



SEED GERMINATION AND SEEDLING GROWTH OF SUNFLOWER (*Helianthus annuus L.*) UNDER SALT STRESSED CONDITIONS

Samir Dev Roy, Debesh Das and Md. Enamul Kabir

Agrotechnology Discipline, Khulna University, Khulna 9208, Bangladesh

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Abstract: The experiment was conducted during October 2014 to December 2014 to evaluate the effect of different levels of salinity on seed germination and seedling growth of sunflower. The factorial experiment consists of three variety of sunflower such as BRAC HySun 33, BARI sunflower-2, KU SL-1 and five levels of salinity viz. 4, 8, 12, 16 dS m⁻¹ with control. The effect of variety and salt stress on seed germination and seedling growth of sunflower were varied significantly. The germination (germination energy, capacity and speed of germination) and seedling growth parameters (root length, shoot length and seedling growth) were significantly affected by salt stress and gradually declined with increasing salinity levels. The variety of BRAC Hysun 33 (V₁) showed better performance upto 12 dS m⁻¹ salinity in laboratory condition.

Keywords: Germination energy, germination percentage, germination speed, seedling growth, seedling vigor index

Introduction

Sunflower (*Helianthus annuus L.*) is one of the popular oil crops in Bangladesh belonging to the family of Asteraceae. It is a crucial source of oil with low amount of saturated fat levels (Saadia *et al.*, 2011). It contains 42- 44% oil and fatty acid (BARI, 2011). Furthermore, this crop is a key source of edible oil which has been used for cooking (Liu and Baird, 2003). About 40% vegetable oil consumption of Bangladesh is met from sunflower and the rest is obtained from mustard, soybean, sesame seed, olive, and cotton seed. Moreover, its seeds are a good source of crude protein and feeding the livestock (Hussain *et al.*, 2011). The major sunflower growing areas in Bangladesh are Rajshahi, Jessore, Pabna, Kustia, Gazipur, Natore, Dinajpur, Patuakhali, Tangile, Bagerhat, Narail, Khulna (BARI, 2011). Now, it is widely cultivated in coastal area of Bangladesh but different abiotic stress such as salinity, water logging and drought directly affect the yield of sunflower (BARI, 2011).

Salinity is one of the most important restrictions for crop production in the world, particularly in arid and semi-arid regions (Dadkhah and Grrifiths, 2006). High salinity is also considered as a major abiotic stress and significant factor affecting crop production all over the world, (Hosseini *et al.*, 2003). About 53% of the coastal areas of Bangladesh are affected by salinity (SRDI, 2012). Under salinity, plant has to face both osmotic and ionic challenge caused by seawater intrusion and shallow saline water tables which is severe during the dry season that limits crop production. In Bangladesh, salinity occurs severely in Boro season in

* Corresponding author: <debeshdasat@gmail.com>

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which large area of coastal land remain fallow. Sunflower might be better alternative crop in dry season and can be grown in our country especially in coastal saline area. So, the study of seed germination and seedling growth of sunflower is crucial factor to select the suitability of sunflower variety for cultivation during dry season of Bangladesh. Therefore, the present research was conducted to evaluate the effects of salt stress on seed germination and seedling growth of sunflower

Materials and Methods

Experimental Setup: The experiment was conducted during October 2014 to December 2014 with collected Sunflower seeds and NaCl from the University. This experiment consists of two factors i.e varieties (BRAC HySun 33, BARI sunflower-2 & KU SL- 1) and five levels of salinity (Control, 4, 8, 12, 16 dS m⁻¹). The experiment was laid out in a Completely Randomized Design (CRD) with five replications. Required amount of sodium salt (NaCl) was estimated and added to prepare respective salt solution (Table 1). Germination experiment was conducted by petridish method by using distilled water and saline soil solution of different concentration.

