Evaluation of Some Local Sorghum (Sorghum Bicolor L. Moench) Genotypes in Rain-Fed

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Abstract A two-year study was conducted on Sorghum (Sorghum bicolor L. Moench) across two environments in North Kordofan State, Sudan, to examine eight grain sorghum genotypes (Qusari, Wad-mergani, Sefera Red-Zinnari, Fraikh, Hamadi, Nilla and Kelash). The Quasari and Kelash genotypes are early flowering and early maturing. The genotype Quasari, Fraikh and Nilla were superior in yield and yield’s performance across all environmental conditions. Positive and significant phenotypic and genotypic correlations were found. Grain yield per hectare had high significant positive correlation with number of grain per panicle and number of panicles per unit area. The variance components for the two environments showed that most of the characters had higher phenotypic and genotypic variance estimates than the environmental variance estimates.

Keywords Sorghum, Genotype, Correlation, Yield, Variability

1. Introduction

Sorghum (Sorghum bicolor L. Moench) is an important staple food crops and provide bulk of raw materials for the livestock and many agro-allied industries in the world (Dogget, 1970). Zinnari varieties are known to out yield local varieties on sandy soils of Kordofan (Sudan), under low rain fall conditions. The diversity of lines expresses a wide range of adaptability to different conditions, including different genotypes from early to late maturing, dwarf to tall, loose to compacted heads, white and red seeded. Zinnari lines are white-seeded types that meets the consumption habits of peoples, thus selection of adapted high yielding lines is highly accepted by consumers. Plant breeders are interested in developing cultivars with improved yield and other desirable agronomic and phenological characters. In order to achieve this goal, the breeders had the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations (Puri, et al. 1982). The selection criteria may be yield, or one or more of the yield component characters. However, breeding for high yield crops require information on the nature and magnitude of variation in the available materials, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in sorghum is quantitatively in nature and polygenically controlled, effective yield improvement and simultaneous improvement in yield components are imperative (Bello and Olaoye, 2009). Selection on the basis of grain yield character alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and reliable (Muhammad, et al. 2003). Knowledge of association between yield and its component traits and among the component parameters themselves can improve the efficiency of selection in plant breeding. Correlation coefficient measures the mutual association between a pair of variables independent of other variables to be considered. Where more than two variables are involved, correlation coefficient alone does not give complete picture of the interrelationship (Fakorede and Opeke, 1985). To determine relationships, correlation analyses are used such that the values of two characters are analyzed on a paired basis, results of which may be either positive or negative. The result of correlation is of great value in the evaluation of the most effective procedures for selection of superior genotypes. When there is positive association of major yield characters component breeding would be very effective but when these characters are negatively associated, it would be difficult to exercise simultaneous selection for them in developing a variety (Nemati, et al. 2009).

The objectives of this study were to: study the variability in grain yield and agronomic characters among some sorghum genotypes in North Kordofan State of Sudan.

2. Materials and Methods
2.1. Site of the Experiment and Climate

A field experiment was conducted during two seasons 2002/03 and 2003/04 under rain-fed conditions at two locations (Khorabied and Ayara) in North Kordofan State, Sudan (13°12’ and 3°14’ E). The area is located in arid and semiarid zone. The soil is sandy with low fertility. Rainfall range between 350-500 mm. (Monthly rainfalls during the experiment are represented in Table 1). Average maximum daily temperatures varied between 30°C to 35°C most of the year.

Table 1. Monthly Mean Rainfall (mm) During the Growing Season for Sorghum (July - October) in 2002 and 2003 in Khorabied and Ayara of North Kordofan of Sudan

| Month   | 2002/03 | 2003/04 |
|---------|---------|---------|
|         | Khorabied | Ayara | Khorabied | Ayara |
| July    | 160      | 180     | 160        | 120   |
| August  | 200      | 110     | 200        | 150   |
| September | 110   | 090     | 045        | 020   |
| October | 040      | 045     | 008        | 009   |
| Total   | 510      | 425     | 413        | 299   |

2.2. Plant Materials

The materials used in this study consisted of eight indigenous grain sorghum genotypes representing the types widely grown in Kordofan and West White Nile districts of Sudan. The eight genotypes were Qasari, Wad-mergani, Sefera Red-Zinnari, Fraikh, Hamadi, Nilla and Kelash.

