. These genotypes are specifically adaptable to better environments. This study suggests

that genotypes viz: 4 (Nal.06.Sc.31) which has low s^2d could be crossed with 8 (Mtwara 09) which has b value approach unit and number of capsule per plant above average to get segregates that are short with high number of capsule per plant, stable and having average response to changing environments.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In the 2011/2012 season, a study was conducted at different locations to identify genotypes that perform consistently well across different environments and to determine genotypes x environment interaction effects on yield and yield components. The study identified that no genotype performed well across environments but breeding line Nal. 06. Sc 31 showed high yield at Naliendele and Nachingwea compared to Lindi 02 which was superior for these sites in previous years. At Tunduru, the released variety, Mtwara 09 showed highest yield. In a combined analysis these two varieties (Nal. 06. Sc 31, and Mtwara 09) also showed high yield performance. Naliendele site recorded the lowest seed yield mean of 187.33 kg/ha and location mean of 359.5 kg/ha, implying that agro-climatic conditions at Naliendele were different from other sites.

According to path analysis, height to first branch indicated very high direct effect on seed yield. Also height to first branch showed relatively high and negative indirect effect via height to first capsule. These results were encouraged by factor analysis which indicated that Plant height, height to first branch, days to 50% flowering and Number of capsules per plant may be more efficient for eligible sesame genotype searching. Therefore, height to first branch should firstly be used in selection to increase seed yield in sesame breeding programs. Indirect effects of plant height and height to first capsule with height to first branch should also be considered for the breeding programs to increase sesame yield. But there is a need to intercross with the taller genotypes which showed high yield, e.g (Ziada 94) inorder to transfer high yielding gene to the shorter varieties.

The investigation of stability of sesame genotypes clearly showed that most of the test genotypes were sensitive to production environments. Hence, their wider adaptability, stability and general performance to the fluctuating growing conditions within and across plant population environments were considerably lowered. The stability analysis provides meaningful information regarding stability and consistency of seed quality performance of sesame genotypes across different environments. Thus it can be concluded that no germplasm accession is found to be good for all the quantitative characters. However, promising accessions have been identified for different traits i.e Lindi 02 and Nal. 06. Sc 49 which has regression coefficients approaching one can be intercrossed with Nal.06.Sc 04 and Nal.95.Sc 9.1 which have low s^2d. Nal.95.Sc.9.1 to give segregates with better combination for total plant height and for number of capsules per plant can be intercrossed with Mtwara 09 which has b value approaching unit and mean value above average and with Nal. 06. Sc 31 which has low s^2d. Thus, a gene pool can be generated by constituting the germplasm lines of interest or by creating a broad based cross. Such material could be useful as a base population to develop promising populations and lines.

Genotypes viz: Nal. 06. Sc 31 was high yielding and found to suit in more favourable environmental conditions. However the other genotype viz; Mtwara 09 showed to have good adaptability under more unfavourable conditions.

6.2 Recommendations

(i) Nal. 06. Sc 31 is recommended for potential sesame agro-ecological areas like in parts of Mtwara (Naliendele) and Lindi regions (Nachingwea) in the southern zone while Mtwara 09 is recommended for agronomically poor areas like Tunduru in Ruvuma region.

(ii) Recommendations for varieties should not be generalized but rather be targeted to specific locations due to significant GXE interactions.

(iii) Nal. 06. Sc 31 should carried forward for National Performance Trial (NPT).

(iv) Lindi 02 and Nal. 06. Sc 49 which have regression coefficients approaching one should be intercrossed with Nal.06.Sc 04 and Nal.95.Sc 9.1 which have low s^2d to give segregates which are stable and have average response for total plant height.

(v) For number of capsules per plant, Mtwara 09 which has b value approaching unit and mean value above average can be intercrossed with Nal. 06. Sc 31 which has low s^2d to get segregate which are stable and average response on this variable.

(vi) Mtwara 09 which has b value approaching unit and high mean value for yield can be intercrossed with Nal. 06.Sc 91 which has low s^2d to get segregates which are stable and have average response on this variable.

(vii) Similar study should be carried in other sesame growing areas of Tanzania including Dodoma, Mbeya and Rukwa in order to get information on consistency of results.

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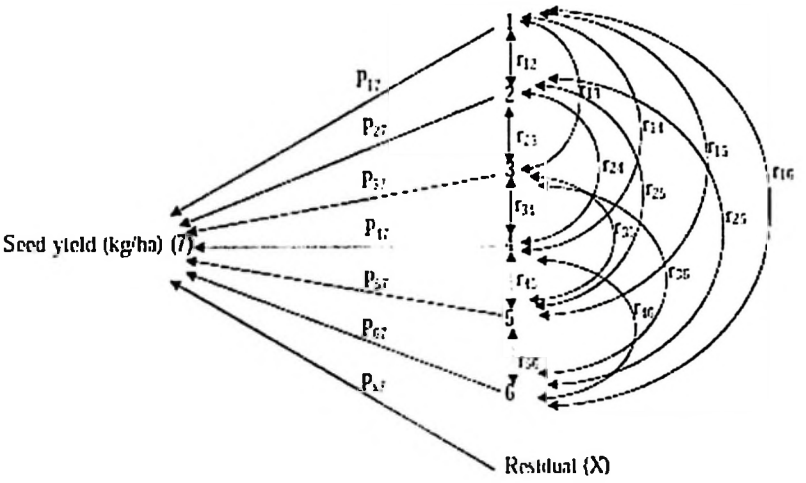
APPENDICES

Appendix 1: Path diagram showing causal relationships among growth and yield traits



Where;
1 = days to50% foweri ng
2 =T otal plant height
3 =H eight to first branch
4 =Height to first capsule
5 =Number of capsule per plant
6 =1000 seed weight

Appendix 2: meteorogical data for three sites (Avaraged)

Month	Max temp (^{0}C)	Min temp (^{0}C)	R/H (%)	Rainfall (mm)	Altitudes (masl)
Naliendele					
January	28.3	22.3	94	18	
February	31.1	24.7	85	16.28	
March	27.1	21.8	76	18.6	135
April	30.6	23.4	68	8.4	
May	30.3	21.1	65	9	
Total	**147.4**	**113.3**	**388**	**70.28**	
Nachingwea					
January	28.9	22.1	76	12.2	
February	31.2	20.7	82	12.6	
March	29.7	20.5	85	14.2	450
April	29.9	21.1	84	4	
May	29.2	19	81	11.72	
Total	**119.2**	**103.4**	**408**	**54.72**	
Tunduru					
January				20.6	
February				23.7	
March				20.7	
April				14.7	615
May				10.2	
Total				**89.9**	