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SOHAG-1, SOHAG-3 AND SOHAG-4 GRAIN SORGHUM VARIETIES RECENTLY RELEASED FOR MIDDLE AND UPPER EGYPT

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#### Abstract

Three grain sorghum varieties were developed and their performance was accepted named: Sohag-1, Sohag-3 and Sohag-4. They were evaluated with other promising varieties according to graded levels of testing B and C on-station trials at four locations, (Nubaria, Fayoum, Assiut and Shandaweel) in 3 successive seasons starting from season 2018. They significantly out-yielded the check variety (Dorado) D-level. The verification trials (14 trials) were conducted on farmer fields in 4 governorates (Qena, Shandaweel, Assiut and El-Fayoum) where sorghum covered the largest area in 2021 growing season. These three varieties were equal or of higher yield than the check variety and had some other advantages. They were subjected to some studies on their reactions to the sorghum main diseases during 2019 and 2020 seasons where their resistance or tolerance were confirmed to stalk rot and long smut diseases. Their tolerance to some threatening insects, i.e. shoot fly, stem borers and aphid were high to a large extent. In addition to their description, the DNA Finger printing was accomplished and proved that these varieties fulfilled the requirements for registration; they were accepted and registered.


Key Words: Sorghum bicolor, Varieties release evaluation, Genetic finger printing.

## INTRODUCTION

Grain sorghum (Sorghum bicolor (L) Monech) is one of the most important strategic crops in the Arab Republic of Egypt. Grain sorghum plants are tolerant to high heat, water deficit, low nitrogen fertilizer. Egypt grows 360000 feddan of and grain sorghum the average yield about 16.5 ardeb/feddan (5.5 Tons per hectare). Accordingly, Egypt is considered the highest country all over the world in the average productivity per hectare (FAO 2020). Egypt is the oldest country to grow sorghum in a regular manner, as well as many sorghum species that belong to sorghum bicolor which were discovered in Nabta playa, southern Egypt (Krystyna, et al 999). Recently. Sorghum Department (SD), Field Crops Research Institute (FCRI), Agricultural Research center ARC at Giza developed the Local grain sorghum variety Giza, in 1983, (Fayed et al. 1983).

SD, FCRI, ARC at Giza release some hybrid to increase grain and green yields from sorghum by successful program for producing hybrid
seed, several cytoplasmic male sterile (A-line) and restores (R-lines) that restore fertility of $\mathrm{F}_{1}$ plants and having good combining abilities must be available and must be available. This program released more hybrids with high grain yield and fodder such as hybrids shandaweel-2 and shandaweel-6 (EL-Nagouly et al 1997).

Three diseases were widespread, namely downy mildew (caused by peronosclerospora sorghi), stalk rot (caused by Acremonium strictum and Fusarium moniliforme) and long smut (caused by Tolyposporium ehrenbergii). Sorghum breeders and pathologists had a cooperating task to produce tolerant varieties and hybrids. Mahmoud (2010) found that Dorado cultivar was resistant to stalk rot under inoculation by toothpick. (Basher et al 2008) found that hybrid-303 and hybrid-305 were resistant to stalk rot, downy mildew and long smut. In the current investigation, the three recent varieties Sohag-1, Sohag-3 and Sohag-4 were introduced and described. The pink stem borer, Sesamia cretica Led is considered the most serious sorghum insects in Egypt (Murad and El- Rawy 2012, El-Rawy et al 2013) the current verities sohag-1, 3 and 4 were these for their insects.

## MATERIALS AND METHODS

The three new promising grain sorghum varieties Sohag-1, Sohag-3 and Sohag-4 were first produced by crossing Giza 15 and Dorado in segregating generation Field at Shandaweel research at station Sohag governorate. Selection for high yielding plants, tolerance to common disease and insects was done for 8 generations from $\mathrm{F}_{1}$ to $\mathrm{F}_{8}$.