Table 1: Preparation of salt solution of NaCl

Salt solution	Salinity level (EC-dSm ⁻¹)	Amount of NaCl added per liter of distilled water
S ₁	0 (Control)	0.0
S ₂	4	2.1
S ₃	8	4.2
S ₄	12	6.3
S ₅	16	8.4

Data collection: Data were collected and calculated on germination percentage (%), germination energy (%), germination capacity (%), germination speed (%), root length (cm), shoot length (cm), seedling growth rate (mg/day), seedling vigor index. Data were collected randomly from five seedlings of each Petridis for root and shoot length measurement.

Germination rate: Percentage of seed germinated at certain period

Germination energy: Percentage of seeds germinated at 72 h (Bam *et al.*, 2006)

Germination capacity: Percentage of seeds germinated at 168 h (Bam *et al.*, 2006).

$$\text{Speed of gemination (\%)} = \frac{\text{Number of seeds germinated at 72 h}}{\text{Number of seeds germinated at 168 h}} \times 100$$

Seedling vigor index = (Average shoot length + average root length) × germination percentage

Seedling growth rate: Amount of dry matter production (g) *per* unit time is seedling growth rate:

$$\text{Seedling growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where, W_1 and W_2 are initial and final dry weight of plant sample, respectively; T_1 and T_2 are initial and final time, respectively.

Statistical analysis: The recorded data were analyzed statistically using MSTAT-C software. Analysis of variance (ANOVA) technique was employed to test the overall significance of the data. The mean differences were adjudged by Duncan's New Multiple Ranges Test (Gomez and Gomez, 1984).

Results and Discussion

Germination energy: The interaction effect between salinity stress and the varieties on germination energy (%) was significant ($P < 0.05$). The highest germination energy (94%) was found in V_1S_1 which was statistically similar in V_1S_2 , V_1S_3 , V_1S_4 and V_2S_2 . The lowest germination energy (59%) was found in V_3S_5 (Table 2). Salinity reduces the imbibitions of water because of lower osmotic potential of the saline solution and causes mineral imbalance and ion toxicity which affect on germination energy. Similar findings also predicted by Munns and Tester (2008) and Rajendran *et al.* (2009). There were a downward tendency between selective germination parameters with increasing salinity. Decrease of germination capacity, germination energy and speed of rice seed due to the effect of increasing salt concentration may be resulted from decreasing osmotic potential of solution, increasing toxic ions and changing in the mobilization balance of seed reservoir. Decreasing germination percent by the effect of increasing salt concentration is consistent with the results of Xiao-Fang *et al.* (2000). It was found that about 86.3% variation in germination energy might be explained by the variation of salinity levels and *per* unit increase of salinity, decreases germination energy 0.783% (Fig. 1).

