

EFFECT OF SALINITY ON GERMINATION AND EARLY GROWTH IN SUNFLOWER (*Helianthus annuus* L.)

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Received: May 15, 1997.

Accepted: September 17, 1998

SUMMARY

Achenes of seven different genotypes of *Helianthus annuus* L. were tested for germination at four concentrations of sodium chloride solutions and their germination behaviour was compared. Seedling growth exhibited similar sensitivity as germination, under high salt levels. The varieties Morden and CO-4 were found to be more sensitive than others. Newly germinated seedlings exhibited a decrease in size with increase in salt levels.

Key words: Germination, *Helianthus annuus* L., salt tolerance

INTRODUCTION

In arid and semi-arid regions, irrigation is relied on because of insufficient rainfall. Salinity has been recognized as a factor limiting crop productivity particularly in irrigated areas. In saline soils, salt concentration in soil solution creates high osmotic pressure, reducing the availability of water to plants and specific ion effects such as toxicity of sodium and chloride.

In several studies on salinity, especially those concerned with germination, a single salt solution of sodium chloride had attracted greater attention (Ayers, 1952; Ashraf *et al.*, 1983). Although salinity effect involved various aspects of life of plants, it was not easy to establish a chain of priorities (Flowers *et al.*, 1977). It may not be simple to get a scale of salt tolerance for plants because some species are sensitive to salt conditions in some periods of their growth and development while they become resistant in others (Sayed, 1985). In India, about 9 million hectares of land is affected by salinity and alkalinity.

Genetic variability for salt tolerance is important for identification of salt-tolerant genotypes. While information are available on the relative salt tolerance of many crops (Mass and Hoffman, 1977), much less is known about intraspecific variation for tolerance. Sunflower has been classified as a moderately salt tolerant crop and

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screening for salt tolerant cultivars can be of use for cultivation in saline soils and also in genetic manipulation. Some sunflower cultivars differed very much in their capacity to germinate under saline conditions (Chandru *et al.*, 1994). Similarly, in safflower, wide variation has been observed among cultivars during germination under saline conditions (Patil *et al.*, 1992). In elemental analysis, both Na^+ and Cl^- concentrations of shoots were lower in tolerant than in susceptible genotypes. Chloride was more related to salt sensitivity than sodium ion (Noble *et al.*, 1984).

Since area under sunflower is increasing every year in different parts of India, covering all types of soils including those of saline nature, the present laboratory investigation was taken up to understand the reactions of sunflower genotypes to salinity in terms of germination with time and initial growth.

MATERIAL AND METHODS

Seven genotypes of sunflower including three hybrids (PAC-99, PAC-36 and PKVSH-27) and four populations (Morden, CO-2, EC-68414 and CO-4) were tested during the investigation. Fifty achenes of the seven genotypes were placed in 150 mm petri dishes on Whatman No.1 filter paper, soaked with distilled water and various concentrations of sodium chloride, 4, 51, 97, 134 and 179 mMdm⁻³. The petri dishes were placed in a germinator under dark at 27°C. For each salt concentration germination (%) was recorded 2, 4, 6 and 9 days from the beginning of the experiment. The influence of salt solution was tested on the 9th day by determining the radicle length in all salt concentrations.

The delay index was calculated as given below:

$$\text{Delay index (DI)}: \frac{(GP_2 - GP_1)}{(GP_2 + GP_1)}$$

where GP_1 = initial germination percentage

GP_2 = germination percentage after 9 days

The data on germination percentage were transformed using angular transformation and processed for statistical analysis. It was analysed as factorial RBD with varieties and concentrations as two factors for each duration of time. Similar procedure was followed for radicle length.

Nine sunflower genotypes viz., EC-68414, CO-1, PAC-308, Morden, CO-4, PKVSH-27, PAC-36, CO-2 and PAC-99, were screened in the field with a natural salinity gradient ranging from 0 to 20 dS m⁻¹ at Agricultural Research Station, Gavgavati in Karnataka State, India. Single row technique was followed. Recommended package of practices was followed. Germination percentage was noted and reduction in germination percentage was calculated.

