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Imbibition and germination in the seeds of *Heliotropium supinum* L.

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Abstract

Imbibition in the seeds of *Heliotropium supinum* L. varies under different temperatures. The optimum temperatures for imbibition and germination are also different. For germination 39% imbibition is essential, and this capability is achieved by 12-week-old seeds. With duration of dry storage imbibition increases. The imbibition and germination percentages decline on re-dry storage of seeds after embeding in mud. A soil moisture of 44% is optimal for germination. A correlation exists between imbibition and germination.

INTRODUCTION

Heliotropium supinum L. is a common associate of vegetation appearing on receding ponds. Its wide but specialized distribution has attracted the attention and prompted imbibition and germination studies of its seeds. Imbibition is actually a process of water uptake and the penetration of water through the seed coat and hydration of the interior of the seed is essentially an absorption process, involving the entire seed and preparing it for germination.

MATERIAL AND METHODS

Ripe *Heliotropium supinum* L. fruits from five different localities of Gwalior were collected on 15.06.1963. They were mixed together, dried under bright sunlight and stored in corked glass bottles in a warehouse, the thermal coditions of which ranged from 25 to 37°C. The seeds were healthy and free from any disease. Their viability was 99% as tested by T.T.C. (2,3,5-triphenyl-tetrazolium chloride) treatment. The seeds which were actually nutlets, were taken out of the fruits whenever required. The temperatures applied to study imbibition and germination were: T_1 — laboratory temperature which ranged from 19.5 to 25.6°C; T_2 — the constant temperature of 35 ± 1.8°C; T_3 — the constant temperature of 10 ± 1.6°C; and T_4 — the alternate temperature of 35 ± 1.8°C and 10 ± 1.6°C for 12 h each during one day. In all the experiments 3 replications were made.

The imbibition was determined in terms of % absorption of water and it was expressed as the difference in weight of seeds after and before immersion in distilled water for different time periods at various temperatures. It was actually the difference in the water content in seed after and before imbibition. Each time 100 seeds were taken in 3 replicates to determine the mean imbibition % of the seed. Germination was studied in sterilised Petri dishes over moist filter paper and 100 seeds were taken in each Petri dish, in 3 replications. The emergence of the radicle was considered as the criterion for germination and the latter was studied for 90 days in each case till complete germination was obtained. The mud treatment was given by tying up the seeds in cheese-cloth, waterlogging in mud at laboratory temperature which ranged from 21.5 to 30°C. The different soil moisture levels i.e. 11, 22, 44, 55 and 100% were maintained on the basis of the oven dry weight of the pond bottom soil. The data were statistically analysed and on account of inequality in the variance in the imbibition and germination percentages, the values were transformed to degrees at a suitable scale — the angular transformations which were used for calculating the analysis of variance (Snedecor and Cochran 1968).

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Effect of temperature on imbibition and germination. The imbibition % at different temperatures and after various periods of time, and the germination % were determined in 22 weeks old seeds (Table 1). The immersion of the seeds for 72 h at constant temperature of $35 \pm \pm 1.8$°C showed the highest imbibition. The values of variance ratio (F) and critical difference (C.D.) or least significant difference (L.S.D.) have revealed that temperature and duration of immersion significantly affected imbibition. None of the temperatures was favourable for germination except T_4 in which it was 75%. This showed that the optimum temperatures for imbibition and germination were different and were T_2 and T_4, rescpectively.

Effect of dry storage on imbibition and germination. The seeds dry-stored for periods of different duration were immersed in distilled water for 72 h at T_4 to observe their imbibibtion %. The germination %

Table 1

Effect of temperature on imbibition and germination

Temperature	Imbibition % in seeds immersed for hours				Mean of 12 values	Germination, %
	0.5	3	24	72		
T_1	16.89 (24.25)	23.5 (28.96)	25.27 (30.14)	36.1 (36.91)	25.44 (30.06)	00
T_2	34.79 (36.1)	52.08 (46.2)	55.08 (47.92)	55.92 (48.41)	49.47 (44.66)	4.1
T_3	6.04 (14.09)	11.27 (19.36)	22.16 (28.01)	23.49 (28.95)	15.74 (22.6)	00
T_4	22.54 (28.32)	27.2 (31.41)	36.4 (37.09)	40.2 (39.34)	31.58 (34.04)	75
Mean of 12 values	20.06 (25.69)	28.51 (31.48)	34.73 (35.79)	38.93 (38.40)		

Analysis of variance of imbibition

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	8.31	4.16	2.35	0.67 NS
Temperature (T)	3	3044.01	1014.67	2.71	162.71 *
Duration of imbibition (D)	3	1111.49	370.5	2.71	59.41 *
T and D	9	124.07	13.79	5.42	2.21 *
Error	30	187.07	6.24		
Total	47	4474.95			

Values in parentheses are angular transformations. NS — not significant at 0.05 P; * — significant at 0.05 P; C. D. — critical difference (±) or least significant difference (L, S. D.) at 0.05 P; D. F. — degree of freedom; F — variance ratio observed; M. S. S. — mean sum of squares; S. S. — sum of squares; and S. V. — source of variation.

of these dry-stored seeds was also determined at T_4 (Table 2). The imbibition % increased with the duration of dry storage and was maximum in 40 weeks old seeds. After-ripening of the seeds for 12 weeks during dry storage, was essential for germination and the imbibition % in such seeds was 39. This revealed the fact that 39% imbibition was essential for germination and this capability was achieved in seeds on their dry storage for 12 weeks. The duration of dry storage significantly affected both the imbibition and germination.