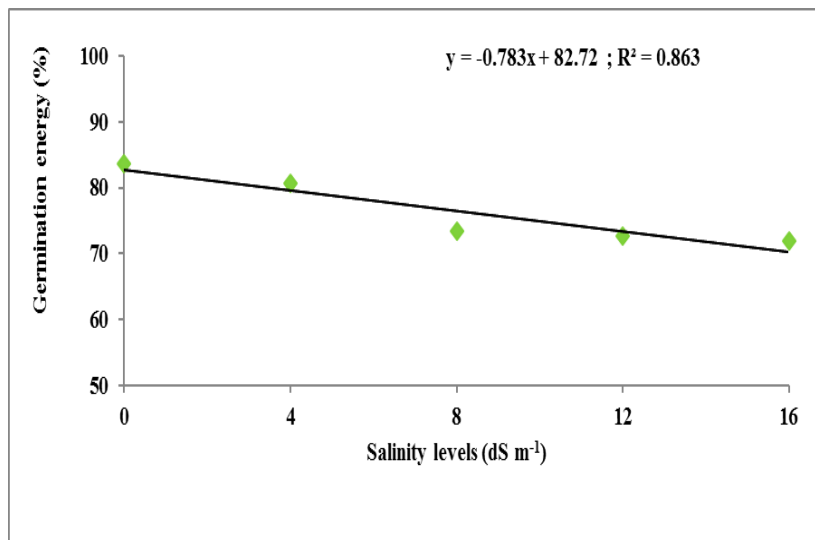


Fig. 1: Relationship between germination energy and salt stress

Germination capacity: The interaction effect between salt stress and the varieties on germination capacity was significant. The highest germination capacity (95%) was found in V_1S_1 and the lowest germination capacity (68%) was found in V_2S_4 (Table 2). It is assumed that extreme salinity might be toxic to the embryo of seed resulting germination inhibited severely (Perez and Tambelini, 1995). Germination capacity was decreased slowly under different treatment levels and it was drastically reduced under different variety levels. In interaction, initially germination capacity was decreased slowly but later it was drastically reduced. Seed germination is the physiological and biochemical phenomenon that takes place with a series of events in seed. At the onset of germination, synthesis of enzyme (α amylase) takes place in endosperm, which plays important role in seed germination. In salt stress, enzyme synthesis might be altered or does not permit the synthesis of specific metabolite required for seed germination which might be affected germination capacity. Lodhi *et al.* (2009) observed that mineral imbalance affect the structure and chemical composition of cell membrane which lead to affect membrane selectivity to transport solute resulting seed germination hampered.

Germination speed: The maximum germination speed (96.57%) was recorded in control and minimum (88.06%) was in 16 dS m⁻¹. It was found that speed of germination was gradually diminished with increasing salinity (Fig. 2).

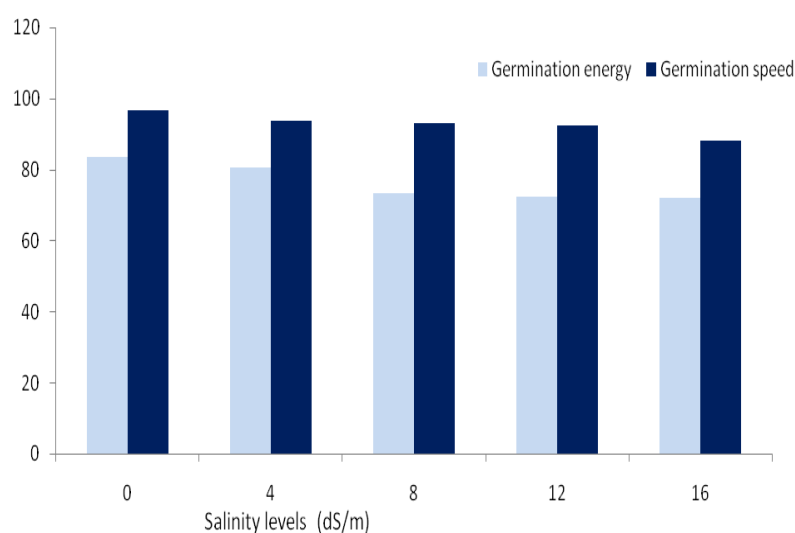


Fig. 2: Effect of salt stress on germination energy and germination speed of Sunflower

The interaction effect between salinity stress and the varieties on germination speed was non-significant. The highest germination speed (99%) was found in V_1S_1 and the lowest germination speed (82.92%) was found in V_2S_3 (Table 2).

Table 2: Interaction effect between variety and salinity on seed germination of Sunflower

