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Germination in osmotic solutions as an index of drought resistance in *Sorghum**

by

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Synopsis: The results of studies conducted to evaluate drought-resistance by determining the influence of simulated drought on the germination of six grain *Sorghum* varieties in osmotic solutions are reported in this paper.

Introduction: The use of D-Mannitol, sugar and other salt solutions to test drought hardiness is a simple, easily repeated test which gives a relative measure of any differences among varieties for this character. This consists of germination of seeds in various osmotic solutions and the assumption involved is that if a seed can germinate by absorbing water against a high osmotic gradient, the resulting plant could also absorb water better on account of its high osmotic pressure.

The present study consists of experiments that were conducted to determine the influence of simulated drought on the germination of six grain *Sorghum* varieties in osmotic solutions with a view to evaluate them for drought resistance.

Review of Literature: The retarding effect of increased osmotic concentrations on absorption of water by seeds was observed by several authors. Yamasaki, (1929) germinated the seeds of hydrophytic and xerophytic rice varieties soaked in three per cent potassium chlorate for two days in distilled water and found that the seeds of hydrophytic varieties germinated well but were soon killed by the toxic action of the salt they had absorbed while those of the xerophytic ones not only showed germination but survived, the seedlings from them growing on in distilled water without being much injured by the potassium chlorate. It was found that xerophytic rice was more resistant than hydrophytic rice and that in the former, the ability to grow in spite of the salt absorbed by the seeds, parallels drought resistance. He concluded that by means of such germination experiments, it may be possible to determine to some extent, the degree of drought resistance of crops. While Bolsumov (1927), Pavlov (1931), Biichinger (1936) Timofeeva (1933) and Semakin (1938) observed a good correlation between ability to germinate in strong sugar solutions and field performance, Skazkin (1938), Amodt and Johnston (1936) and Birdsall and Neatby (1944) did not find such a correlation. (Quoted by Ashton, 1948).

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Rachel Uhvits (1946) tested the germination of alfalfa seeds on substrates supplied with the solution of sodium chloride and mannitol at osmotic pressures ranging from one to 15 atmospheres. She found that higher the concentrations of sodium chloride and mannitol, the lower were the rate and the percentage of germination of alfalfa seeds; the retardation and reduction of germination were greater on sodium chloride than on mannitol substrates at equal osmotic pressures. No correlation with drought resistance has been mentioned.

Powell and Pfeifer (1946) used D-Mannitol solution to create the controlled drought and concluded that two generations of Cheyenne Winter wheat had highly correlated growth rates when the seed was germinated under droughty conditions. Helmerick and Pfeifer (1954) found that germination and early growth of Yogo winter wheat were significantly superior to that of Cheyenne Winter wheat when germinated under controlled limited moisture conditions. They concluded that the differential germination and growth response between the two varieties were inherent rather than environmental.

Dotzenko and Dean (1959) germinated six alfalfa varieties in mannitol solutions and the data show that the number of seeds germinated in each variety decreased as the osmotic pressure of the mannitol solution was increased. The variety x treatment interaction was highly significant indicating that the ability to germinate at high osmotic pressures is heritable.

Wiggans and Gradner (1959) studied the effectiveness of various solutions for simulating drought conditions as measured by germination and seedling growth of radish and *Sorghum* and found that five atmospheres of sucrose, glucose and D-Mannitol had only a slight effect on reducing germination of radish and *Sorghum* seed while five atmospheres of PVP (Polyvinyl pyroltdone) and sodium chloride almost completely inhibited germination and radicle growth of *Sorghum* and radish.

Evans and Stickler (1961) conducted experiments to determine the influence of simulated drought on germination and seedling growth of four grain *Sorghum* varieties and showed that germination decreased with increasing moisture tension.

Materials and Methods: *Sorghum strains studied:*

Co. 1, Co. 19 and Co. 20 Rainfed strains

Co. 4, Co. 12 and Co. 18 Irrigated strains.

Chemicals and concentrations tried :

D-Mannitol : 0.2, 0.3, 0.4 Molar
Sucrose : 0.2, 0.3, 0.4 Molar
Sodium chloride : 0.05, 0.10, 0.15, 0.2 Molar
Distilled water : Control.

