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Effect of Seed Priming of Two Stored Sudangrass Genotypes on Seed Germination, Seedling Vigor, Growth and Forage Yield and Its Component

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seed priming is a technique, which could improve the germination and establishment on the seeds, which were stored for 1.5 years under normal conditions. Therefore, this study was designed to evaluate the effect of different seed priming techniques, through un-soaked seed (control), Hydro-priming (soaked with distill water), 25 ppm of salicylic acid, 1.5% of Calcium chloride ($CaCl_2$) and 3% of Potassium dihydrogen phosphate (KH_2PO_4) for 10 hours on seed germination%, seedling vigor and forage yield of two sudangrass genotypes (Piper black and Giza1). Two experiments (laboratory and field) were conducted at Sakha Agric. Res. Station, ARC, Egypt, during the two successive summer seasons 2019 and 2020.The results obtained indicated that 25 ppm of salicylic acid followed by 1.5% of $CaCl_2$ and 3% of KH_2PO_4 treatments significantly affected on seed germination percentage, shoot and root length, fresh and dry seedling weight, seed vigor index, seedling vigor index, electrical conductivity and forage yield. Piper black genotypes were the highest in seed germination percentage, seed vigor index and seedling dry weight, but it was the lowest of electrical conductivity. It could be concluded that seed priming may serve as an appropriate treatment for accelerating the emergence so improve cutting and forage yield of sudangrass genotypes under study. Significant differences for fresh yield ton /hectare and piper black had higher fresh, dry and total yield ton /hectare than Giza1. Seed priming had highly significant differences at all cuts in the two seasons and SA25 ppm Salsilc acid treatment had

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superior and the highest dry yield in the two seasons, while control treatment was the lowest dry yield. Technique of seed priming led to improving germination, seedling characters, and forage yield under experiment conditions in comparison to non-primed seed (dry seed) in sudangrass seed stored for 1.5 years. Salicylic acid with 25 ppm had the highest values followed by1.5% of $CaCl_2$ and 3% of KH_2PO_4 in the field conditions. Piper black genotype was the best as compared with Giza1 genotype, which gave the highest seed germination %, seedling vigor and viability. May be recommended for hydropriming seeds for 10 hours in water, which led to an increase in the total fresh yield by 30%, the highest seed germination percentage (94.00 and 92.50%), seed vigor index (20.79 and 19.84) and seedling vigor index (2194.11 and 2236.47) as practical seeds about 10 hours treatment.

Keywords: Seed soaking; forage sudangrass; piper black; Giza1; vigor; field establishment.

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is one of the important summer forage crops that is a source for food, fodder and feed to animals. It is also an important food crop after wheat, rice and maize which is extremely tolerate drought, making it an excellent choice for semi-arid and dry areas where moisture is a limiting factor for crops [1] and [2] . In Egypt, harvested has reached about 153,546 ha for that production quantity 792,044 tons (FAOSTAT 2019) https://www.fao.org/faostat/en/#data/QCL [3]. Therefore, great efforts have been directed towards improving fodder yields of forage sorghum and sudangrass. Considering recent climate changes, sorghum production could reduce the expected food shortages for animal as a direct and human as an indirect food [4].

For many years, several strategies to improve growth and crop development has been investigated. These strategies are based on old, expensive, and slow techniques. As a solution to overcome these adverse conditions in the agricultural land, seed priming is one of the most common techniques used by farmers which depending on prior exposure converting seeds or young seedlings to chemical agents or abiotic stresses making them more resistant to different stresses [5].

Seed priming is a controlled wetting process followed by re-drying that allows the seeds to imbibe water and initiate the internal biological processes necessary for germination, but does not allow the seeds to actually germinate. Various seed priming techniques have been developed which include hydropriming, halo-priming, osmopriming and hormonal priming. Hydropriming generally enhances seed germination and seedling emergence by soaking the seeds in water. One potential way of improving establishment is to develop seed treatments that can increase early and rapid emergence, stand establishment, enhancing seed with low vigor, higher water use efficiency, increasing in deeper roots, increasing in root growth, uniformity in emergence, germination in wide range of temperature, break of seed dormancy, initiation of reproductive organs, better competition with weed, early flowering and early maturity, resistance to abiotic stresses (such as drought, salinity and heat) and diseases [6] and [7]. Halo-priming is a pre-sowing soaking of seeds in salt solutions, which enhances germination and seedling emergence uniformly under adverse environmental conditions and normal condition such as NaCl, KCl, KNO_3, and $CaCl_2$ [8]. Osmopriming is the most widely used type of seed priming in which seeds are soaked in aerated low water potential solution [9]. Hormonal priming is soaking of seed in hormone solution that is referred as hormonal priming such as Gibberellic acid, Salicylic acid and Ascorbic acid etc. On the other hand, salicylic acid (SA) is known as an endogenous growth regulator of phenolic type distributing in a wide range of plant species, which induces biotic and a biotic stress tolerance in crops [10]. The role of salicylic acid in seed germination, enzymatic activity, plant growth and yield have been described by salicylic acid mediated in photosynthesis transpiration, stomata regulation, nutrient uptake and transport [11]. Among several osmotic, $CaCl_2$ was used to direct the water potential of the solution during seed priming. Calcium is an essential nutrient and plays vital structural and signaling roles in plants [12]. Also, Ca modulates plant responses to abiotic stresses as a stress sensor and transducer [13]. [14] Reported better stand establishment, higher seedling vigor and yield in direct-seeded rice owing to osmopriming with $CaCl_2$. Seed priming with KH_2PO_4 solutions gave better seed germination of some legume seeds stored for 20 - 44 years [15,16].