RESULTS AND DISCUSSION

Germination of different sunflower genotypes as influenced by time and graded levels of salt concentrations, i.e., 4, 51, 97, 134 and 179 mM dm⁻³ under laboratory conditions, are presented in Table 1. The genotype PAC-36 recorded a higher percent germination of 62.7 followed by CO-2 (50.2%). The variety CO-4 failed to germinate in two days, indicating genetic variability among the genotypes. Irrespective of genotype, germination percentage reduced drastically as salt concentration of the added solution increased from 4.0 to 179 mM dm⁻³. CO-4 was affected the most and failed to germinate at 4 mM dm⁻³. Final germination percentage recorded 9 days after incubation was maximum (76.3%) over different salt levels in case of PAC-36 and remained more than 31 percent in the other genotypes except CO-4 (30.4).

Table 1: Germination percentage of sunflower genotypes with the increase in duration (days) of incubation under different salt levels (mM dm⁻³)

Genotype	Time (Days)				Mean
	2	4	6	9	
Hybrids					
PAC-99	38.9	50.1	60.8	66.8	54.1
PAC-36	62.7	76.6	82.5	83.4	76.3
PKVSH-27	42.8	47.7	52.2	53.7	49.1
Varieties					
CO-2	50.2	55.3	61.3	65.9	58.2
Morden	27.8	31.1	41.3	45.3	36.4
EC-68414	28.6	41.9	47.7	54.1	43.1
CO-4	0.0	30.9	43.2	47.6	30.4
SE m±	1.24	1.51	1.24	1.31	-
CD (**P<0.01)	3.44	4.9	3.43	3.62	-
Concentration (mM dm ⁻³):					
4	56.6	70.5	79.9	84.3	72.8
51	48.7	63.1	70.8	78.0	65.1
97	37.7	46.4	52.4	56.0	48.1
134	9.9	19.5	24.2	25.6	19.8
179	2.74	9.0	11.8	13.4	9.10
SE m±	1.05	1.27	1.04	1.11	1.12
CD (**P<0.01)	2.90	3.54	2.89	3.07	3.10
Hybrids /Varieties x Concentrations					
SE m±	2.77	3.40	2.70	2.90	2.94
CD (**P<0.01)	7.67	9.40	7.70	8.10	8.21

Genotypes

Morden (1.3%), EC-68414 (2.6%) and CO-4 (1.2%) registered lower germination percentages at 179 mM dm⁻³ (Table 2). Performance of PAC-36 which was far

Table 2: Delay index of sunflower genotypes under different salt concentrations

Genotype	Salt concentrations (mM dm^{-3})					Mean
	4	51	97	134	179	
PAC-99	0.32	0.45	0.87	2.77	12.7	3.42
PAC-36	0.04	0.03	0.06	2.64	3.3	1.21
PKVSH-27	0.21	0.34	0.21	2.60	0	0.67
CO-2	0.09	0.18	0.11	2.30	8.3	2.21
MORDEN	0.32	0.58	1.86	4.30	1.3	1.70
EC-68414	0.29	1.31	2.82	9.30	2.6	3.30
CO-4	0.19	0.87	0.92	0.77	1.2	0.79

Table 3: Effect of different salinity levels on mean radicle length (mm) of sunflower genotypes (after 9 days)

Genotype	Salinity level (mM dm^{-3})					Mean
	4	51	97	134	179	
Hybrid						
PAC-99	61.1	55.0	22.7	8.6	0.9	29.7
		(0.0)	(63.1)	(85.9)	(98.5)	(61.9)
PAC-36	39.7	38.1	29.5	9.8	0.5	23.5
		(4.0)	(25.7)	(75.3)	(98.0)	(50.7)
PKVSH-27	56.3	11.4	6.7	0.0	0.0	14.9
		(79.9)	(88.2)	(100.0)	(100.0)	(92.0)
Varieties						
CO-2	51.7	50.8	18.1	3.2	1.1	24.9
		(1.7)	(65.0)	(93.8)	(97.9)	(64.6)
MORDEN	25.9	19.4	3.9	0.0	0.0	16.4
		(25.1)	(50.2)	(100.0)	(100.0)	(68.8)
EC-68414	61.4	9.5	6.1	0.5	0.0	19.4
		(84.6)	(90.0)	(99.1)	(100.0)	(93.4)
CO-4	22.6	9.3	3.1	0.0	0.0	11.6
		(58.8)	(86.3)	(100.0)	(100.0)	(86.3)
	Genotype	Concentration			Interaction	
CD (**P<0.01)	5.30	4.79			1.85	

Values in the parentheses represent percent reduction in radicle length due to high salinity in relation to the control, i.e., 4 mM dm^{-3}

better under non-saline conditions, recorded significantly higher germination of 83.4 percent 9 days after germination also (Figure 1).