Variety X Salinity levels	Germination Energy (%)	Germination Capacity (%)	Germination Speed (%)	Seedling Vigor index
V ₁ S ₁	94 a	95 a	99	455.42 abc
V ₁ S ₂	91 a	93 a	97.88	391.57 abcd
V ₁ S ₃	89 a	90 ab	97.77	555.88 a
V ₁ S ₄	91 a	93 a	97.77	473.42 abc
V ₁ S ₅	90 a	93 a	94.77	533.1 ab
V ₂ S ₁	93 a	94 a	98.94	546.74 a
V ₂ S ₂	80 ab	82 abc	97.14	333.98 bcd
V ₂ S ₃	63 c	77 bc	82.92	302.78 cd
V ₂ S ₄	63 c	68 c	91.51	267.92 cd
V ₂ S ₅	69 bc	70 c	98.46	282.28 cd
V ₃ S ₁	64 c	70 c	91.77	397.27 abcd
V ₃ S ₂	71 bc	82 abc	86.11	380.62 abcd
V ₃ S ₃	64 c	77 bc	83.49	350 abcd
V ₃ S ₄	66 bc	74 c	89.46	316.8 cd
V ₃ S ₅	59 c	72 c	83.79	237.8 d
CV (%)	14.17	12.36	9.78	18.26
Level of Significance	0.05	0.05	Ns	0.05

** Means bearing same letter are not significantly different; S₁ = control, S₂ = 4 dS m⁻¹, S₃ = 8 dS m⁻¹, S₄ = 12 dS m⁻¹, S₅ = 16 dS m⁻¹, V₁ = BRAC HySun 33, V₂ = BARI sunflower- 2, V₃ = KUSL- 1

Noreen and Ashraf (2008) conducted an experiment on alleviation of adverse effects of salt stress on sunflower and reported that mobilization of seed reserves during seed germination is crucial because it supplies substrate for proper functioning of different metabolic processes that essential for growth of embryonic axis which contributes translocation of assimilates from seed, resulting seed germination. It was observed that per unit increase of salinity leads to decrease seedling growth rate 1.497 mg.day⁻¹.

Seedling vigor index: The interaction effect between salinity stress and the varieties on seedling vigor index was significant. The maximum seedling vigor index (555.88) was found in V₁S₃ and the minimum seedling vigor index (237.8) was found in V₃S₅ (Table 2). In case of Sunflowers seed, all the germination parameters were decreased under different levels of salinity in comparison with control. This might be due to as higher the saline solution, higher the solute in medium and high concentrated solute inhibit imbibitions of seed, resulting metabolic activities hampered and ultimately seed germination was decreased.

Root length: The effect of salinity stress and the varieties on root length was significant (P < 0.05). The highest root length (4.43 cm) was found in V₂S₁ and the lowest root length

(1.44 cm) was found in V₃S₅ (Table 3). Salinity is the result of osmotic pressure that leads reduction in water absorption, ultimately cell division and differentiation affected resulting shoot length and root length is diminished. Mer *et al.* (2000), observed that by increasing salinity, plumule length in wheat, barley, pea and cabbage seeds decreased. They pointed out that decreasing the growth of young seedlings by increasing salinity, was because of the most decreasing of water absorption by radicle and subsequently by accumulation of soluble salts in cells.

Table 3. Interaction effect between variety and salinity on seedling growth parameters of sunflower

Variety X Salinity levels	Shoot length (cm)	Root length (cm)	Seedling Growth Rate (mg day ⁻¹)
V ₁ S ₁	3.59 a	2.89 bcd	58.40 cdef
V ₁ S ₂	2.47 abcde	2.23 bcde	63.00 bcde
V ₁ S ₃	2.7 abcd	2.43 bcde	64.60 bcde
V ₁ S ₄	2.16 bcdef	2 cde	58.40 cdef
V ₁ S ₅	2.09 bcdef	2.66 bcde	72 abcd
V ₂ S ₁	2.62 abcde	4.43 a	88 a
V ₂ S ₂	1.9 bcdef	2.67 bcde	74.4 abc
V ₂ S ₃	1.69 cdef	1.78 de	78 ab
V ₂ S ₄	1.45 ef	1.75 de	58 cdef
V ₂ S ₅	1.40 ef	1.84 de	54.2 defg
V ₃ S ₁	2.76 abc	3.53 ab	44.28 fg
V ₃ S ₂	3.10 ab	3.17 bc	44.28 fg
V ₃ S ₃	1.51 def	2.46 bcde	48.60 efg
V ₃ S ₄	1.20 f	2.06 cde	39.72 g
V ₃ S ₅	1.05 f	1.44 e	44.44 fg
CV (%)	18.83	17.37	10.98
Level of Significance	0.05	0.01	0.05