Also, compared fifteen varieties of fodder sorghum and found significant differences among genotypes in fodder and dry yields at all cuts [17]. Evaluated some newly developed sweet sorghum genotypes for some forage attributes. Found significant differences among genotypes in green yield, dry matter yield, days to flowering, plant height and stem diameter [18]. Dry forage yield was found to be significantly and positively associated with fodder yield, plant height and stem diameter [19]. The relationship between dry forage yield and each of yield components except, leaf/ stem ratio was positive and significant [20].

It grows under inadequate and erratic rain fall, low fertility, soils of poor structure and low water holding capacity. Although sorghum is highly stress resistant, it is sensitive to salt during germination, and salt exposure can limit early seedling establishment and reduce final yields [21]. The most sensitive stages, for many types of crop species to stress conditions, are seed germination and early seedling growth [22,24].

Seed priming with salicylic acid led to increasing germination under low temperature condition and improving chilling tolerance faster [25]. It is evident from the above-mentioned literature that seed priming with Ca salts, especially $CaCl_2$, can improve vigor, growth, and development of cereals in stressful environments. Water stress is a growing problem around the globe, and seed priming with $CaCl_2$ may help to mitigate the adverse effects of drought stress.

The purpose of this study was to assess the effect of different seed priming techniques, un-soaked seed (control), Hydro-priming (soaked with distilled water), salicylic acid, $CaCl_2$ and KH_2PO_4 on seed germination%, seedling vigor and forage yield of two sorghum genotypes (Piper black and Giza1), seeds dry-stored under room temperature and humidity for 1.5 year during the two successive summer seasons 2019 and 2020.

2. MATERIALS AND METHODS

The present work includes two experiments (laboratory and field) which were conducted at Sakha Agric. Res. Station, ARC, Egypt, during 2019 and 2020 growing summer seasons, to achieve the best treatment of pre-sowing seeds of two sudangrass genotypes (Piper black and Giza1) which were stored for 1.5 years in normal conditions. It aims to improve performance of germination percent and seedling vigor, seedling vigor index and forage yield. The experiments were laid out in a completely randomized design (CRD) with four replicates for laboratory experiment and a split plot design for field experiment with three replications during both seasons.

2.1 Laboratory Experiment

A laboratory experiment was conducted at Seed Technology Res. Dept at Sakha Agriculture Res. Station., during the two successive summer seasons 2019 and 2020. The groups of priming as hydro priming with distilled water, salicylic acid (25 ppm) and $CaCl_2$ (1.5 %) and kH_2PO_4 (3%) and dry seed as a control. Sudangrass seeds were prepared for the two experiments by soaking seeds in hydro priming with distilled water and solutions of salicylic acid (25 ppm), $CaCl_2$ (1.5 %) and KH_2PO_4 (3%) for 10 hours and control by non-priming seeds (dry seeds). Then seeds were washed with distilled water and dried.

2.2 Laboratory Characters

2.2.1 Seed vigor test

• **Germination Percentage:** it was calculated by counting only normal seedling 10 days after planting according to [26]. Eight replications of 50 seeds per lot were planted in plastic boxes of 40 x 20 x 20 cm dimensions and contained sterilized sand. The boxes were watered and kept at 25 C° in an incubated chamber for 10 days according to international rules of [26]. The boxes were arranged in a completely randomized design (CRD) with four replicates during both seasons. Germination percentage and seed vigor index were estimated according to [26].

• **Electrical conductivity test (EC):** Four sub-samples each of 50 seeds were taken from the pure seed portion of each seed grade. Each sub-sample was weighed to the nearest two decimal points after which it was placed in 500 ml conical flask containing 250 ml distilled water. The flasks were covered and then incubated at 25 ± 1ºC for 24-hour period. Electrical conductivity measures were recorded at the end of each test period at 20ºC using a calibrated electrical conductivity meter (CMD 830 WPA conductance meter and is expressed as Msm^{-1}).

• **Seedling vigor test:** At the final count, ten normal seedlings from each replicate were randomly taken to measure seedling characters.

• **Shoot and radical length and fresh and dry seedling weight:** shoot and root length were determined from ten normal seedlings taken at random from each replicate, and weight to obtain fresh seedling weight (g), then dried in a forced air oven at 70^{o}C to a constant weight and then weight to obtain seedlings dry weight (g).

• **Seedling Vigor Index (SVI)** was determined and calculated according to [26].

SVI = Germination percentage X Seedling length (cm)

Percentage of field emergence: The numbers of emerged seeds were counted daily according to the seedling evaluation [27]. Until the constant count was achieved three samples ware taken for field experiment to measure shoot and radical length and fresh and dry seedling weight after 20 and 26 days after sowing.

Field Experiment: Field experiments were conducted at the Sakha Agric. Res. Station, ARC, Egypt, during 2019 and 2020 summer seasons. The soil texture of the experimental site was clay loam and their physical and chemical analyses are shown in Table (1).

The preceding crop was faba bean in both seasons. The experiments were laid out in a split plot design with three replications during both seasons. The plot size was 10.5 m^2 (3.5 m x 3 m) consisted of five ridges 3.5 m long and 60 cm wide. Seeds were planted on May 29th and 31th in the first and second season, respectively. Two genotypes of sudangrass namely Piper black and Giza1 were used in this study. Seeding rate was 20 kg/fed., and sowing inhills spaced 25 cm at one side of ridge. The experimental site was fertilized phosphorus in the form of calcium superphosphate (15.5% P2O5), during soil tillage at the rates of 150 Kg/fed., While nitrogen fertilizer was added (at a rate of 100 kg N fed) at three equal doses in form of urea 46.5% after sowing before irrigation and after 1st and 2nd cuts. Three cuts were taken during each growing season. The first cut was taken after forty five days from sowing and, the other two cuts were taken subsequently every thirty days. Fresh and dry forage yield (ton/ hectare), plant height (cm), number of stems were taken as a mean counting ten hills(hills =0.15 m2), fresh and dry leaf / stem percent were measured.