2.3. Experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) in four replications. Each plot consisted of seven rows five meters long, 60 cm apart and intra-row spacing of 20 cm.

Before sowing, seeds were treated with Fernisan-D of 3g/kg seed against soil fungi and insects. Sowing was on 22nd of July, 2002 and 2003. Five seeds were sown in each hill. Seedlings were thinned to three plants per hill after three weeks from sowing. Hand hoeing weeding practiced twice, the first one after two weeks from sowing and the second after four weeks from sowing.

2.4. Data Collection

In each plot, the five middle rows were used to measure for the following characters:

1. Plant height (cm): measured from soil surface to the tip of the main head as an average of ten plants, randomly chosen, just before harvesting.
2. Days to 50% flowering were recorded as the number of days from the sowing date to the day on which 50% of the plants in a plot reached anthesis at least halfway down the panicle.
3. Days to maturity: the number of days from sowing date to the day on which 95% of the panicles in a plot reached physiological maturity, as monitored by the appearance of black glumes.
4. Straw weight (kg/ha): calculated by weighing the dry hay of harvested rows of each plot.
5. Number of panicles per plot: obtained by counting the total number of heads in each plot.
6. Panicle length (cm): Mean length of the panicle measured on a sample of ten panicle measured from the base to the tip of the head.
7. Panicle weight (g): random five heads of each plot weighed and divided by five.
8. Number of grains per panicle
9. Grain weight (g): based on random sample of 100-seeds taken four times from the bulked seeds of each experimental unit.
10. Grain yield per plant (g).
11. Grain yield (kg/ha): panicles from each plot were harvested, sun dried, threshed, weighed and converted to kg/ha.

2.5. Statistical Analysis

Individual analysis of variance was performed for all traits on each location according to the procedure described by Gomez and Gomez (1984) for the randomized complete block design. The combined analysis of variance was done, for all traits, following the method described by LeClerg et al. (1962), based on a randomized complete block design.

For mean comparison, the means were separated using Duncan Multiple Range Test (DMRT) at 0.05 level of significance, according to the procedure described by Gomez and Gomez (1984).

2.6. Phenotypic and Genotypic Variances

Phenotypic (σ²_ph) and genotypic (σ²_g) variances were estimated using individual analysis of variance as follows:

\[ σ²_g = M2-M3 \]

\[ r = \frac{σ²_g}{σ²_g + σ²_e} \]

Where: \( σ²_e \) is the error variance (M3) for RCBD.

2.7. Heritability

The broad sense heritability (h²) was estimated for each trait according to Johnson et al. (1955), using the formula:

\[ h² = \frac{σ²_g}{σ²_g + σ²_e} \]

The genetic coefficient of variation (GCV %) was computed, according to the formula suggested by Burton and De Vane (1953) as follows:

\[ GCV% = \sqrt{\frac{σ²_e}{σ²_g}} \times 100 \]

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2.8. Correlation coefficient

The correlation coefficient was determined by using the formula suggested by Miller et al. (1958), as follows:

\[ r = \frac{cov.x_1x_2}{\sqrt{var.x_1} \times \sqrt{var.x_2}} \]

Where:

\( r = \) correlation coefficient

\( cov.x_1x_2 = \) covariance between traits \( x_1 \) and \( x_2 \)

\( var.x_1 = \) variance of trait \( x_1 \)

\( var.x_2 = \) variance of trait \( x_2 \)
3. Results and Discussion

Genotype had significant effect on plant height at the two locations in both seasons (Table 2). Kelash genotype had a lesser plant height. This result confirmed the results of previous studies of Abdalla (1991), Abd Rahaman (1985), Alejandro (1982), Bakheit (1990) and Hassan (2005). They found that the cultivars of grain sorghum significantly affect the plant height. Genotype had significant effect on number of days to 50% flowering and to days 95% physiological maturity. Qussari genotype was the earliest among all genotypes at the two locations in both seasons (Table 2). Mean time to anthesis and days to maturity varied very considerably from one location to another, probably as consequence of environmental conditions and genotypic differences. Similar findings were reported by Whiteman and Wilson (1965). Hassan (2005) found that the cultivars significantly affect number of panicles/m2, panicle weight and straw yield (Table 3). Qussari had the highest number of grains per panicle. The genotypes Kelash, Nilla, and Feraikh had highest number of grains per panicle.

