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Response of germination and early seedling growth of phog (*Calligonum polygonoides*) and khara lana (*Haloxylon recurvum*) to temperature and salinity*

V S RATHORE[1], J P SINGH[2], N S NATHAWAT[3], B MEEL[4] and S BHARDWAJ[5]

Regional Research Station, Central Arid Zone Research Institute, Bikaner, Rajasthan 334 004

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Shrubs cover > 70 % landscape in Indian hot arid region, and are economically and ecologically very important. Phog (*Calligonum polygonoides* L.) is an important shrub which provides fodder, fuelwood and used for sand dune stabilization (Singh *et al.* 2008). Khara lana (*Haloxylon recurvum*) is an halophytic shrub which is used as source of choa and saji (a product of sodium carbonate), alternative fodder, and suitable for remediation of saline lands (Rathore *et al*. 2008).The interaction effects of temperature and salinity play an important role in regulating the germination and early seedling growth of plants in arid region (Khan and Ungar 1998). Germination and early seedling growth responses of *C. polygonoides* and *H. recurvum* to temperature and salinity are poorly understood. The aim of present study is to describe the germination and early seedling growth response of these species to temperature and salinity.

Seeds were collected from experimental farm of CAZRI, RRS, Bikaner, India. Experiments were carried out during 2009 in RBD with three replications. Treatments consisted of five constant temperatures (15, 20, 25, 30, 35°C). Salinity treatments comprised six NaCl levels (0,100,200, 300, 400, 500 mM) for *H. recurvum* and seven NaCl levels (0, 25, 50,100,200,300, 400 mM) for *C. polygonoides*. Germination was carried out in plastic Petri-dish. The 25 seeds were placed on two layers of filter paper moistened with 10 ml of test solutions as per treatment and distilled water (0 mM NaCl). Germination was recorded on alternate day. The proportion of seed germinated at 20 days and 30 days after incubation in *H. recurvum* and *C. polygonoides*, respectively was expressed as final percentage germination (G_F). Length of five seedlings selected randomly from each replicate was measured at the end of incubation period. G_F were arcsine transformed before statistical analysis. Data were subjected to analysis of variance for factorial RBD. For analysis of seedling growth of *C. polygonoides* samples from four temperature (15, 20, 25, 30 °C) and salinity (0, 25, 50, 100 mM NaCl) regimes were used.

Seeds germination of both species was significantly affected by temperature, salinity, and their interaction (Table 1). Highest G_F of *C. polygonoides* was recorded at 20 °C, and its G_F decreased with deviation of temperature from 20 °C. The highest G_F of *H. recurvum* was recorded at 15 °C, and it decreased progressively with an increase in temperature. The 15–20 °C temperature seems to be optimum for the germination of both species. Reduction in germination with deviation of temperature from optimum might be attributed to denaturation of protein, membrane dysfunction and finally the termination of metabolic activities required for germination.

Salinity inhibited germination of both species (Table 1). The G_F of *C. polygonoides* was 7.1, 19.5, 43.2 % less at 25, 50, 100 mM NaCl, respectively than control. The G_F of *H recurvum* with 300, 400, 500 mM NaCl was 80.2, 84.9, 95.8 % lower respectively, compared to control. Results support that germination response to salinity is species-specific. Germination of *C. polygonoides* was completely inhibited at 200 mM NaCl concentration, in contrast *H. recurvum* showed 7.7 to 59.8 % germination at the same level of salinity. Inhibitory effect of salinity varied with shift in temperature and was more pronounced at higher temperatures. The finding is in agreements as those reported by Gulzar and Khan (2001) but contradicted to the finding of Aiazzi *et al.* (2002). Germination of *H. recurvum* was completely inhibited with 300 mM NaCl at 30 °C and with 500 mM NaCl at 20 °C. The germination of *C. polygonoides* was completely inhibited with 200 mM NaCl at 15–30°C, but at 35 °C no germination was recorded even with 100 mM NaCl. Higher incubation temperature could increase the Na^+ and Cl^- influxes via cell membrane, which increase inhibition to the physiological process required for germination.

*Short note

[1]Senior Scientist (e mail: rathoreiari@yahoo.co.in), [2]Principal Scientist (e mail: singh_jpbkn@yahoo.com) [3]Senior Scientist (e mail: nathawatns@rediffmail.com) [4]Scientist (Senior scale) (e mail: birbalmeel@yahoo.co.in) [5]Scientist (e mail: sseema26@rediffmail. com)

Table 1 Final germination percentage (G_F) of *C. polygonoides* and *H. recurvum* as influenced by temperature and salinity

Temperature (ºC)	Final germination (%)														
	Calligonum polygonoides NaCl (mM)								*Haloxylon recurvum* NaCl (mM)						
	0	25	50	100	200	300	400	Mean	0	100	200	300	400	500	Mean
15	52.4	45.4	41.5	30.2	0.0	0.0	0.0	24.2	90.0	68.8	59.8	30.9	24.6	14.4	48.1
20	53.2	51.7	43.1	34.4	0.0	0.0	0.0	26.0	90.0	71.2	36.1	19.0	17.4	0.0	38.9
25	34.4	31.1	27.5	22.5	0.0	0.0	0.0	16.5	82.3	66.9	31.0	17.4	9.3	0.0	34.5
30	22.5	21.4	19.0	13.2	0.0	0.0	0.0	10.9	45.4	28.2	8.6	0.0	0.0	0.0	13.7
35	14.8	14.8	11.5	0.0	0.0	0.0	0.0	5.9	32.7	23.5	7.7	0.0	0.0	0.0	10.7
Mean	35.4	32.9	28.5	20.1	0.0	0.0	0.0		68.1	51.7	28.6	13.5	10.3	2.9	
	Salinity		Temperature		Salinity × temperature				Salinity		Temperature		Salinity × temperature		
LSD (P = 0.01)	1.9		1.6		4.3				3.6		3.9		8.9		

