

## Original Research Article

### **Effect of Seed Priming Of Two Sudangrass Genotypes Stored On Seed Germination, Seedling vigor, Growth and Forage Yield and Its Component**

#### **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 CaCl<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> 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<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> 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 were highly significant differences at all cuts in the two seasons and SA25ppm Salsilc acid treatment had 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 25ppm was the highest values followed by 1.5% of CaCl<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> 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.

**Key words:** Seed soaking, Forage sudangrass, Piper black, Giza1, vigor, field establishment.

## INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is considered one of the important summer forage crops. In Egypt, there are a shortage in green forages during summer season, While, berseem clover is generously used to feed animals during the winter season. Therefore, great efforts have been directed towards improving fodder yields of forage sorghum and sudangrass. **Khandelwal et al (2015)** reported that sorghum (*Sorghum bicolor* L. Moench) is known as food / fodder/ feed for animals worldwide. 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.

In addition, sorghum is the most important forage crop to tolerate water deficit especially in semi-arid regions in tropical and sub – tropical zones where moisture is a limiting factor for crop .**Ghasemi et al (2012)** compared fifteen varieties of fodder sorghum and found significant deferences among genotypes

in fodder and dry yields at all cuts. **Maarouf and Moataz (2009)** evaluated some newly developed sweet sorghum genotypes for some forage attributes. They found significant differences among genotypes in green yield, dry matter yield, days to flowering, plant height and stem diameter. **Kumar Srivas and Singh (2004)** stated that dry forage yield was found to be significantly and positively associated with fodder yield, plant height and stem diameter. **Carpici and Celik (2010)** concluded that the relationship between dry forage yield and each of yield components except, leaf/ stem ratio was positive and significant.

It grows under inadequate and erratic rain fall high radiation, 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 (Zhu et al., 2018).

Sorghum is an important source, particularly in the arid and semi-arid regions (**Reddy et al., 2004**). Considering recent climate changes, sorghum production could reduce the expected food shortages for animal as a direct food and human as an indirect food (**Abdalla and Gamarhang 2011**).

The most sensitive stages, for many types of crop species to stress conditions, are seed germination and early seedling growth (**Amany and Hoda 2015**), (**Rahimi, 2013**) and (**Rashid et al. 2004**).

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. A common method employed is seed priming. Seed priming is a controlled hydration

process followed by re-drying that allows seed to imbibe water and begin internal biological processes necessary for germination, but which does not allow the seed to actually germinate. Various seed priming techniques have been developed which include hydropriming, halo-priming, osmopriming and hormonal priming etc. Hydropriming generally enhances seed germination and seedling emergence. Hydropriming defined as soaking of seeds in water ( **chen, 2011**). Halopriming is a pre-sowing soaking of seeds in salt solutions, which enhances germination and seedling emergence uniformly under adverse environmental conditions and normal condition. NaCl, KCl, KNO<sub>3</sub>, and CaCl<sub>2</sub> are used (**Bajehbaj, 2010**). Evaluated the effects of NaCl priming with KNO<sub>3</sub> on the germination traits and seedling growth of four *Helianthus annuus* L. cultivars under salinity conditions and reported that germination % of primed seeds was greater than that of un-primed seeds. Osmopriming is the most widely used type of seed priming in which seeds are soaked in aerated low water potential solution. Priming of seeds in osmoticums has been reported to be an economical, simple and a safe technique for seedling establishment and crop production under stressed conditions (**Guzman and Olave, 2006**). Hormonal priming is soaking of seed in hormone solution which is referred as hormonal priming. Gibberelic acid, Salicylic acid, Ascorbic acid, Cytokinins etc can be used for these purposes. Investigated the primed seeds of carrot, onion and tomato were showing that priming these seeds with GA3 led to increasing the germination percentage and germination rate.

Similar to other priming techniques, hydropriming generally enhances seed germination and seedling emergence, although there are exceptions. (**Harris et al., 1999**) demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly improved establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. This simple, low-cost, low-risk intervention also had

positive impacts on the wider farming system, cost effective economic and livelihoods and the technology has proved highly popular with farmers (**Harris et al., 1999, 2000**).