** Means bearing same letter are not significantly different; S₁ = Control, S₂ = 4 dSm⁻¹, S₃ = 8 dS m⁻¹, S₄ = 12 dS m⁻¹, S₅ = 16 dS m⁻¹, V₁ = BRAC HySun 33, V₂ = BARI sunflower-2, V₃ = KUSL-1, NS - Non significant

Shoot length: The interaction effect between salinity stress and the varieties on shoot length was significant (P < 0.05). The highest shoot length (3.59 cm) was found in V₁S₁ and the lowest shoot length (1.05 cm) was found in V₃S₅ (Table 3). By increasing salinity up to 10 ds m⁻¹ dry weight of plumule and radicle decreased. It is probably due to decreasing in remobilization of reservoirs from cotyledons to embryo axis. The factors that affect the

growth rate of embryo axis, also are affecting the mobility of reservoirs and its remobilization from cotyledons to embryo axis (Akita and Cabuslay, 1990).

Seedling growth rate: The combined effect of salinity stress and the varieties on Seedling growth rate was significant. The highest seedling growth rate (88 mg day⁻¹) was found in V₂S₁ and the lowest seedling growth rate (39.72 mg day⁻¹) was found in V₃S₄ (Table 3). Salinity reduces the permeability of water into seedling which affect on photosynthesis ultimately reduction in seedling weight (Massai *et al.*, 2004). Chloride and sodium ions enhancement in plant is one of the negative effects on plant parts which cause unfair condition for crop survival by stopping various mechanisms such as photosynthesis, stomatal conductance and transpiration rate. The results of the present study are agreed with Jamil *et al.* (2006), who reported that effect of salt (NaCl) stress on germination and early seedling growth of four vegetable species and observed that increased salinity caused a significant reduction in germination percentage, root and shoot length, fresh root and shoots weights and seedling growth rate. The figure shows that variation of 88.6% seedling growth rate is explained with different levels of salinity (Fig. 3).

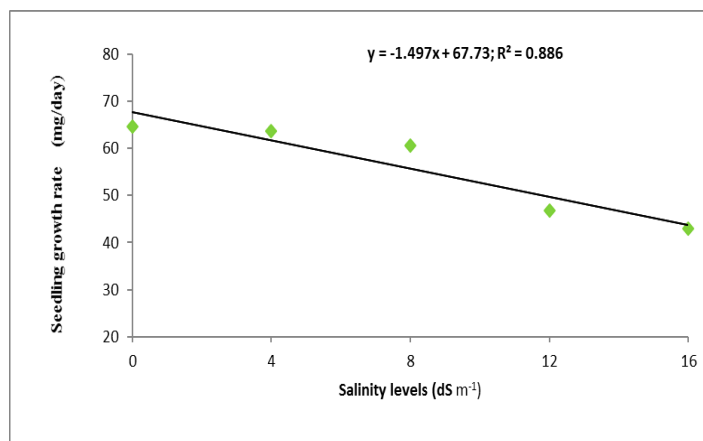


Fig. 3: Relationship between different salt stress and seedling growth rate of Sunflower

Conclusion

The effect of variety and salt stress on seed germination and seedling growth of sunflower were significantly. Germination and seedling growth of sunflower are significantly affected by salt stress. Germination percentage (%), germination energy (%), germination capacity (%), germination speed (%), root length (cm), shoot length (cm), seedling growth rate (mg day⁻¹), seedling vigor index were gradually decreased with increasing salinity but sharply decline after salinity of 12 dS m⁻¹. The variety BRAC HySun 33 showed better performance over the other two varieties.

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