The percent reduction in germination between two successive salt levels was computed to know the critical salinity level for germination in each genotype (Figure 1). Out of the three hybrids, PKVSH-27 and PAC-99 had lower germination over days of incubation, Higher germination percentage was observed in PAC-36 which was the most promising among the hybrids. In general, the varieties had lower critical salinity range than the hybrids where percent germination was more than 65 percent except in PKVSH-27.

The germination of these genotypes was also compared in the field (Figure 2). In the case of the hybrids (PAC-36, PAC-99 and PKVSH-27), critical salinity level (EC_c) resulting in higher percent reduction in germination was between low to medium (< 2-8) and high (> 8.0 dS m⁻¹) but it remained lower than that observed under laboratory conditions (13.4 to 17.9 dS m⁻¹). The critical salinity level for Morden in the field was between <2 and 4-8 dS m⁻¹ as against 13.4 to 17.9 dS m⁻¹ under laboratory conditions. This indicated that stress in the field was due to confounded effects of various salts, water table conditions, etc. This indicated that stress in the field due to confounded effects of various salts was more harmful than that experienced in laboratory due to single-salt salinity. Earlier studies have shown a positive correlation between laboratory germination and field emergence (Dighe *et al.*, 1978) thereby laboratory germination serve as an index of field emergence.

The effect of salinity on delay of germination was also calculated and expressed as delay index. As salinity concentration of the medium increased, delay index also increased (Table 2). Delay index was highest at 179 mM dm⁻³ in the case of PAC-99, PAC-36 and CO-2. However, Morden and EC-68414 had the index maximum at 134 mM dm⁻³. This study apparently indicated that a maximum delaying effect in germination was at the critical salinity level. Data on early growth of different sunflower genotypes assessed in terms of mean radicle length are presented in Table 3. Under non-saline conditions (4.0 mM dm⁻³), EC-68414 recorded the highest radicle length (61.4 mm) followed by PAC-99, PKVSH-27 and CO-2. As salinity increased, radicle length decreased significantly and reduction was to the extent of 100 percent at 179 mM dm⁻³ over control but PAC-99 and PAC-36 recorded a significant radicle length at 134 mM dm⁻³. This indicated that eventhough their seeds germinated at 179 mM dm⁻³, they failed to put up subsequent growth (radicle length). At 97 mM dm⁻³, most of the genotypes recorded better growth than under higher salt concentrations but still a reduction in the radicle length was in the order of 90%.

It can be concluded that salinity had a suppressive and delaying effect on germination and was more intensive under field salinity conditions. The delaying effect on germination was high at the critical salinity level for germination. Seedling vigor in terms of radicle length was more prone to stress than germination. This study indicated that PAC-36 among hybrids and CO-2 among varieties are significantly superior over the others under salinity conditions.