Effect of mud treatment and later drying on imbibition and germination. 7 weeks old seeds were embedded in mud having waterlogged conditions for 14 weeks and later dried in air at a temperature ranging from 21.5 to 30°C. These treated seeds were again dry stored in usual warehouse conditions for 71 weeks. The imbibition and germination %

of these treated seeds were determined under T_4 (Table 3). The imbibition and germination % significantly declined under this treatment which could be due to the leaching out of some chemical substances and to bringing on secondary dormancy. Fresh seeds did not germinate under conditions normally favourable to germination in the earlier experiment, hence were supposed to possess primary dormancy.

Table 2

Effect of dry storage on imbibition and germination

Parameter, %	Duration of dry storage in weeks					
	4	8	12	20	40	94
Imbibition	10.7 (19.06)	18.35 (25.33)	38.62 (38.42)	40.2 (30.27)	74.29 (59.64)	73.31 (58.91)
Germination	00	00	18 (24.92)	53 (46.72)	92 (73.82)	95 (77.35)

Analysis of variance of imbibition

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	12.81	6.4	3.64	14.38 *
Duration of storage	5	4200.61	840.12	2.57	1887.91 *
Error	10	4.45	0.45		
Total	17	4317.85			

Analysis of variance of germination

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	4.31	2.16	2.69	0.25 NS
Duration of storage	5	17887.68	3577.54	3.8	408.86 *
Error	10	87.51	8.75		
Total	17	17979.51			

Values in parentheses are angular transformations. Abbreviations same as in Table 1.

Soil moisture requirement for germination. 76 weeks old seeds were placed for germination at different moisture levels under T_4 (Table 4). A water content of 44% was the optimum moisture level for germination.

Correlation analysis. The correlation coefficient "r" between imbibition and germination in the seeds after different periods of dry storage was 0.97, indicating that a strictly functional relationship did not exist between them, although there was a trend. The values of "r" was in the positive fraction, hence increasing imbibition tended to be associated with increasing germination. By the "t" test (test of significance) it was found that the correlation coefficient was significant at 0.05 and 0.01 levels of probability when the total number of observations in each case was 18 (n=18).

Table 3

Effect of mud treatment and later drying on imbibition and germination

Parameter, %	Treatment	
	treated	control
Imbibition	47.88 (43.77)	73.31 (59.06)
Germination	78 (62.05)	93 (74.93)

Analysis of variance of imbibition

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	53.89	26.94	12.23	1.68 NS
Treatment	1	350.67	350.67	9.97	21.85 *
Error	2	32.1	16.05		
Total	5	436.66			

Analysis of variance of germination

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	8.28	4.14	11.01	0.32 NS
Treatment	1	248.71	248.71	8.98	19.12 *
Error	2	26.03	13.01		
Total	5	283.02			

Values in parentheses are angular transformations. Abbreviations same as in Table 1.

Table 4

Soil moisture requirement for germination

Soil moisture level, %	11	22	44	55	100
Germination, %	00	00	80	74	00

Analysis of variance

S.V.	D.F.	S.S.	M.S.S.	C.D.	F
Replication	2	7.6	3.8	4.59	0.19 NS
Moisture level	4	21398.4	5349.6	5.93	270.18 *
Error	8	158.4	19.8		
Total	14	21564.4			

Abbreviations same as in Table 1.

DISCUSSION

The seeds of *Heliotropium supinum* L. showed varied imbibition % under different temperatures. The imbibition was promoted by high temperature of 35°C and was retarded by low temperature of 10°C. The optimum temperature requirements for imbibition and germination were different: constant temperature of 35°C and alternate temperature of 35°C and 10°C for 12 h each during 24 h, respectively. During imbibition, the water hydrates colloidal particles of the seed tissue, causing them to increase in size, as they change from solid to gel state. The extent to which imbibition occurs is determined by three factors, the composition of the seed, the permeability of the seed coat to water and the availability of water. The views of Brown and Worley (1912), Shull (1920) and Mayer and Mayber (1963) are noteworthy in this regard. The variation in the rate of imbibition of water under different temperatures appeared to be due to the changes in the permeability of the seed coat to water.

The imbibition increased with age of the seeds and during aging, the seeds were dry-stored in a warehouse. Dry storage caused after--ripening in the seeds, which most probably increased the permeability of their seed coat to water. The seeds required at least 39% imbibition of water to germinate, a capability attained by them on dry storage for 12 weeks. The mud treatment and prolonged dry storage there after reduced imbibition and germination %, which may by caused by leaching out of some chemical substances and the inducement of secondary dormancy. Mullick and Chatterji (1967) concluded that a prolonged period of dry storage of the seeds of *Clitoria ternatea* L. increased imbibition and germination and the physical and chemical treatments which were proved advantageous to imbibition were also beneficial to germination. Bhatia (1965), Chatterji and Mohnot (1967, 1968), and Agarwal and Vyas (1970) made similar observations. The seeds failed to germinate under deficient as well as excess soil moisture conditions i.e. 22 and 100%, respectively and showed maximum germination at 44% soil moisture. In nature the seeddlings also appeared on the drying pond bed when sufficient moisture still remained there. This showed a definite correlation between environmental requirements for germination and the ecological conditions occurring in the habitat of the plant and the seeds.

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Pęcznienie i kiełkowanie nasion Heliotropium supinum L.

Streszczenie

Pęcznienie nasion *Heliotropium supinum* zależy od temperatury. Różne też są optymalne temperatury pęcznienia i kiełkowania. Do kiełkowania niezbędne jest 39% pęcznienie, którą to zdolność osiągają 12-tygodniowe nasiona. Czas pęcznienia wzrasta wraz z czasem przechowywania nasion w suchych warunkach. Pęcznienie i kiełkowanie wyrażone w % zmniejsza się po ponownym wysuszeniu nasion zanurzonych w błocie. Optymalna do kiełkowania jest gleba o wilgotności 44%. Wykazano korelację między pęcznieniem i kiełkowaniem.