Sorghum varieties differing in drought hardiness were selected to study the effect of the three chemicals, D-Mannitol, sucrose and sodium chloride in the various osmotic concentrations mentioned above, on germination. As the higher concentrations of NaCl. solutions were found to practically inhibit germination, the lower concentrations were chosen.

One hundred seeds of each variety were placed on filter paper discs in petri dishes saturated with 10 cc of each of the osmotic solutions to simulate drought and with distilled water for the control, each treatment being replicated twice. The germination counts were recorded daily for 10 days.

The experiment was repeated twice and the trend of results was identical. The summary of the data collected is presented in Table I.

TABLE I.

Percentage of germination—Summary of data.

Strain	Distilled water	D. Mannitol			Sucrose			Sodium chloride			
		0.2 M.	0.3 M.	0.4 M.	0.2 M.	0.3 M.	0.4 M.	0.05 M.	0.10 M.	0.15 M.	0.20 M.
Co. 1	85.0	35.0	37.5	32.5	55.0	35.0	30.0	52.5	35.0	57.5	37.5
Co. 4	70.0	25.0	15.0	15.0	50.0	25.0	17.5	32.5	27.5	60.0	37.5
Co. 12	40.0	75.0	75.0	5.0	12.5	12.5	10.0	45.0	20.0	42.5	17.5
Co. 18	40.0	12.5	10.0	10.0	37.5	17.5	10.0	40.0	35.0	55.0	35.0
Co. 19	95.0	90.0	70.0	75.0	92.5	90.0	65.0	92.5	87.5	85.0	82.5
Co. 20	90.0	50.0	52.5	42.5	67.5	52.5	32.5	60.0	47.5	57.5	47.5

Analysis of Variance

Source	DF	S. S.	M. S. S.	'F' Value
Varieties	5	24464·35	4892.87	104.50
Treatments	10	7740·90	744·09	16·53
Control *vs* Chemicals	1	2030·49	2030·49	43·37
Between Chemicals	2	2849·00	1424·50	30·43
Concentration within chemical	7	2861·41	408·77	8·73
Varieties x Treatments	50	2645·94	52·92	1·13
Varieties x Control & Chemical	5	324·37	64·87	1·38
Varieties x Between Chemicals	10	1029·47	102·95	2·19
Varieties x Concentration within Chemicals	35	1292·10	36·92	...
Error	60	2809·49	46·82	...

C. D. for varieties 5.03.

Co. 19	Co. 20	Co. 1	Co. 4	Co. 18	Co. 12
67·42	46·80	40·26	34·13	30·23	24·53

Results and Discussion: The data reveal that the number of seeds germinated in each variety decreased as the osmotic pressure of the solution increased. The higher the concentration of the chemical solution, the lower were the rate and percentage germination of *Sorghum* seeds in the D-Mannitol and sucrose solutions.

Even though the difference between different varieties and between different treatments were found to be significant at one per cent level, the interaction between varieties and treatments was not significant. Of the six strains, the maximum germination percentage was obtained in Co. 19 followed by Co. 20, Co. 1, Co. 4, Co. 18 and Co. 12, indicating thereby the distinct superiority of the three rainfed strains over the irrigated strains and the ranking of the strains in the decreasing order of drought resistance.

Germination decreased with increasing osmotic concentration since the hydration of seeds decreases as the concentration of the substrate increases, and where the germination is very low, the average absorption is also uniformly low. Differences in response to the different solutions at the isosmotic concentrations suggest a toxic effect at the higher concentrations.

Sergeev and Lebedev (1936) correlated drought resistance with salt resistance. Treatment with weak solutions of potassium chlorate, copper sulphate, sodium chloride and sucrose was found helpful in determining xerophytism. In paddy, Yamasaki observed that seeds of low land varieties germinated well in these solutions but were soon killed by the toxic effect of the salts. Seeds of the upland (xerophytic) varieties, on the contrary, showed good germination and survived toxic effects.

Summary and Conclusions: Germination studies on six grain *Sorghum* varieties in various osmotic solutions were conducted to evaluate the strains for drought resistance.

As the ability of the seeds to germinate in osmotic solutions parallels drought resistance, the rainfed strains of *Sorghum* were observed to be distinctly superior to the irrigated strains, the ranking of the strains in the decreasing order of drought resistance being Co. 19, Co. 20, Co. 1, Co. 4, Co. 18 and Co. 12.

By means of such germination experiments, it may be possible to determine to some extent, the degree of drought resistance of varieties.

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