There were significant differences among genotypes in plant height and yield related characters at the two locations (Table 4). Average yield over all genotypes in the two seasons at Khorabied (982 kg/ha) was greater than Ayara (689 kg/ha). This was mainly due to the higher number of grains per head at Khorabied than at Ayara. Dogget (1970) and Beil and Atkins (1967) reported that higher seed number generally is the most important yield component associated with increased in yield of sorghum. The reduction in the number of grains per panicle at Ayara was due to water stress at mid-season, caused by the relatively low amount of rains. Hultquist (1973) reported that water stress reduced significantly number of grains per panicle. The variance components for the two environments showed that most of the characters had higher phenotypic and genotypic variance estimates than the environmental variance estimates (Table 5). Therefore, expressions for most of the characters were genetic, which can be exploited in breeding programs. This finding is in agreement with the findings of Basu (1981) and Abu-Gasim and Kambal (1985) and Bello, et al. (2007) for several quantitative for characters in sorghum genotypes. Zaveri et al. (1989) also reported similar results in pearl millet. Lukhele (1981) and Bello et al (2007) observed that high error or environmental variance estimate for some characters similar to what was obtained in this study could be attributable to sample size. To reduce error and consequently increase the precision and reliability of estimates, Allard and Bradshaw (1964) suggested increasing sample size and number of environments or years during trials. However the disadvantage of this suggestion would be delay in the release of results.

### Table 2. Effects of Genotype on Plant Height, Days to 50% Flowering, and Days to 95% Maturity of Sorghum

| Genotypes  | Plant Height(cm) | 50% Flowering (days) | 95% Maturity (days) |
|------------|------------------|----------------------|---------------------|
|            | Khorabied | Ayara | Khorabied | Ayara | Khorabied | Ayara |
| Qussari    | 109.6     | 93.7  | 60.00f   | 66.0  | 80.3f   | 79.5  |
| Wad-Mergani| 160.4     | 117   | 71.3b    | 72.0  | 97.5b   | 97.0  |
| Sefera     | 131.3     | 105   | 77.8a    | 66.0  | 89.8d   | 89.8  |
| Red zenari | 157.00    | 120   | 64.3de   | 75.0  | 85.5e   | 85.5  |
| Fereikh    | 162.8     | 13.   | 62.8ef   | 70.0  | 87.3e   | 88.3  |
| Hamadi     | 153.6     | 128   | 75.7a    | 74.0  | 101.3a  | 101   |
| Nilla      | 152.3     | 138   | 68.7ab   | 73.0  | 93.0c   | 93.0  |
| Kelash     | 103.4     | 89.9  | 66.7cd   | 66.0  | 91.5cd  | 90.0  |
| CV%        | 7.14%     | 7.14  | 3.01%    | 3.01  | 1.73%   | 2.43  |

### Table 3. Effects of Genotype on Straw Weight, Number of Panicles /m2 and Panicle Weight of Sorghum

| Genotypes  | Straw Weight (kg/ha) | No. of Panicles/m2 | Panicle Weight(g) |
|------------|----------------------|--------------------|-------------------|
|            | Khorabied | Ayara | Khorabied | Ayara | Khorabied | Ayara |
| Qussari    | 2.8cd     | 2.4   | 80.00a    | 43.0a | 447      | 345   |
| Wad-Mergani| 5.3ab     | 2.7   | 58abc     | 26.0a | 395      | 350   |
| Sefera     | 6.3a      | 2.8   | 50bc      | 21.0b | 252      | 134   |
| Red zenari | 5.9a      | 2.8   | 71ab      | 30.0a | 402      | 35.0  |
| Fereikh    | 4.8ab     | 3.9   | 57abc     | 38.0a | 445      | 325   |
| Hamadi     | 5.00ab    | 4.6   | 60abc     | 27.0a | 387      | 210   |
| Nilla      | 4.2bc     | 3.5   | 55abc     | 43.0a | 372      | 280   |
| Kelash     | 2.6d      | 2.4   | 42c       | 37.0a | 252      | 295   |
| CV%        | 21.9%     | 21.9  | 26.05     | 26.05 | 40.5     | 40.5  |
Two Locations