Three new varieties (sohag-1, sohag-3, and sohag-4) were tested in 8 on-station trials of B and C levels carried out during 2018 and 2019 seasons; however, the evaluation was verified in 4 on-farm trials carried out at four governorates during 2020 season. Dorado variety was used as check in all trials. The on-station trials (B and C levels) were conducted at four locations with three replicates in each trial where the plot size included 6 rows; 6 meter long and 60 cm width. The D level (in Fields) were conducted on farmers' fields where the size and number of replicates were enlarged to 10 rows, and four replicates, in a randomized complete block design (Steel and Terrie 1997). In all trials, planting was done in hills spaced 20 cm apart. Thinning at two plants per hill was practiced three weeks after planting.

Cultural practices were done as recommended at each location and plant protection was undertaken as needed. Grain yield was estimated on a plot basis and as a percentage of new variety over check variety (Dorado). Data of the On-station Trials was recorded for days to $50 \%$ heading, plant height (cm) and 1000-kernel weight (g). Statistical analysis was accomplished according to standard procedures (Steel and Torrie 1997) using the DSAASTAT Version 1.1 (Update: 18/03/2011)., and Microsoft excel software. Agricultural Genetic Engineering Research Institute (AGERI), Agricultural Research center (ARC) executed the genetic finger printing of the 3 new varieties. Genomic DNA of leaves of ten seedlings for each variety was extracted according to the manufacturer recommendation. 10 mer random primers (shortly nominated, OPZ.20, OPZ 19, OPG. H, OPZ. 16 OPZ 07, OPZ.11, OPZ. 13 OPD.02, OPE. 17 and OPG 09) were used getting out RAPD Profile of the genetic fingerprint. The RAPD profile was tabulated to distinguish among different genotypes. Testing the three new varieties and the check (Dorado variety) for diseases was done at Giza and Shandaweel Research stations.

Distinctness, Uniformity and Stability tests (DUS): The morphological characteristics of the 3 new varieties were performed by the Central Administration of Seed Certification (CASC) according to the International Union for the Protection of new Varieties of Plants (UPOV),

## Stalk- rot- reaction

The new varieties Sohag-1, Sohag-3 and Sohag-4 were evaluated for resistance to stalk rot disease under field condition at Giza Research Station. Separately infected toothpicks with ( Acremonium strictum and Fusarium moniliforme) were inserted into small holes made on the stalk of the plant using a sterile needle. Inoculation pathogen was made approximately 10 cm above the ground, on day 60 after sowing (Karunakar et al 1993). Four weeks later, the severity of the disease will be determined inoculation to record disease rating to screen grain sorghum genotypes resistant to stalkrot disease for Sohag-1, Sohag-3 and Sohag-4 varieties. The infection levels, were inferred according to the set criterion as follow (Azzam et al 2010) Disease severity index of (Acremonium strictum and Fusarium moniliforme) infestation based on numerical categorization and level of infection.

| Level of infection | Category Numerical |
| :--- | :---: |
| Highly resistant | $0.0-0.5$ |
| Resistant | $0.6-1.0$ |
| Moderately resistant | $1.1-1.5$ |
| Moderately susceptible | $1.6-3.0$ |
| Susceptible | $3.1-4.0$ |
| Highly Susceptible | $4.1-5.0$ |

Long smut disease
The new genotypes with the check variety were screened for resistance to long smut disease under natural infection at Shandaweel Research Station where percentage of infection was recorded after 90 days for planting. Tested grain sorghum genotypes were classified following the scale adopted by Gowda et al. (1989) with some modifications as follows:

## Level of infection

Highly resistant
Resistant
Moderately resistant
Moderately susceptible
Susceptible
Highly Susceptible

## Category Numerical

$0.0-5.0$ \%
$5.1-10.0 \%$
$10.1-20.0$ \%
20.1-30.0 \%
$30.1-50.0$ \%
$50.1-100.0 \%$

## Insects infestation

Three field experiments were conducted at Nubaria Research station, El-Behiera Governorate, Arab Al-Awamer Research Station, Assiut Governorate and Shandaweel Research Station Sohag Governorate during 2018 season. Twenty plants from each plot (from on- station trials) were measured after 35 days from planting date with four replicates for the three new varieties to be infested by Sesamia cretica (No. of infested plants and No. of plants with dead hearts).