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 (**Fahraji et al., 2014**). The role of salicylic acid in seed germination, enzymatic activity and plant growth and yield have been described by salicylic acid mediated in photosynthesis transpiration, stomata regulation, nutrient uptake and transport (**Gunes et al., 2005**). Seed priming with salicylic acid led to increasing germination under low temperature condition and improving chilling tolerance faster (**Sedghi et al., 2010**).

Among several osmotic,  $\text{CaCl}_2$  is used to direct the water potential of the solution during seed priming. (**Rehman et al., 2011**) reported better stand establishment and higher seedling vigor and yield in direct-seeded rice owing to osmopriming with  $\text{CaCl}_2$ . Calcium is an essential nutrient and plays vital structural and signaling roles in plants (**Tang and Luan, 2017**). It is suggested that Ca modulates plant responses to abiotic stresses as a stress sensor and transducer (**Dodd et al., 2010**). It is evident from the above-mentioned literature that seed priming with Ca salts, especially  $\text{CaCl}_2$ , can improve vigor, growth, and development of cereals in stressful environments. Water stress is a growing problem around the globe, and seed priming with  $\text{CaCl}_2$  may help to mitigate the adverse effects of drought stress.

The main objective of this study was determining the best method of priming to improve field emergence, seedling growth and forage yield of seed sudangrass genotypes stored 1.5 year under Sakha environmental conditions.

## **MATERIAL AND METHOD**

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 aim 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.

**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  $\text{CaCl}_2$  (1.5 %) and  $\text{KH}_2\text{PO}_4$  (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 ),  $\text{CaCl}_2$  (1.5 %) and  $\text{KH}_2\text{PO}_4$  (3%) for 10 hours and control by non-priming seeds (dry seeds). Then seeds were washed with distilled water and dried.

#### **Laboratory Characters:**

##### **Seed vigor test:**

- **Germination Percentage:** it was calculated by counting only normal seedling 10 days after planting according to **ISTA (1999)**. Eight replications of 50 seeds per lot were planted in plastic boxes of 40 x 20 x20 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 **ISTA (1999)**. 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 **ISTA (1999)**.

- **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  $25 \pm 1^\circ\text{C}$  for 24-hour period. Electrical conductivity measures were recorded at the end of each test period at  $20^\circ\text{C}$  using a calibrated electrical conductivity meter (CMD 830 WPA conductance meter and is expressed as  $\text{Msm}^{-1}$ ).

- **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  $70^\circ\text{C}$  to a constant weight and then weight to obtain seedlings dry weight (g).

- **Seedling Vigor Index (SVI)** was determined and calculated by the following equation of **ISTA, 1985** Rules:

$$\text{SVI} = \text{Germination percentage} \times \text{Seedling length (cm)}$$

**Percentage of field emergence:** The numbers of emerged seeds were counted daily according to the seedling evaluation **AOSA, 1986** until the constant count was achieved and two samples 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<sup>2</sup> (3.5m\*3m) consisted of five ridges 3.5 m long and 60 cm wide. Seeds were planted on May 29<sup>th</sup> and 31<sup>th</sup> 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 in hills spaced 25 cm at one side of ridge.

The experimental site was fertilized Phosphorus in the form of calcium superphosphate (15.5% P<sub>2</sub>O<sub>5</sub>), 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 before the first in form of urea 46.5 % after sowing 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 =0.15m<sup>2</sup>), fresh and dry leaf / stem percent were measured.

**Table 1: Some mechanical, chemical properties of soil**

Soil properties	Soil type
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	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 <sup>-1</sup> )	3.16	3.05
Organic matter	1.24	1.50
Available P mg Kg <sup>-1</sup>	12.0	12.02
Available NH <sub>4</sub> mg Kg <sup>-1</sup>	12.6	12.6
Available NO <sub>3</sub> mg Kg <sup>-1</sup>	11.8	11.8
Available K mg Kg <sup>-1</sup>	350	350
Cations (meq L <sup>-1</sup> )	-	-
Ca <sup>++</sup>	6.0	6.0
Mg <sup>++</sup>	1.5	1.5
Na <sup>+</sup>	13.0	13.0
K <sup>+</sup>	0.5	0.5
Anions (meq L <sup>-1</sup> )	-	-
HCO <sub>3</sub> <sup>-</sup>	5.0	5.0
Cl <sup>-</sup>	14.0	14.0
SO <sub>4</sub> <sup>--</sup>	2.0	2.0
CO <sub>3</sub> <sup>-</sup>	0	0

### Statistical analysis:

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. Using **MSTAT-C (1986)**.