2.3 Statistical Analysis

A completely randomized design (CRD) with four replicates was used for laboratory experiment and a split plot design for field experiment with three replications during both seasons following [28].

Table 1. Some mechanical, chemical properties of soil

Soil properties	Soil type	
	2019	**2020**
Clay %	50	54
Sand %	18.7	11
Silt %	31.3	35
Soil texture (%)	Clayey	Clayey
pH (1: 2.5 water suspension)	7.9	8.2
EC (dSm^{-1})	3.16	3.05
Organic matter	1.24	1.50
Available P mg Kg^{-1}	12.0	12.02
Available NH_4 mg Kg^{-1}	12.6	12.6
Available NO_3 mg Kg^{-1}	11.8	11.8
Available K mg Kg^{-1}	350	350
Cations (meq L^{-1})	-	-
Ca^{++}	6.0	6.0
Mg^{++}	1.5	1.5
Na^{+}	13.0	13.0
K^{+}	0.5	0.5
Anions (meq L^{-1})	-	-
HCO_3^{-}	5.0	5.0
Cl^{-}	14.0	14.0
SO_4^{--}	2.0	2.0
CO_3^{--}	0	0

3. RESULTS AND DISCUSSION

3.1 Laboratory Experiment

Results of viability and seed vigor test of the studied sudangrass genotypes as affected by the treatments under study are presented in Table 2. Sudangrass genotypes were significantly varied regarding viability and seed vigor. Piper black genotype had the highest values of germination percentage (88.93 and 87.67%), seed vigor index (20.53 and 19.58) and the lowest electrical conductivity (16.62 and 17.67 µ-mohs) in 2019 and 2020 seasons, respectively. [29,30] found that significant differences between genotypes of sudangrass regarding germination %, electrical conductivity and seed vigor index, while seedling vigor index was insignificant of seedling at laboratory experiment. Hydropriming had the highest seed germination percentage (94.00 and 92.50%), seed vigor index (20.79 and 19.84) and seedling vigor index (2194.11 and 2236.47) in 2019 and 2020 seasons, respectively.

Hydropriming and 25 ppm of salicylic acid was the lowest value of electrical conductivity (9.57,10.60, 9.65 and 10.70 mSm-1) in the two seasons, respectively.

The effects of different seed priming on the two genotypes for the shoot and root length, seedling fresh and dry weight. Piper black genotype had the highest seedling dry weight (0.152 and 0.094 g). Hydropriming was the tallest shoot length (18.02 and 17.09 cm) as shown (Table 3).

It is reported that [31] hydro-priming treatment with soaking duration 2 hours has positive significant effects on increasing seed quality parameters includes seed germination %, germination rate, shoot and root length, shoot dry weigh , root dry weight and electric conductivity of seed leakage.

Hydropriming and 25ppm of salicylic acid had the tallest root length (12.93, 12.13, 12.62 and 11.67 cm) and seedling fresh weigh (0.461,0.418 0.486 and 0.487 mg) in the two seasons, respectively [32]. While, 25ppm of salicylic acid had the highest seedling dry weight (0.158 and 0.108 g). [29] found that all the priming treatments (hydro-priming,KNO3 1% and $CaCl_2$1%) significantly affected the fresh weight, shoot length, root length and vigor index of forage sorghum. It is reported that [33,34] who reported that priming with gibberelic acid (GA), salicylic acid (SA) and ascorbic acid (ASC) led to increasing germination characteristics (germination % and germination index) of aged seed. Hydro improved establishment and early vigor and SA (25 ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport.

It is found [29], all the priming treatments significantly affected the fresh weight, shoot length, root length and vigor index of forage sorghum. It is reported that [33] priming with gibberelic acid (GA), salicylic acid (SA) and ascorbic acid (ASC) led to increasing germination percentage shoot and root length and seedling fresh and dry weight of aged seed. It is showed that [35] seed priming with salicylic acid and CaCl2 led to increasing the germination percentage (%), seedling length (cm), seedling fresh weight (g), seedling dry weight (g) and vigor index.

3.2 Field Experiment

Regarding the field experiment the seed priming led to improved field germination and seedling growth of sorghum (Table 4). Data revealed that insignificant different between two sudangrass genotypes except Piper genotype had the highest shoot length (25.28 and 24.46 cm) in the two seasons, respectively; and seedling dry weight (0.342 mg) in the secondseason only. Hydropriming and 1.5% $CaCl_2$ were the highest seed field germination percentage (92.83, 89.00, 90.17 and 84.00%) in the two seasons; respectively. Treatments 1.5% of $CaCl_2$ and 3% of KH_2PO_4 had the highest shoot length. While, 1.5% of $CaCl_2$ produced the highest root length (6.13 and 5.15 cm). Also, 25ppm salicylic acid, 1.5% of $CaCl_2$ and 3% of KH_2PO_4 had the highest seedling fresh weight and seedling dry weight in 2019 and 2020 seasons, respectively.