## RESULTS AND DISCUSSION

The performance of yield components and agronomic traits contributed in the final expression of grain yield was presented in Table 1. Other essential traits such as plant height, days to $50 \%$ heading and 1000kernels weight were presented in Table 2. The varieties Sohag-1, Sohag-3 and Sohag-4 were evaluated in 2018 season in 5 B- level trials distributed at

5 locations where Theis grain yield surpassed the check variety (Dorado). The relative seasonally grain yields were $122.69,115.61$ and $109.34 \%$ for Sohag-1, Sohag-3 and Sohag-4, respectively. These varieties were evaluated in 2019 season in three locations in C- levels trials where grain yield surpassed the variety (Dorado); the relative seasonal grain yields were 115.88, 121.18 and $126.35 \%$ for Sohag-1, Sohag-3 and Sohag-4, respectively.

Table 1. Actual and relative grain yield (ard/fed) of the three new varieties compared with the check variety (Dorado) over locations during 2018 to 2021.

| Trail | Seasons | Locations | LSD | Check | Sohag-1 |  | Sohag-3 |  | Sohag-4 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | Actual | $\begin{gathered} \text { Relative } \\ \% \end{gathered}$ | Actual | $\begin{array}{\|c\|} \hline \text { Relative } \\ \% \end{array}$ | Actual | $\begin{array}{\|c} \hline \text { Relative } \\ \% \end{array}$ |
| B | 2018 | Shandaweel | 0.88 | 21.40 | 24.55 | 114.72* | 25.35 | 118.46* | 23.40 | 109.35* |
|  |  | New valy | 0.73 | 19.35 | 20.3 | 104.91* | 19.75 | 102.07* | 20.15 | 104.13* |
|  |  | Aswan | 0.69 | 16.20 | 22.7 | 140.12* | 18.10 | 111.73* | 18.60 | 114.81* |
|  |  | Assiut | 3.35 | 18.00 | 23.15 | 128.61* | 22.98 | 127.67* | 20.28 | 112.67 |
|  |  | Nubaria | 3.76 | 19.75 | 24.7 | 125.06* | 23.33 | 118.13* | 20.88 | 105.72 |
|  |  | Means |  | 18.94 | 23.08 | 122.69* | 21.90 | 115.61 | 20.66 | 109.34 |
| C | 2019 | Shandaweel | 1.23 | 19.30 | 25.5 | 132.12* | 24.83 | 128.65* | 26.30 | 136.27* |
|  |  | Assiut | 1.26 | 15.37 | 16.87 | 109.76* | 17.8 | 115.81* | 18.80 | 122.32* |
|  |  | Fayoum | 1.23 | 14.57 | 15.41 | 105.77 | 17.35 | 119.08* | 17.55 | 120.45* |
|  |  | Means |  | 16.41 | 19.26 | 115.88 | 19.99 | 121.18 | 20.88 | 126.35 |
| D | 2020 | Qena | 1.64 | 16.60 | 20.03 | 120.66* | 20.80 | 125.30* | 20.80 | 125.30* |
|  |  | Shandaweel | 1.64 | 17.27 | 19.23 | 111.39* | 23.17 | 134.17* | 22.17 | 128.38* |
|  |  | Assiut | 2.40 | 17.45 | 19.73 | 113.06 | 21.37 | 122.42* | 18.43 | 105.61 |
|  |  | Fayoum | 1.02 | 17.33 | 21.03 | 121.36* | 22.97 | 132.51* | 19.47 | 112.32* |
|  |  | Means |  | 17.35 | 20.00 | 115.27 | 22.50 | 129.70 | 20.02 | 115.44 |
| D | 2021 | Aswan | 1.16 | 16.83 | 16.50 | 98.04 | 18.33 | 108.93* | 18.9 | 112.30* |
|  |  | Qena | 1.11 | 12.27 | 14.47 | 117.93* | 17.18 | 140.05* | 14.93 | 121.74* |
|  |  | Shandaweel | 2.19 | 18.50 | 19.30 | 104.32 | 20.30 | 109.73 | 20.8 | 112.43* |
|  |  | Fayoum | ns | 17.23 | 16.53 | 95.94 | 19.90 | 115.47 | 16.30 | 94.58 |
|  |  | Means |  | 16.21 | 16.70 | 104.06 | 18.93 | 118.55 | 17.73 | 110.26 |