## RESULTS AND DISCUSSION

### Laboratory Experiment:

Results of viability and seed vigor test of the studied sudangrass genotypes as affected by the treatment under study are presented in Table 2. Sudangrass genotypes were significantly varied regarding viability and seed vigor. Piper black genotype was 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  $\mu$ -mohs) in 2019 and 2020 seasons, respectively. **Shehzad et al. (2012)** and **Al-Baladawi and Hamza (2017)** found that significant differences between genotypes of sudangrass regarding germination %, electrical conductivity and seed vigor index, while seedling vigor index, insignificant of seedling at laboratory experiment. Hydropriming was 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  $\text{mSm}^{-1}$ ) in the two seasons, respectively.

**Table 2. Germination%, electrical conductivity ( $\text{mSm}^{-1}$ ), seed vigor index and seedling vigor index as affected by different seed priming in sudangrass genotypes in 2019 and 2020 seasons.**

Treatment	Germination%		Electrical conductivity (mSm <sup>-1</sup> )		Seed vigor index		Seedling vigor index	
	2019	2020	2019	2020	2019	2020	2019	2020
<b>Genotypes</b>								
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
<b>Priming</b>								
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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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 show the effect of different seed priming on the two genotypes for the shoot and root length, seedling fresh and dry weight. Piper black genotype was the highest seedling dry weight (0.152 and 0.094 g). Hydropriming was the tallest shoot length (18.02 and 17.09 cm). Hydropriming and 25ppm of salicylic acid was 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 (**Moradi et al. 2009**). While, 25ppm of salicylic acid was the highest seedling dry weight (0.158 and 0.108 g). **Shehzad et al. (2012)** found that all the priming treatments (hydro-priming, KNO<sub>3</sub> 1% and CaCl<sub>2</sub>1%) significantly affected the fresh weight, shoot length, root length and vigor index of forage sorghum. **Azadi et al. (2013)** and **Kaur and Kaur (2005)** 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 (25ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport.

**Shehzad et al. (2012)** found all the priming treatments significantly affected the fresh weight, shoot length, root length and vigor index of forage sorghum. **Azadi et al. (2013)** who reported that 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. **Kumari et al. (2017)** showed that seed priming with salicylic acid and  $\text{CaCl}_2$  led to increasing the germination percentage (%), seedling length (cm), seedling fresh weight (g), seedling dry weight (g) and vigor index.

**Table 3. Shoot length (cm), root length (cm), seedling fresh weight (g) and seedling dry weight (g) as affected by different seed priming in sudangrass genotypes after 10 days from laboratory sowing in 2019 and 2020 seasons.**

Treatment	Shoot length (cm)	Root length (cm)	Seedling fresh weight (g)	Seedling dry weight (g)
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	2019	2020	2019	2020	2019	2020	2019	2020
<b>Genotypes</b>								
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	**	**
<b>Priming</b>								
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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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.

Regarding the first sample in the field experiment of 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 was the highest shoot length (25.28 and 24.46 cm) in the two seasons, respectively and seedling dry weight (0.342 mg) in the second season only. Hydropriming and 1.5% CaCl<sub>2</sub> were the highest seed field germination percentage (92.83, 89.00, 90.17 and 84.00%) in the two seasons; respectively. 1.5% of CaCl<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> were the highest shoot length. While, 1.5% of CaCl<sub>2</sub> produced the highest root length (6.13 and 5.15 cm). Also, 25ppm salicylic acid, 1.5% of CaCl<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> were the highest seedling fresh weight and seedling dry weight in 2019 and 2020 seasons, 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
<b>Genotype</b>										
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
Gizal	86.53 a	83.33 a	23.51 b	22.49 b	5.21 a	4.26 a	2.68 a	1.78 a	0.366 a	0.282 b
F-test	NS	NS	**	**	NS	NS	NS	NS	NS	**
<b>Priming</b>										
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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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.

For the second sample in 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 effect of seed shows priming on seedling characters were highly significant. 1.5% of CaCl<sub>2</sub> and 3% of KH<sub>2</sub>PO<sub>4</sub> were the highest shoot length, while hydropriming and 25ppm of salicylic acid were the highest root length. 25ppm of salicylic acid was the highest seedling fresh weight. While, all the priming treatments significantly affected the seedling dry weight in the two seasons in comparison with control. SA (25ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport.