Regarding the field experiment, the highest shoot length (50.37 and 49.63 cm) and root length (10.86 and 10.26 cm) for Piper black genotype in 2019 and 2020 seasons, respectively in (Table 5). The effects of seed priming on seedling characters were highly significant. Treatments 1.5% of CaCl2 and 3% of KH2PO4 were the highest shoot length, while hydropriming and 25ppm of salicylic acid were the highest root length. Treatment 25ppm of salicylic acid was the highest seedling fresh weight. While, all the priming treatments significantly affected the

Table 2. Germination%, electrical conductivity (mSm-1), seed vigor index and seedling vigor index (at laboratory) as affected by different seed priming of sudangrass genotypes during 2019 and 2020 seasons

Treatment	Germination%		Electrical conductivity (mSm^{-1})		Seed vigor index		Seedling vigor index	
	2019	2020	2019	2020	2019	2020	2019	2020
Genotypes								
Piper black	88.93 a	87.67 a	16.62 b	17.67 b	20.53 a	19.58 a	1869.71 a	1906.76 a
Giza1	86.40 b	85.00 b	20.39 a	21.42 a	20.44 b	19.48 b	1698.93 a	1732.90 b
F-test	**	**	**	**	**	**	NS	NS
Priming								
Control	84.00 b	82.50 b	32.88 a	33.92 a	19.89 d	18.93 d	1397.94 c	1403.94 c
Hydro	94.00 a	92.50 a	9.57d	10.60 d	20.79 a	19.84 a	2194.11 a	2236.47 a
SA 25ppm	87.33 ab	86.00 ab	9.65 d	10.70 d	20.66 b	19.69 b	1970.16 ab	2029.28 a
$CaCl_2$ 1.5%	85.00 b	84.00 b	17.28 c	18.30 c	20.69 ab	19.73 ab	1665.23 c	1717.10 b
KH_2PO_4 3%	88.00 ab	86.67 ab	23.15 b	24.20 b	20.42 c	19.46 c	1694.15 bc	1712.36 b
F-test	*	*	**	**	**	**	**	**

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 3. Shoot length (cm), root length (cm), seedling fresh weight (g) and seedling dry weight (g) (at laboratory) as affected by different seed priming of sudangrass genotypes in 2019 and 2020 seasons

Treatment	Shoot length (cm)		Root length (cm)		Seedling fresh weight (g)		Seedling dry weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
Genotypes								
Piper black	16.70 a	15.80 a	11.45 a	10.51 a	0.454 a	0.419 a	0.152 a	0.094 a
Giza1	16.07 a	15.16 a	10.69 a	9.81 a	0.423 a	0.389 a	0.146 b	0.059 b
F-test	NS	NS	NS	NS	NS	NS	**	**
Priming								
Control	14.66 c	13.77 c	8.65 b	7.71 c	0.363 b	0.321 c	0.141 c	0.053 b
Hydro	18.02 a	17.09 a	12.93 a	12.13 a	0.461 a	0.418 ab	0.148 b	0.060 b
SA 25ppm	17.44 ab	16.54 ab	12.62 a	11.67 a	0.486 a	0.487 a	0.158 a	0.108 a
$CaCl_2$ 1.5%	16.23 bc	15.32 bc	10.60 b	9.67 b	0.420 ab	0.375 bc	0.147 b	0.097 a
KH_2PO_4 3%	15.57 c	14.69c	10.54 b	9.63 b	0.461 a	0.418 ab	0.150 b	0.064 b
F-test	**	**	*	**	*	**	**	*

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively.*

Table 4. Field germination % and seedling characters affected by different seed priming at the first sample (20 days from sowing) of Sudangrass genotypes in 2019 and 2020 seasons

	Field germination %		Shoot length		Root length		Seedling fresh weight		Seedling dry weight	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
					Genotype					
Piper black	88.00 a	83.80 a	25.28 a	24.46 a	5.30 a	4.38 a	2.78 a	1.89 a	0.375 a	0.342 a
Giza1	86.53 a	83.33 a	23.51 b	22.49 b	5.21 a	4.26 a	2.68 a	1.78 a	0366 a	0.282 b
F-test	NS	NS	**	**	NS	NS	NS	NS	NS	**
					Priming					
Control	80.00 b	76.83 c	21.15 d	20.26 c	5.10 bc	4.46 b	1.82 c	0.94 c	0.286 c	0.193 c
Hydro	92.83 a	89.00 a	22.49 c	21.38 c	5.52ab	4.60 ab	2.50 b	1.62 b	0.335 bc	0.272 b
SA 25ppm	86.33 ab	83.17 b	24.80 b	23.97 b	4.88 bc	3.71 c	3.08 a	2.18 a	0.406a	0.359 a
$CaCl_2$ 1.5%	90.17 a	84.00 ab	26.19 a	25.37 a	6.13 a	5.15 a	3.27 a	2.37 a	0.437 a	0.391 a
KH_2PO_4 3%	87.00 ab	84.83 ab	27.34 a	26.39 a	4.64 c	3.67 c	2.97 a	2.07 a	0.388 ab	0.343 a
F-test	*	**	**	**	**	**	**	**	**	**

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

seedling dry weight in the two seasons in comparison with control. SA (25ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport.

Interaction effect between genotypes and seed priming treatments on see germination percentage, shoot length, seedling fresh weight, electrical conductivity and seed vigor index are shown in Table 6. Piper black treatment with Hydro priming had effect on seed germination percentage (98.00 and 96.67%), shoot length (18.10 and 18.15%) and seed vigor index (20.84 and 19.89). While, 25ppm of salicylic acid had the highest viability (lowest of electrical conductivity) (4.84 and 5.90 mSm-1)), while, 25 ppm of salicylic acid and 3% of KH2PO4 had the highest seedling fresh weight (0.410, 0.508, 0.423 and 0.523 g) with Piper black genotype in both seasons, respectively. It is reported that [29] seed priming may serve as an appropriate treatment for accelerating the emergence of sudangrass genotypes studied.