Heritability ($h^2$) for Yield and Yield Components Combined across The mental ($σ^2_{g}$) and heritability e s-

High $σ^2_{g}$ was also observed for some characters, this reveals

Grain yield (kg/ha)
Grain yield/plant (g)
Number of grains/panicle (g)
Number of panicles/plot
Straw weight (kg/ha)
Days to maturity
Days to 50% flowering
Straw weight (kg/ha)
Number of panicles/plot
Panicle weight (g)
Number of grains/panicle
Grain yield/plant (g)

Table 4. Effects of Genotype on Number of Grains per Panicle, 100-seed Weight and Grain Yield of Sorghum

Table 5. Estimate of Phenotypic ($σ^2_{ph}$), Genotypic ($σ^2_{g}$) and Environmental ($σ^2_{e}$) Variances for Ten Characters

Table 6. Estimates of mean Genetic Coefficient of Variation (GCV%), and Heritability ($h^2$) for Yield and Yield Components Combined across The Two Locations

The means, ranges and coefficient of variations a namely; genotypic coefficient of variation (gcv) and heritability estimates across the two locations are presented in Table 6. High gcv was also observed for some characters, this reveals that the genotypes have a broad base genetic background as well as good potential that will respond positively to selection. Similar results were obtained by William et al. (1987) while studying effect of environment on yield components of sorghum. In this study, characters such as plant height, days to 50% flowering and days to 95% maturity would respond positively to selection when selected because of their high broad sense heritability (Table 6) agreed with the findings of Eckebil et al. (1997), Totok (1997) and Biswas et al. (2001). On the other hand, grain weight per panicle, number of grains per panicle, 100- seed weight and grain yield would not respond to selection because of their low heritability estimates in this sorghum population.

However, similar results were observed by Bello et al. (2001) and Bello et al. (2000) they reported that the low heritability estimate of grain yield is due to the direct or indirect multiplicative effects of several yield components on grain yield. Obilana and Fakorede (1986) reported that, if a character is influenced by environment, its heritability would be low in a population in which plant environments vary widely. On the other hand, in another population in which the environment is rigidly controlled so that those variations do not occur, the same character would tend to have high heritability.

Head weight (g) had highly significant and positive correlation with hay weight, plant height, number of head per plot, while it had highly significant and negative correlation with days to 50% flowering, 100 grain weight, at the two locations. Hay weight had highly significant and positive correlation with plant height, yield weight, number of head per plot, while it had highly significant and negative correlation with 100 grain weight. Plant height was highly significant and positive correlation with yield /ha. Badwal (1997) observed that the plant positive correlation with yield. Yield (t/ha$^{-1}$) was highly significant and positive correlation with number of heads per plot and number of grain per head. The correlation of yield with number of grain per panicle reported by many workers: Dabholkar et al. (1970), Liang et al. (1969) and Abifarin and Pickett (1970). Days to 50% flowering were significant and positive correlation with 100 grain weight and significant and negative correlation with number of heads per plot. Grain yield/ha had highly significant positive correlation with number of grains per head at the two locations in the two seasons .The similar results were found by DabholKar et al. (1970), Kambah and Abael Gasim (1976), Liang et al. (1969) and Abifarin and Pickett (1970).

4. Conclusions

Based on the results of this study, the superiority of the Quasari over the other genotypes suggests its adoption as one of the high yielding cultivars in this area. Quasari and Kelash genotypes are early flowering and maturity. They recommended for the short rainfall seasons in sandy soil of North Kordofan state of Sudan, where rainfall was less than 300
mm and might be used in breeding programs for development of early maturing genotypes in Sudan.

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