Values followed by different letters are significantly different at $P < 0.01$

Seedling growth of both species showed significant response to temperature, salinity and their interaction (Fig 1, 2). Highest seedling growth of *C. polygonoides* was recorded at 20 °C. The highest seedling growth of *H. recurvum* was observed at 20–25°C. The favourable temperature for the seedling growth of both the species was slightly higher than for germination. Seedling growth of both the species decreased with an increase in salinity (Figs 1, 2). Seedling length of *C. polygonoides* with 50 and 100 mM NaCl were 23.1 and 42.8% less respectively, compared to the control. Seedling length of *H. recurvum* with 300, 400, 500 mM NaCl was 75.0, 85.5, 94.7% less respectively, compared to control (Fig 2). The inhibition of seedling growth by salinity was more in *C. polygonoides* than *H. recurvum*. Halophytes typically accumulate high concentrations of ions to lower the osmotic potential in response to increasing salinity, which enables them to absorb water from saline medium and ensure continued growth (Zhao *et al.* 2003). Response of seedling growth to salinity changed with shift in temperature. Salinity-induced inhibition

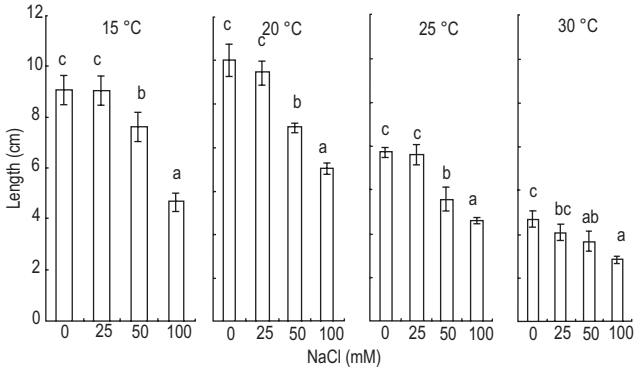

Fig 1 Effect of temperature and NaCl concentration on the seedling growth of *C. polygonoides*. Bar represents mean ± SE. Different letters indicate significant difference between treatments ($P < 0.01$).

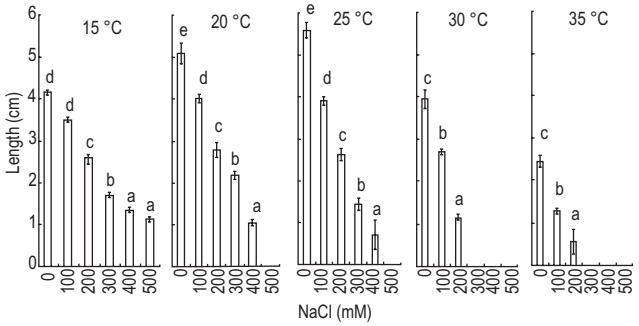

Fig 2 Effect of temperature and NaCl concentration on seedling growth of *H. recurvum*. Bar represents mean ± SE. Different letters indicate significant difference between treatments ($P < 0.01$).

of seedling growth was more pronounced at higher temperature (25 and 30°C).

It is concluded that the optimum temperature for germination and seedling growth of these species ranges from 15 to 20 °C, and *C. polygonoides* could germinate over a wide range of temperature under non-saline condition and up-to 100 mM NaCl at optimum temperature. *H. recurvum* could germinate up to 400 mM NaCl under optimum temperature.Temperature modulates the germination and early seedling growth response of the species to salinity. Germination of seeds occurs only when both the temperature and salinity are favourable; this helps to persistence of seed bank and spreading the germination over time. Delay and postpone of germination under high salinity and temperature is part of the adaptive strategy of species to survive in the harsh environment of desert region like north-western India.

SUMMARY

Experiment was conducted to assess the effect of temperature and salinity on germination and seedling growth of *C. polygonoides* and *H. recurvum*. Seeds were incubated

at five temperatures (15, 20, 25, 30 and 35 °C) with six NaCl concentrations (0,100, 200, 300, 400 and 500 mM) for *H. recurvum* and with seven NaCl concentrations (0, 25, 50, 100, 200, 300, and 400 mM) for *C. polygonoides*. The 20–25 °C temperature seems to optimum for germination and seedling growth of *C. polygonoides* and *H. recurvum*. Germination and seedling growth were inhibited by either an increase or a decrease in temperature from the optimal temperature. The *C. polygonoides* germinated up to 100 mM NaCl concentration, whereas *H. recurvum* germinated up-to 400 mM NaCl concentration under optimal temperatures. The 50 % reduction in seedling growth of *C. polygonoides* and *H. recurvum* was recorded with > 50 mM and 300 mM NaCl, respectively. The interaction effect of temperature and salinity on all measured variables was significant. Salinity-induced inhibition of germination and seedling growth was more at higher temperatures in both species. These results provide information pertaining to germination behaviour of species, and shows that in arid region, selection of suitable planting time and site must take into account both salinity and temperature.

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