It is indicated that [30] technique of seed priming is effective in improving field emergence and grain yield of sorghum under wide range of environmental conditions.

Regarding of field experiment of both seasons interaction of sudangrass genotypes and seed priming effect seedling vigor traits are shown (Table 7). Treatment 25ppm salicylic acid with Piper black genotype gave the highest shoot length (28.87 and 28.04cm), seedling fresh weight (3.80 and 2.90mg), and seedling dry weight (0.496 and 0.480 g) in the 2019 and 2020 seasons, respectively [30]. Indicated that technique of seed priming is effective to improving field emergence and grain yield of sudangrass under wide range of environmental conditions.

Concerning the second field experiment sample shoot length (cm) at 25 ppm of Salicylic acid was (52.80cm) in the first season, 1.5% of CaCl2 (55.88 cm) and 3% of KH_2PO_4 (56.80 cm) in the second season with Piper black which gave the tallest shoot length in (Table 8). 25 ppm of Salicylic acid and 1.5% of CaCl2 with Piper black genotype gave the heaviest seedling fresh weight in the two seasons. While, hydropriming and 25ppm of salicylic acid with Giza1 genotype gave the heaviest seedling fresh weight in the second season. Also, hydropriming gave the heaviest seedling dry weight (7.40 and 6.50 g) with Giza1 genotype in 2019 and 2020 seasons, respectively.

Data presented in (Table 9) revealed that piper black had higher plant height, steam diameter and number of stems characters than Giza1 at the three cuts in the two seasons 2019 and 2020.

As seed priming SA 25 ppm Salicylic acid had superior plants at the three cuts in both seasons for plant height, stem diameter and number of stems as mean of ten plants. Interaction of genotypes and seed priming were highly significant at first and second cuts for plant height in the first season and third cut in second season. Which had 138,132, 124 cm and 148,139 and 132 cm for plant height for the two seasons, respectively. Meanwhile 1.97, 1.94, 1.84 cm and 1.94, 1.87, 1.79 for stem diameter on first and second seasons, respectively. Interaction of genotypes and seed priming was highly significant and significant effects at first and third cut for stem in the second season, respectively. Interaction of genotypes and seed priming had highly significant effect at first cut in the first season and significant at third cut in the second season for

Table 5. Seedling characters affected by different seed priming at the second sample (26 days from sowing) in Sudangrass genotypes in 2019 and 2020 seasons

Treatment	Shoot length		Root length (cm)		Seedling fresh weight (g)		Seedling dry weight (g)	
	20119	2020	2019	2020	2019	2020	2019	2020
Genotypes								
Piper black	50.37 a	49.63 a	10.86 a	10.26 a	25.12 a	24.16 a	3.80 a	3.92 a
Giza1	45.59 b	44.92 b	8.36 b	9.67 b	24.90 a	25.11 a	3.90 a	3.98 a
F-test	**	**	**	**	NS	NS	NS	NS
Priming								
Control	40.73 c	40.33 c	6.04 c	5.09 b	11.45 c	9.78 c	2.84 b	1.96 b
Hydro	44.30 bc	43.66 bc	13.10 a	12.47 ab	25.82 b	25.82 b	5.57 a	4.69 a
SA 25ppm	46.85 b	46.04 b	12.25 a	17.01 a	33.35 a	33.94 a	5.68 a	4.76a
$CaCl_2$ 1.5%	55.15 a	54.27 a	7.80 bc	6.97 b	27.84 b	27.17 ab	5.32 a	4.40 a
KH_2PO_4 3%	52.87 a	52.09 a	8.85 b	8.27 b	26.59 b	26.45 b	4.86 a	3.94 a
F-test	**	**	**	*	**	**	*	*

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 6. Germination %, shoot length, seedling fresh weight, electrical conductivity (mSm-1) and seed vigor index (at laboratory) as affected by interaction between different seed priming and sudangrass genotypes in 2019 and 2020 seasons.

Genotypes	Seed priming	Germination%		Shoot length (cm)		Seedling fresh weight (g)		Electrical conductivity (mSm^{-1})		Seed vigor index	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Piper black	Control	84.00 bc	82.67 bc	12.83 d	12.91 c	0.256 c	0.270 d	29.59 b	30.63 b	20.04 e	19.09 e
	Hydro	98.00 a	96.67 a	18.10 a	18.15 a	0.338 a-c	0.351 cd	12.75 h	13.80 h	20.84 a	19.89 a
	SA 25ppm	88.67 a-c	87.33 a-c	16.08 a-c	16.20 ab	0.410 a	0.508 a	4.84 j	5.90 j	20.45 d	19.48 d
	$CaCl_2$ 1.5%	92.00 ab	90.67 ab	15.17 bc	15.27 b	0.342 a-c	0.440 a-c	16.28 f	17.30 f	20.71 a-c	19.76 a-c
	KH_2PO_4 3%	82.00 bc	81.00 bc	16.34 a-c	16.47 ab	0.423 a	0.523 a	19.66 d	20.70 d	20.63 cd	19.67cd
Giza1	Control	84.00 bc	82.33 bc	14.49 cd	14.63 bc	0.269 c	0.372 b-d	36.17 a	37.20 a	19.73 f	18.77 f
	Hydro	90.00a-c	88.33 a-c	15.95 a-c	16.03 ab	0.385 ab	0.485 a	6.39i	7.40 i	20.74 a-c	19.79 a-c
	SA 25ppm	86.00a-c	84.67 bc	16.80 ab	16.87 ab	0.363 a-c	0.465 ab	14.45 g	15.50 g	20.80 ab	19.91 ab
	$CaCl_2$ 1.5%	78.00 c	77.33 c	15.29 bc	15.37 b	0.297 bc	0.311 d	18.28 e	19.30 e	20.67 bc	19.70 bc
	KH_2PO_4 3%	94.00 ab	92.33 ab	12.81 d	12.91 c	0.299 bc	0.313 d	26.64 e	27.70 c	20.22 e	19.25 e
F-test		*	*	*	*	**	**	**	**	**	**