**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
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							(g)	
	20119	2020	2019	2020	2019	2020	2019	2020
<b>Genotypes</b>								
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
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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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.

Interaction effect between genotypes and seed priming treatments on seed 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 was the highest viability (lowest of electrical conductivity) (4.84 and 5.90 mSm<sup>-1</sup>), while, 25ppm of salicylic acid and 3% of KH<sub>2</sub>PO<sub>4</sub> were the highest seedling fresh weight (0.410, 0.508, 0.423 and 0.523 g) with Piper black genotype in both seasons, respectively. **Shehzad et al. (2012)** reported that it is concluded that seed priming may serve as an appropriate treatment for accelerating the emergence of sudangrass genotypes studied. **Al-Baldawi and Hamza (2017)** indicated that technique of seed priming is effective in improving field emergence and grain yield of sorghum under wide range of environmental conditions.

**Table 6: Germination %, shoot length, seedling fresh weight, electrical conductivity (mSm<sup>-1</sup>) and seed vigor index 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 <sup>-1</sup> )		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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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
Gizal	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 <sub>2</sub> 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 <sub>2</sub> PO <sub>4</sub> 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.

Regarding the first field experiment sample the results indicated that interaction of sudangrass genotypes and seed priming effect seedling vigor traits are shown in Table 7. 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. **Al-Baldawi and Hamza (2017)** indicated that technique of seed priming is effective to improving field emergence and grain yield of sudangrass under wide range of environmental conditions.

**Table 7: Seedling characters as affected by interaction of different seed priming and sudangrass genotypes in the first 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	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 <sub>2</sub> 1.5	25.49 c	24.80 c	3.00 b	2.09 bc	0.394 cd	0.317 c
	KH <sub>2</sub> PO <sub>4</sub> 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 <sub>2</sub> 1.5	26.88 bc	25.94 bc	3.54 a	2.64 a	0.480 ab	0.302 c
	KH <sub>2</sub> PO <sub>4</sub> 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.

Concerning the second field experiment sample shoot length (cm) at 25ppm of Salicylic acid was (52.80cm) in the first season, 1.5% of CaCl<sub>2</sub> (55.88 cm) and 3% of KH<sub>2</sub>PO<sub>4</sub> (56.80 cm) in the second season with Piper black which gave the tallest shoot length in (Table 8). 25ppm of Salicylic acid and 1.5% of CaCl<sub>2</sub> 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.

**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
	CaCl <sub>2</sub> 1.5	56.70 b	55.88 a	34.97 a	34.12 a	6.32 ab	5.42 ab
	KH <sub>2</sub> PO <sub>4</sub> 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
	CaCl <sub>2</sub> 1.5	53.60 a	52.67 ab	20.72 ab	20.22 bc	4.32 b-e	3.38 b-e
	KH <sub>2</sub> PO <sub>4</sub> 3	48.30 b	47.37 bc	26.61 bc	25.66 a-c	4.83 b-d	3.89 b-d
<b>F-test</b>		**	*	**	**	**	**

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

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

As seed priming SA25ppm Salsilc 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 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 and at first cut in the first season and significant at third cut in the second season for number of stems as

mean of ten plants character. These results were in harmony with those obtained by **Amany and Hoda (2015)**, **Al-Baldawi and Hamza (2017)**. Seed priming technique is effective to improve traits studied in comparison with non-primed seed. This is consistent with what mentioned by **Moradi and Younesi (2009)**.

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 25ppm Salsic 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 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 same results were reported by **Amany and Hoda (2015)**, **Shehzad et al. (2012)** and **Kumari et al. (2017)**.

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 there 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 was highly significant differences at all cuts in the two seasons and SA25ppm salsic 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<sub>2</sub> 1.5 which had 39.27 and 33.8 for second cut , 26.89 and 22.6 for third cut.These results were agreement with those **Amany and Hoda (2015)** and **Harris et al. (1999)**. SA (25ppm) encourage photosynthesis transpiration, stomata regulation, nutrient uptake and transport. **Singh and Usha (2003)** observed that application of salicylic acid increased 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 indicated that treatment piper black with SA25ppm gave the highest mean values at all traits, followed by CaCl<sub>2</sub> 1.5 and KH<sub>2</sub>PO<sub>4</sub> 3 .while the control treatment had the lowest one for all traits.