[^0]Table 2. Average performance of three new varieties compared with Dorado (check) for days to $\mathbf{5 0 \%}$ flowering, plant height (cm) and 1000 - kernel weight (g).

| Trail | Check | Sohag-1 |  | Sohag-3 |  | Sohag-4 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Relative\% | Actual | Relative\% | Actual | Relative\% |  |
| Days of 50\% <br> Flowering | 77.58 | 76.94 | 97.19 | 76.83 | 99.17 | 75.55 | 97.36 |
| Plant height | 153.49 | 170.56 | $115.91^{*}$ | 169.97 | $102.42^{*}$ | 168.75 | $104.51^{*}$ |
| 1000 Kernel <br> weight | 30.26 | 32.04 | $104.97^{*}$ | 35.79 | $109.26^{*}$ | 32.55 | $104.01^{*}$ |

* Significant at 0.05 level of probability.

The three varieties Sohag-1, Sohag-3 and Sohag-4 were evaluated in 2020, the three varieties were distributed at 4 locations where its grain yield surpassed the check variety (Dorado); the relative seasonally grain yields for Sohag-1, Sohag-3 and Sohag-4 were 115.27, 129.70 and $115.44 \%$ respectively. Moreover, in 2021 the three varieties distributed at 5 locations where its grain yield surpassed the check variety (Dorado); the relative seasonally grain yields for Sohag-1, Sohag-3 and Sohag-4 were 104.06, 118.55 and $110.26 \%$, respectively.

Average grain yield of Sohag-1 cultivated in 16 trials (B, C, D levels) was $19.76 \operatorname{ard} /$ fed. The average relative grain yield compared with Dorado variety was $114.48 \%$. The difference between actual yield for Sohag-1 and Dorado variety (check) in all trials was significant.

Sohag-3 was evaluated in 16 trials (B, C and D levels) as shown in Table (1). Average grain yield for all trials was $20.83 \mathrm{ard} / \mathrm{fed}$ and the average relative grain yield for Sohag-3 compared with check (Dorado variety) was $121.26 \%$. The increase in grain yields of this variety compared to the check in most trials was significant.

Sohag-4 was evaluated in 16 trials (B, C and D levels). Average grain yield for all trials was $19.82 \mathrm{ard} / \mathrm{fed}$ and the average relative grain yield for sohag-4 compared with check (Dorado variety) was $115.35 \%$ in all trials was significant.

Table (2) presents average performance of the three new verities (Sohag-1, Sohag-3 and Sohag-4) compared with Dorado variety as check for days to $50 \%$ heading, plant height (cm) and 1000-kernel weight. For days to $50 \%$ heading, the differences between check variety and Sohag-1, Sohag3 and Sohag-4 were not significant. The new varieties were significantly increased compared to about the check variety (Dorado) in plant height (cm). The difference between Sohag-1, Sohag-3 and Sohag-4 in plant height were significant. The new varieties were significantly increased over the check variety in 1000 -kernel weight. The new variety Sohag-3 had the largest 1000-kernel weight ( 35.79 g ).

## Disease resistance

Stalk - rot disease
The reaction of grain sorghum genotypes to A. strictum and F.maniliforms (separately) tested at Giza field using toothpick stalkinoculation technique is presented in Table 3. The results indicated that the three new varieties (Sohag-1, Sohag-3 and Sohag-4) were resistant to the two diseases (grade 1.2 or less) as well as the check Dorado. Acremonium wilt caused by (A.Strictum and F.moniliforms). Similar results were recorded by El- Shafey et al (1979) and El-Assiuty (1982) using the same technique inoculation on sorghum cultivars NES- 1818 and NES-11324 that were highly resistant to A. strictum. Mahmoud (2010) found that Dorado cv was resistant to stalk- rot under inoculation by toothpick.