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 7. Seedling characters as affected by interaction of different seed priming and sudangrass genotypes (20 days from sowing) in 2019 and 2020 seasons

Genotypes	Seed priming	Shoot length (cm)		Seedling fresh weight (g)		Seedling dry weight(g)	
		2019	2020	2019	2020	2019	2020
Piper black	Control	22.05 de	21.08 de	1.70 f	0.83 f	0.284 f	0.198 d
	Hydro	23.18 d	22.56 d	2.45 c-e	1.58 cd	0.338 c-f	0.302 c
	SA 25ppm	28.87 a	28.04 a	3.80 a	2.90 a	0.496 a	0.480 a
	$CaCl_2$ 1.5	25.49 c	24.80 c	3.00 b	2.09 bc	0.394 cd	0.317 c
	KH_2PO_4 3	26.80 bc	25.81 bc	2.95 bc	2.04 bc	0.365 c-e	0.411 ab
Giza1	Control	20.25 f	19.43 f	1.94 ef	1.05 ef	0.288f	0.189 d
	Hydro	21.80 df	20.20 ef	2.55 b-d	1.66 b-d	0.332 d-f	0.242 cd
	SA 25ppm	20.72 ef	19.90 ef	2.35 de	1.46 de	0.317 ef	0.400 b
	$CaCl_2$ 1.5	26.88 bc	25.94 bc	3.54 a	2.64 a	0.480 ab	0.302 c
	KH_2PO_4 3	27.88 ab	26.97 ab	3.00 b	2.10 b	0.411 bc	0.275 c
F-test		**		**	**	**	**

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 8. Seedling characters as affected by interaction of different seed priming and sudangrass genotypes in second sample in 2019 and 2020 seasons

Genotypes	Seed priming	Shoot length (cm)		Seedling fresh weight (g)		Seedling dry weight(g)	
		2019	2020	2019	2020	2019	2020
Piper black	Control	39.90 f	39.43 d	12.65 d	9.74 d	2.98 de	2.12 de
	Hydro	45.00 c-e	44.15 cd	17.97 cd	17.03 cd	3.74 c-e	2.88 c-e
	SA 25ppm	52.80 a	51.90 ab	33.46 ab	32.64 a	6.08 ab	5.19 ab
	CaCl2 1.5	56.70 b	55.88 a	34.97 a	34.12 a	6.32 ab	5.42 ab
	KH2PO4 3	57.43 bc	56.80 a	26.58 a	27.25 ab	4.89 b-d	3.99 b-d
Giza1	Control	41.55 ef	41.23 cd	10.24 cd	9.82 d	2.70 e	1.8 e0
	Hydro	43.60 d-d	43.17 cd	33.68 cd	34.61 a	7.40 a	6.50 a
	SA 25ppm	40.90 de	40.17 d	33.25 d	35.23 a	5.27 bc	4.33 bc
	CaCl2 1.5	53.60 a	52.67 ab	20.72 ab	20.22 bc	4.32 b-e	3.38 b-e
	KH2PO4 3	48.30 b	47.37 bc	26.61 bc	25.66 a-c	4.83 b-d	3.89 b-d
F-test		**	*	**	**	**	**

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

number of stems as mean of ten plants character. These results were in harmony with those obtained by [22,30]. Seed priming technique is effective to improve traits studied in comparison with non-primed seed. This is consistent with what mentioned by [32].

Data in Table 10 shows significant and highly significant differences for fresh and dry leaf stem percent for all cuts in the two seasons and piper black gave higher fresh and dry leaf/stem percent than Giza 1 genotype. Data also indicated that SAS 25 ppm Salicylic acid resulted in the highest fresh and dry leaf /stem percent at all cuts in the two seasons while, control treatment had the lowest for all cuts in the two seasons. Interactions of genotypes and seed priming were highly significant at first cut and significant for third cut in the first season for dry leaf/stem percent and highly significant for second cut in the second season for dry leaf /stem only similar results were reported by [32,29,35].

Data in Table (11) indicated significant differences at the second cut in the first season for fresh yield ton /hectare only and piper black had higher fresh yield than Giza1 and there are significant differences at first and second cuts and their total for dry yield ton /hectare between two genotypes but they were highly significant and significant at the first cut and their total in the second season, respectively .At these cases piper black was higher than Giza1. Seed priming had highly significant differences at all cuts in the two seasons and SA 25 ppm Salicylic acid treatments was the superior and had the highest dry yield(ton /hectare) in the two seasons, while control treatment was the lowest one. Followed by $CaCl_2$ 1.5 which had 39.27 and 33.8 for second cut, 26.89 and 22.6 for third cut. These results were in agreement with those obtained by [22]. SA (25ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport. It is observed that [36,37] application of salicylic acid led to increasing the plant dry weight. Data presented in Table 12 revealed that highly significant and significant interaction effects between two sudangrass genotypes and seed priming treatments indicating that treatment piper black with SA25ppm gave the highest mean values at all traits, followed by $CaCl_2$ 1.5 and KH_2PO_4 3 .while the control treatment had the lowest value for all traits.