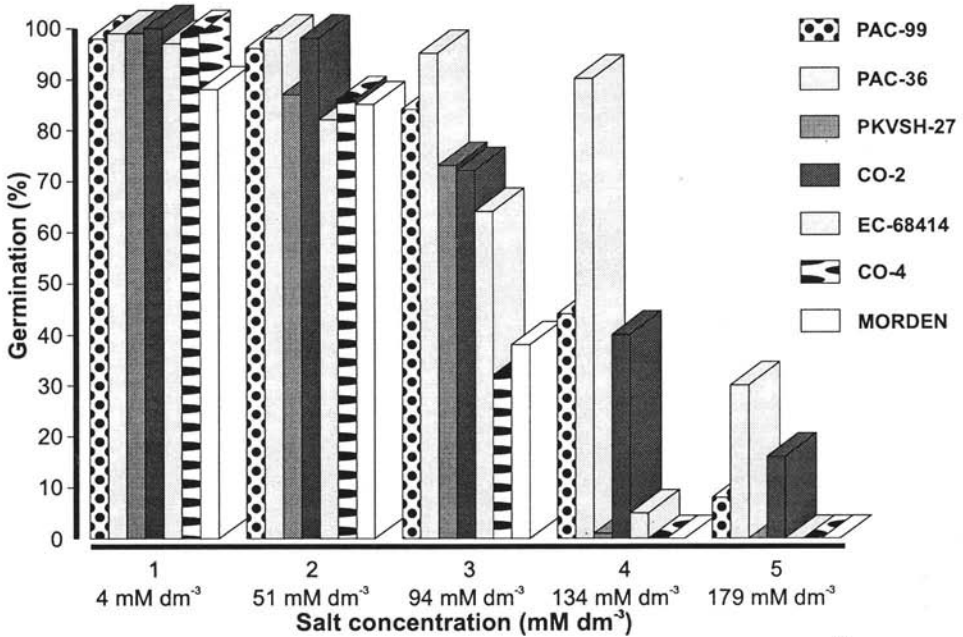


Figure 1: Germination percentage as influenced by salt concentration (mM dm^{-3}) in sunflower (laboratory studies)

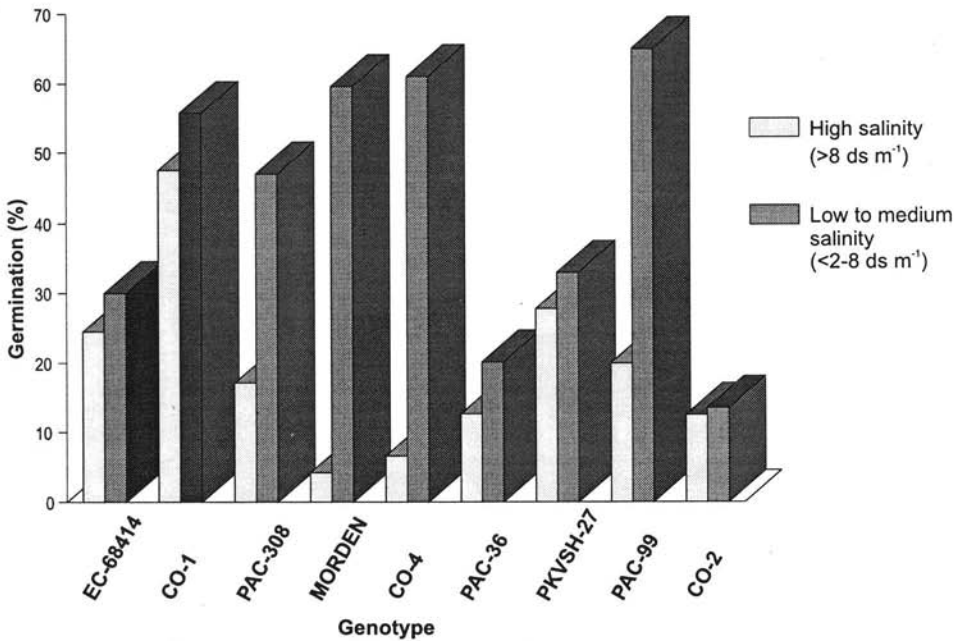


Figure 2: Percentage reduction in germination as influenced by different salinity levels (field studies)

ACKNOWLEDGMENTS

The authors renders thanks to Dr. M. Sujatha, Dr. I.Y.L.N. Murthy and Dr. P.S. Vimala Devi for help in getting the paper to the final form.

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**EFFECTO DE LA SALINIDAD (*Helianthus annuus* L.)
TEMPRANO EN GIRASOL**

RESUMEN

Los aguenios de siete genotipos diversos de *Helianthus annuus* L. fueron testados para germinación en cuatro concentraciones de cloruro sódico y el comportamiento germinativo fue comparado. El crecimiento de las plántulas mostró una sensibilidad similar a la germinación, bajo condiciones de estrés salino. Morden, EC-68414, CO-4 y PKVSH-27 fueron encontradas mas sensitivas que otras. Las plántulas germinadas exhibieron un decrecimiento de tamaño de las plántulas con el incremento de los niveles de salinidad.

**EFFET DE LA SALINITÉ SUR LA GERMINATION ET LA
CROISSANCE PRÉCOCE DU TOURNESOL (*Helianthus
annuus* L.)**

RÉSUMÉ

La germination des akènes de sept génotypes différents d'*H. annuus* L., a été testée selon quatre concentrations de chlorure de sodium et leur comportement vis à vis de la germination comparé. La croissance des plantules révèle une même sensibilité à la germination sous les diverses conditions de stress salin. Les génotypes Morden, EC-68414, CO-4 et PKVSH-27 sont apparus plus sensibles que les autres. Des plantules fraîchement germées réagissent par une diminution de leur taille consécutive à l'augmentation des niveaux de salinité.