## Long smut disease

Long smut caused by $T$. Ehrenbergii is the most prevalent smut in Egypt; therefore, the tested new varieties (Sohag-1, Sohag-3and Sohag-4) were screened for disease reaction under field natural infection in Shandaweel Agricultural Research Station where environmental conditions favored the disease prevalence. The results presented in Table (4) showed that all varieties were highly resistant with infection percentage ranging from 3.00 to $6.7 \%$.

Table 3. Evaluation of grain sorghum genotypes for resistance to stalkrot disease (A. strictum and $F$. monififorme).

| Genotypes | A. strictum |  |  | F. monififorme |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| Sohag-1 | 0.7 | 0.3 | 0.5 | 0.8 | 0.6 | 0.7 |
| Sohag-3 | 0.6 | 0.8 | 0.7 | 0.8 | 0.4 | 0.6 |
| Sohag-4 | 0.8 | 1.0 | 0.9 | 0.6 | 0.8 | 0.7 |
| Dorado | 0.6 | 1.0 | 0.8 | 0.6 | 0.4 | 0.5 |

Table 4. Reaction of new grain sorghum varieties to long smut disease.

| Genotypes | Infection\% |  |  |
| :---: | :---: | :---: | :---: |
|  | 2018 | 2019 | Mean |
| Sohag-1 | 4.1 | 6.7 | 5.4 |
| Sohag-3 | 4.6 | 3.8 | 4.2 |
| Sohag-4 | 6.8 | 4.4 | 5.6 |
| Dorado | 3.0 | 6.0 | 4.5 |

## Infestation by $S$. cretica

Data in Table (5) showed that, the three varieties Sohag-1, Sohag-3 and Sohag-4 have relatively good level of resistance to infestation by larvae of S.cretica. While, Sohag-1 and Sohag-4 varieties showed reduction in infestation by S.cretica with 6.67 and $8.75 \%$ infested plants, respectively and 3.75 and $3.75 \%$ dead hearts, respectively compared by Sohag-3 variety ( $12.50 \%$ infested plants and $6.0 \%$ dead hearts). These results are in harmony those reported by Mourad and El-Rawy (2012) El-Rawy et al (2013).

Table 5. Infested plants and plants with dead hearts percentages under natural infestation with $S$. cretica during 2018 season in three locations.

| Genotypes | S. cretica |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Infested plants (IP)\% |  |  |  | Dead hearts (DH) \% |  |  |  |
|  | Nubaria <br> Res. St. | Assiut <br> Res. St. | Shandaw eel Res. St. | $\overline{\mathbf{X}}$ | Nubari a Res. St. | Assiut Res. St. | $\begin{gathered} \text { Shanda } \\ \text { weel } \\ \text { Res. St. } \end{gathered}$ | $\mathbf{X}$ |
| Sohag-1 | 5.0 | 6.25 | 8.75 | 6.67 b | 2.5 | 3.75 | 5.0 | 3.75 b |
| Sohag-3 | 10.0 | 12.5 | 15.0 | 12.5 a | 5.0 | 6.5 | 6.5 | 6.0 a |
| Sohag-4 | 7.5 | 8.75 | 10.0 | 8.75 b | 3.75 | 2.5 | 5.0 | 3.75 b |
| $\overline{\mathbf{X}}$ | 7.5 | 9.17 | 11.25 | - | 3.75 | 4.25 | 5.5 | - |
| $\begin{aligned} & \text { L.S.D } \\ & \mathbf{0 . 5 \%} \end{aligned}$ |  |  |  | 3.0 |  |  |  | 1.91 |

Description of Sohag-1, Sohag-3 and Sohag-4
The morphological characteristics of the new released cultivar shown in Table 6 were carried out by the Central Administration of Seed Certification (CASC) according to the International Union for the Protection of New Varieties of Plants (UPOV). The Distinctness, Uniformity and Stability (DUS) test have been done before releasing the cultivar. In conclusion, we can strongly recommend the new grain sorghum varieties i.e., Sohag-1, Sohag-3and Sohag-4 to be grown in all grain sorghum production areas in Egypt.