Table 9. Effect of different seed priming on plant height, stem diameter and number of stems of forage sudangrass at the three cuts in 2019 and 2020, seasons

		Plant height cm						Stem diameter cm						Average number of stems hill					
		2019			2020			2019			2020			2019			2020		
Main		cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3
Genotypes	Piper black	119.1a	115.0a	109.0a	133.1a	127.0a	122.5a	1.70a	1.65	1.60a	1.49a	1.43a	1.37a	8.8a	7.7a	6.8	12.6a	10.8a	9.9a
	Giza 1	113.8b	110.0b	105.0b	128.7b	122.0b	119.0b	1.65b	1.60	1.55b	1.34b	1.38b	1.33b	7.9b	6.9b	6.3	11.7b	10.0b	9.1b
F.Test		*	**	**	**	**	**	**	NS	*	*	*	**	*	**	NS	*	*	**
Sub plot	L.S.D	0.67	0.35	0.18	0.42	0.24	0.24	0.004	—	0.004	0.004	0.004	0.004	0.10	0.06	0.15	0.12	0.09	0.03
Treatment	Control	101.0e	93.0e	88.0e	113.0e	107.7e	105.0e	1.48d	1.42e	1.37e	1.17e	1.13e	1.08e	5.3e	4.7e	4.1e	8.0e	6.9e	6.1e
	Hydro	108.0d	103.0d	97.0d	123.0d	118.0d	113.0d	1.75c	1.52d	1.47d	1.38d	1.33d	1.28d	6.5d	5.8d	4.9d	10.1d	9.3d	8.3d
	SA 25ppm	138.0a	132.0a	124.0a	148.0a	139.8a	132.0a	1.87a	1.82a	1.78a	1.69a	1.63a	1.58a	12.2a	10.6a	9.6a	16.3a	14.0a	12.4a
	CaCl2 1.5	123.0b	123.0b	118.0b	139.0b	133.3b	129.0b	1.77b	1.72b	1.68b	1.58b	1.53b	1.45b	9.8b	8.4b	7.8b	14.5b	11.7b	10.9b
	KH2PO4 3	113.0c	114.0c	108.0c	132.0c	126.7c	123.0c	1.76b	1.63c	1.56c	1.48c	1.43c	1.38c	8.0c	7.3c	6.3c	12.1c	10.2c	9.7c
F.Test		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D		1.8	2.5	2.0	1.4	1.4	1.3	0.039	0.039	0.039	0.042	0.042	0.042	0.65	0.28	0.26	0.44	0.32	0.33
Interaction A*B	F.Test	**	NS	**	NS	NS	**	NS	NS	NS	**	NS	*	**	NS	NS	NS	NS	*
	L.S.D	2.6	—	2.8	—	—	1.8	—	—	—	0.055	—	0.055	0.45	—	—	—	—	0.461

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively.*
** Hill =0.15m^2*

Table 10. Effect of different seed priming treatments on fresh leaf /stem percent and Dry leaf /stem percent of forage Sudangrass at the three cuts in 2019 and 2020, seasons

		Fresh leaf /stem percent						Dry leaf /stem percent					
		2019			2020			2019			2020		
Main		cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3	cut1	cut2	cut3
Genotypes	Piper black	19.5a	22.7a	24.6a	18.7a	21.1a	23.3a	26.0a	28.1a	30.8a	24.5a	26.9a	28.7a
	Giza 1	18.6b	21.7b	23.7b	17.8b	20.1b	22.3b	24.6b	26.6b	29.3b	22.9b	24.9b	26.9b
F.Test		**	*	*	**	*	*	*	**	**	**	*	**
Sub plot	L.S.D	0.033	0.153	0.088	0.033	0.176	0.233	0.185	0.058	0.121	0.120	0.240	0.058
	Control	16.08e	18.7e	20.5e	14.8e	16.8e	18.3e	18.7e	20.8e	22.0e	17.0e	18.6e	19.8e
	Hydro	17.3d	19.8d	22.3d	16.2d	18.7d	20.92d	21.7d	23.5d	26.3d	19.3d	21.8d	23.1d
	SA 25ppm	22.8a	25.5a	27.3a	21.7a	24.7a	28.2a	30.8a	33.4a	36.3a	31.5a	34.3a	37.6a
	CaCl2 1.5	20.3b	24.4b	26.1b	20.3b	22.6b	25.1b	28.5b	31.4b	34.8b	27.9b	30.0b	32.1b
	KH2PO4 3	18.8c	22.4c	24.5c	18.3c	20.3c	21.6c	26.8c	27.7c	30.6c	22.9c	25.0c	26.8c
F.Test		**	**	**	**	**	**	**	**	**	**	**	**
L.S.D		0.451	0.275	0.281	0.371	0.46	0.981	0.526	0.872	0.650	0.612	0.509	0.648
Interaction A*B	F.Test	NS	NS	NS	NS	NS	NS	**	NS	*	NS	**	NS
	L.S.D	—	—	—	—	—	—	0.68	—	0.839	—	0.719	—

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 11. Effect of different seed priming on Fresh Yield ton/hectar and Dry Yield ton/hectar of forage sudangrass at the three cuts in 2019 and 2020, seasons