UNDER PEER REVIEW

**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<sup>2</sup>

**Table (10) Effect of different seed priming 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
	CaCl <sub>2</sub> 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
	KH <sub>2</sub> PO <sub>4</sub> 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	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/hectare and Dry Yield ton/hectare 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 on some traits of Sudangrass 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.

## 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 25ppm was the highest values followed by 1.5% of  $\text{CaCl}_2$  and 3% of  $\text{KH}_2\text{PO}_4$  in the field conditions. Piper black genotype was the best as compared with Giza1 genotype, which were 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.

## REFERNCE

- A. O. S. A., (1986). Seed Vigor Testing Handbook: Contribution No.32 to the Handbook on Seed Testing. Association of Official Seed Analysis (AOSA), Springfield, IL. USA., Pages:93.
- Abdalla, H and Y. Gamarhange (2011). Climate change: selection of sorghum genotype with wide adaptation, AG 17 for rain-fed areas of Sudan. *Int J Agric Sci.*1:144-155.
- AL-Baldawi M. H. K and J. H. Hamza, (2017). Seed priming effect on field emergence and grain yield in sorghum. *Journal of Central European Agriculture.* 18(2), p.404-423.
- Ali, S, A. R. Khan, G. Mairaj, M. Arif, M. Fida and S. Bibi, (2008). Assessment of different crop nutrient management practices for yield improvement. *Aust. J. Crop Sci.*, 2(3): 150-157.
- Amany M.Sallam and Hoda I.M.Ibrahim (2015).Effect of Grain Priming with Salicylic Acid on Germination Speed, seedling characters, Anti-Oxidant Enzyme Activity and Forage Yield of Teosinte. *American-Eurasian J.Agric.&Environ.Sci.*,15(5):744-753.

- Azadi M.S, S.A. Tabatabaei, E. Yoynesi, M. R. Rostami and M. Mombeni, (2013). Hormone priming improves germination characteristics and enzyme activity of sorghum seeds (*Sorghum bicolor* L.) under accelerated aging. *Cercetări Agronomice în Moldova*. 3 (155):49-56.
- Bajehbaj A. F, (2010). The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. *African Journal of Biotechnology*. 12:1764-1770.
- Chen K (2011). Antioxidants and dehydrin metabolism associated with osmopriming-enhanced stress tolerance of germinating spinach (*Spinacia oleracea* L. cv. Bloomsdale) seeds. Graduate Theses and Dissertations Paper 10471. Iowa State University.
- Carpici, E.B. and N.Celik (2010) Determining possible relationships between yield and yield – related components in forage maize (*Zea mays* L.) Using correlation and path analysis. *Not. Bot. Hort. Agrobot. Cluj* 38 (3): 280-285
- Dodd, A. N., J. Kudla and D. Sanders (2010). The language of calcium signaling. *Annual Review of Plant Biology* 61:593-620.
- FAOSTAT. (2017). Food and Agriculture Organization of the United Nations Database of agricultural production. FAO Statistical Databases.
- Fahraji, S. S., M. A. Kheradm, M. M. Raofi and E. Fatahi, (2014). Effect of salicylic acid on germination, leaf area, Shoot and root growth in crop plants. *Intl. Res. J. Appl. Basic. Sci.*, 8(9): 1454-1458.
- Ghasemi.A, Karim. MH( Karim Koshteh) and M.M. Ghasemi (2012).Green fodder yield performance of different varieties of soraghum grown in an arid region. *International Journal of Agriculture and Crop Sciences* Vol., 4(13), 839-843
- Gunes, A., A. Inal, M. Alpashan, N. Cicek, E. Guneri, F. Eraslan and T. Guzelerdu, (2005). Effect of exogenously applied salicylic acid on the

- induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). Arch. Agro. Soil Sci., 51: 687-695.
- Guzman M and J. Olave, (2006). Response of growth and biomass production of primed melon seed (*Cucumis melo* L. cv. Primal) germination to salinity level and N-forms in nursery. Journal of Food Agriculture and Environmental Ethics. 4:163-165.
- Harris D, A. Joshi, P. A. Khan, P. Gothakar and P. S. Sodhi, (1999). On-farm seed priming in semi-arid agriculture: Development and evaluation in corn, rice and chickpea in India using participatory method. Experimental Agriculture. 35: 15-29.
- Harris D, R. S. Tripathi and A. Joshi, (2000). On-farm priming to improve crop establishment and yield in direct seeded rice in IRRI: “International Workshop on Dry-seeded Rice Technology”. Bangkok, 25–28 January. The International Rice Research Institute, Manila, the Philippines, 164.
- I.S.T.A, (1985). International rules for seed testing. Seed Sci. Technol., 13:307-355.
- I.S.T.A, (1999). International rules for seed testing association. Seed Sci. and Technology 27, 155-165.
- Kumari N, P. K. Rai, B. M. Bara and I. Singh, (2017). Effect of halo priming and hormonal priming on seed germination and seedling vigour in maize (*Zea mays* L) seeds. Journal of Pharmacognosy and Phytochemistry . 6(4): 27-30.
- Khandelwal .v, M.shakha, B.S.Jod, viS. Nathawat and S.K. Dashora (2015) Genetic parameters and charater Association in sorghum (*sorghum bicolor* (L.) Moench) . Indian Journal of science and technology, Vol. 8 (22): 1-5.

- Kaur S, A. K. Gupta and N. Kaur, (2005), Seed priming increases crop yield possibly by modulating enzymes of sucrose metabolism in chickpea. *J. Agro and Crop Sci.* 191, 81-87.
- Kumar Srivas,S. and U.P.Singh (2004) Genetic variability, character association and path analysis of yield and its component traits forage maize (*Zea mays L.*). *Range & Agro forestry*, 25 (2): 149-153.
- Maarouf I. Mohamed and Moataz A. Mohamed (2009)Evaluation of newly developed sweet sorghum (*sorghum bicolor*) genotypes for some forage attributes. *American – Eurasian J.Agric. & Environ. Sci.*, 6(4): 434-440.
- Moradi, A and O. Younesi, (2009). Effects of osmo- and hydro-priming on seed parameters of grain sorghum (*Sorghum bicolor L.*). *Australian Journal of Basic and Applied Sciences*, 3 (3), 1696-1700.
- Mstat-C (1986)A micro computer program for the design experiment Michigan State Univ, USA.
- Rahimi A, (2013). Seed priming improves the germination performance of cumin (*Cuminum syminum L.*) under temperature and water stress. *Industrial Crops and Products*, 42: 454-460.
- Rashid A, D. Harris, P. A. Hollington and M. Rafiq, (2004), Improving the yield of mungbean (*Vigna radiata*) in the North West Frontier Province of Pakistan using on-farm seed priming. *Exp. Agric.* 40, 233–244.
- Reddy, B, S. Ramesh and P. Reddy (2004). Sorghum breeding research at ICAISAT goals, strategies, methods and accomplishments. *Int Sorghum Millets Newsl.*45:5-12.

- Rehman H, M. Farooq, S. M. A. Basra, and I. Afzal, (2011). Hormonal priming with salicylic acid improves the emergence and early seedling growth in cucumber. *J. Agric. Soc. Sci.*, 7: 109–113.
- Sedghi M, A. Nemati and B. Esmailpour, (2010). Effect of seed priming on germination and seedling growth of two medicinal plants under salinity. *Emirates Journal of Food and Agriculture*. 22(2):130-139.
- Shehzad M, M. Ayub, A. U. H. Ahmad and M. Yaseen, (2012). Influence of priming techniques on emergence and seedling growth of forage sorghum (*Sorghum bicolor* L.). *The Journal of Animal & Plant Sciences*, 22(1): 154-158.
- Singh, B. and K. Usha, 2003. Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. *Plant Growth Regulation* 39: 137–141.
- Tang, R. J, and S. Luan (2017). Regulation of calcium and magnesium homeostasis in plants: from transporters to signaling network. *Current Opinion in Plant Biology* 39:97-105
- Zhu G, C. Y. Song, L. L. Yu and X. B. Chen (2018). Alleviation effects of exogenous growth regulators on seed germination of sweet sorghum under salt stress and its physiological basis. *Acta Agronomica Sinica*. 44(11): 1713–1724.