Table 6. Morphological characteristics of the new released grain sorghum varieties Sohag-1, Sohag-3and Sohag-4 according to the International Union for the Protection of New Varieties of Plants (UPOV).

| No. | Characteristics | Description |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Sohag-1 | Sohag-3 | Sohag-4 |
| 1 | Seedling: anthocyanin coloration of | 7 | 3 | 3 |
| 2 | Leaf: anthocyanin coloration of blade | 3 | 1 | 1 |
| 3 | Leaf: intensity of green color | 5 | 5 | 5 |
| 4 | Leaf: color of midrib | 1 | 1 | 1 |
| 5 | Leaf: area of | 7 | 9 | 9 |
| 6 | Plant: time of panicle emergence | 5 | 5 | 5 |
| 7 | Glume: anthocyanin coloration | 1 | 1 | 1 |
| 8 | Stigma: anthocyanin coloration | 1 | 1 | 1 |
| 9 | Stigma: color | 1 | 3 | 1 |
| 10 | Stigma: length | 3 | 5 | 5 |
| 11 | Flower with pedicel: length of flower | 3 | 5 | 3 |
| 12 | Glume: color at end of flowering | 1 | 1 | 1 |
| 13 | Panicle: density at end of flowering | 7 | 7 | 7 |
| 14 | Plant: length | 5 | 7 | 7 |
| 15 | Stem: diameter | 7 | 7 | 7 |
| 16 | Leaf: length of blade | 3 | 3 | 7 |
| 17 | Leaf: width of blade | 7 | 3 | 3 |
| 18 | Panicle: length | 3 | 3 | 3 |
| 19 | Panicle: length of neck | 3 | 3 | 1 |
| 20 | Panicle: density at maturity | 7 | 7 | 7 |
| 21 | Panicle: position of broadest part | 3 | 3 | 3 |
| 22 | Glume: color at maturity | 3 | 3 | 3 |
| 23 | Glume: length | 3 | 5 | 3 |
| 24 | Grain: color | 7 | 1 | 1 |
| 25 | Weight of 1000 grains | 7 | 5 | 5 |
| 26 | Grain: shape in dorsal view | 3 | 3 | 3 |
| 27 | Panicle: density at maturity | 7 | 7 | 7 |
| 28 | Panicle: position of broadest part | 3 | 3 | 3 |
| 29 | Grain: content of tannin | 0 | 0 | 0 |
| 30 | Grain: type of endosperm | 0 | 0 | 0 |
| 31 | Grain: color of vitreous endosperm | 0 | 0 | 0 |

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## سوهاج＇وسوهاج 「 و سو هاج ؛ أصناف ذرة رفيعة أططت حديثا <br> للزراعة فى مصر الوسطى ومصر العليا

أحمد الرفاعى عبد العظيم مراد، عبد الله عبد الو هاب أمير، ميثيل فخرى سابا، عزمى مصطفى القاضى، سهير جوزيف لطيف، ميرفت مترى المنشاوى، حاتم إبراهيم على، خالد محمد محمود، أمل عبدالرحيم تاج الاين، اعتماد محمد حسين احمد، محمد اللبيد محمد الصنير، هبه محمد حافظ، يوسف محمد يوسف القاضي، عمر ابو الحسن يونس عبد الرحيم، يوسف عجمى على يوسف،

على زين العابدين＂، عابد عبد الجليل عطا＇، عادل محمد اللراوى＂و محمد على محمد يوسف＂ّ．
「．قسم أمر اض الذرة－معود بحوث أمر اض النباتات－مركز البحوث الزر اعيةــ الجيزة「「．معهـ بحوث وقاية البناتات－مركز البحوث الزر اعيةـ الجيزة




 صنف المقارنة هـع بعض（المديزات（المحصولية．ولّا لرست تثفاعلات واستجابة（لاصناف مع مسنبات（لامراض

 بالاضافة المى وصفها فإن بصهة الحمض النووى كانت منجزة ويعد استبفاء كافة متطلبات التسجيل تم قبولها

وتسجبئه．
(لمجبة المصربية لتربية النبات זr(1):


[^0]:    * Significant at 0.05 level of probability.