		Fresh Yield ton/hectare								Dry Yield ton/hectare							
		2019				2020				2019				2020			
Main		cut1	cut2	cut3	Total	cut1	cut2	cut3	Total	cut1	cut2	cut3	Total	cut1	cut2	cut3	Total
Genotypes	Piper black	40.22a	30.46a	19.28a	90.06a	39.63a	28.25a	21.30a	89.20a	5.14a	3.78a	2.26a	11.19a	5.26a	3.64a	2.59a	11.50a
	Giza 1	38.79a	28.16b	20.23a	87.11a	36.65a	28.27a	20.54a	85.47a	4.74b	3.33b	2.05b	10.14b	4.71b	3.47a	2.50a	10.69b
F.Test		NS	*	NS	NS	NS	NS	NS	NS	*	*	**	*	**	NS	NS	*
L.S.D		—	0.46	—	—	—	—	—	—	0.07	0.1	0.0095	0.181	0.029	—	—	0.1095
Sub plot	Control	27.85e	18.56e	10.71e	57.07e	26.89e	17.37e	12.64e	56.95e	2.81e	1.79e	1.00e	5.59e	2.90e	1.79e	1.26e	5.95e
	Hydro	32.84d	24.99d	19.35c	77.11d	33.32d	22.61d	15.18d	71.11d	3.64d	2.74d	1.38d	7.78d	3.93d	2.55d	1.74d	8.21d
	SA 25ppm	52.84a	39.27a	26.89a	119.00a	49.03a	37.91a	29.16a	116.10a	7.50a	5.43a	3.57a	16.49a	7.26a	5.43a	3.93a	16.61a
	CaCl2 1.5	45.46b	33.80b	22.61b	101.86b	43.98b	33.80b	25.47b	103.24b	6.00b	4.36b	2.76b	13.14b	6.07b	4.45b	3.17b	13.69b
	KH2PO4 3	38.79c	29.99c	18.80d	87.82c	37.49c	29.58c	22.13c	89.20c	4.76c	3.47c	2.07c	10.31c	4.76c	3.62s	2.62c	11.00c
F.Test		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D		1.55	1.41	10.33	11.51	1.55	1.41	7.35	8.14	0.21	0.23	0.1595	0.319	0.202	0.1	0.333	0.426
Interaction A*B	F.Test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
	L.S.D	—	—	—	—	—	—	—	—	—	—	—	—	—	0.13	—	—

**, ** and NS indicated P<0.05%, P<0.01% and not significant, respectively*

Table 12. Effects of Interaction between different seed priming treatments of Sudangrass genotype on some traits under study at the three cuts in 2019 and 2020, seasons

Interaction		2019									2020				
MAIN	**SUB**	**Plant height cm**	**Plant height cm**	**Number of stems**	**Dry leaf \stem percent**	**Dry leaf \stem percent**	**Dry leaf \stem percent**	**Fresh Yield ton \ hectare**	**Stem diameter cm**	**Stem diameter cm**	**Number of stems**	**Dry leaf \stem percent**	**Fresh Yield ton \ hectare**	**Total Fresh Yield ton \ hectare**	**Plant height cm**
		cut1	**cut3**	**cut1**	**cut1**	**cut2**	**cut3**	**cut1**	**cut1**	**cut3**	**cut3**	**cut2**	**cut2**	**-**	**cut3**
Piper black	Control	102	91.33	5.5	19.7	21	23	28.70	1.55	1.4	6.5	19.16	18.16	59.33	109.3
	Hydro	110	100	7.00	23.2	25	27.66	33.32	1.65	1.55	8.66	22.66	23.09	74.80	115
	SA 25ppm	143.33	123.3	13.00	31.2	34	36.66	53.69	1.95	1.82	13.16	36.0	37.03	116.62	133.3
	CaCl2 1.5	125	121	10.2	28.8	32.3	35.16	46.24	1.9	1.73	11.16	30.83	34.27	104.72	130
	KH2PO4 3	115.33	110.7	8.33	27.2	28.2	31.33	39.75	1.75	1.65	10.0	26.0	28.70	89.63	124.7
Giza 1	Control	100	85.33	5.00	17.7	20.5	21.0	27.04	1.5	1.32	5.66	18.0	16.66	54.57	101.7
	Hydro	105.67	95.00	6.00	20.2	22.0	25.0	32.37	1.62	1.46	8.0	21.0	22.13	67.43	112.3
	SA 25ppm	131.67	125.7	11.3	30.3	32.8	36.0	51.88	1.93	1.76	11.66	32.66	38.79	115.57	132
	CaCl2 1.5	120.67	115	9.5	28.2	30.5	34.47	44.51	1.83	1.7	10.66	29.16	33.32	100.91	127.7
	KH2PO4 3	111.33	105	7.66	26.5	27.2	29.83	37.91	1.72	1.6	9.33	24	30.46	88.77	121.3
F.Test		**	**	**	**	*	*	*	**	**	*	**	**	*	**
L.S.D		2.57	2.78	0.45	0.68	1.13	0.84	2.00	0.055	0.055	0.46	0.72	0.81	2.76	1.78

** and ** indicated P<0.05%, P<0.01% respectively*

4. CONCLUSION

Technique of seed priming led to improving germination, seedling characters, and forage yield under experiment conditions in comparison to non-primed seed (dry seed) in sudangrass seed stored about 1.5 years. Salicylic acid with 25 ppm was the highest values followed by1.5% of $CaCl_2$ and 3% of KH_2PO_4 in the field conditions. Piper black genotype was the best as compared with Giza1 genotype, which had the highest seed germination %, seedling vigor and viability. May be recommended for hydropriming seeds for 10 hours in water, before sowing which led to an increase total fresh yield by 30% more than dry seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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