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Rajeev Dhiman
Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

Dinesh Kumar
Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

CL Thakur
Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

HP Sankhyan
Department of Tree Improvement and Genetic Resources, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

Corresponding Author:
Dinesh Kumar
Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India

Effect of storage temperature, soaking period and chemical solutions on seed germination of *Wendlandia exserta* ROXB. DC

Rajeev Dhiman, Dinesh Kumar, CL Thakur and HP Sankhyan

Abstract
Wendlandia exserta Roxb. DC. Commonly known as Chila, Ratela, Tikli, is well distributed throughout the sub-Himalayan tract upto 1400m elevation, especially on the areas that are vulnerable to landslides. It is a good fuel wood species and also provides small timber. Larger areas can be covered with this species, particularly which are sloppy and prone to soil erosion. Intensive research is required on the propagation of this species. The present investigation was conducted at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. The seeds were stored at different temperatures *viz*., Room temperature, 10 ± 1 ºC and 0 ± 1 ºC. Thereafter, the seeds were treated with different growth regulators-IAA, IBA, NAA, GA_3, KIN, and Ethrel and salt solutions ($MgSO_4$ and KNO_3) at different soaking periods, *viz*., No soaking, 6 hour and 12 hour. Germination studies were carried out to record the Initiation of germination, germination percentage and germination energy. The experiment was laid out in completely randomised design (factorial). The results revealed that treatment with GA_3 without soaking under 10 ± 1 ºC gave higher germination percentage (38.48%). The seeds took minimum 11.82 days for germination at 0 ± 1 ºC and 10.89 days (for no-soaking). The interaction effect of storage temperature with soaking period for germination per cent with maximum value of 28.47% (12 Hrs. soaking at 0 ± 1 ºC). For initiation of germination, the interaction of storage temperature with various treatments, storage temperature with soaking period and chemical treatment, storage temperature with soaking time was significant with minimum values in control at 0 ± 1 ºC, 6.73 days under control at 0 ± 1 ºC (with no soaking) and 9.33 days in $MgSO_4$ for 6hrs soaking at room temperature and IAA at 0 ± 1 ºC with no soaking. The interaction of storage temperature with soaking period and treatment, storage temperature with soaking periods was significant for germination energy with maximum value 47.27 per cent (no soaking at room temperature) and 77.05% in Kinetin at 0 ± 1 ºC with 6hrs soaking.

Keywords: Storage temperature, soaking and chemical solutions, etc.

Introduction
Wendlandia exserta Roxb. DC. Commonly known with different names i.e., Chila, Ratela, Tikli etc. belonging to Rubiaceae family is one such spp. which has been well distributed throughout the sub-Himalayan tract upto 1400m elevation, in outer Himalaya, Chotanagpur and parts of Indian peninsula. It is also prominent in Shivalik hills where the area is vulnerable to landslides. It comes gregariously in areas where soil is exposed due to disturbances or on abandoned agriculture. This species prefers to grow in loose soils which are exposed to direct sunlight since the species is light demander. The tree flower in clusters in the month of March-April and the seeds of the species mature in May-June which is very minute just like sand. About 130 seeds are recorded in 1 gram with the help of digital seed counter. The wood of this species is used for construction purposes, fuel, for making agricultural implements and also as a small timber in villages. Some or very few animals were observed feeding on the leaves of this species but in Himalayan region where not even a single animal was observed to feed on the leaves of this species, it may be due to the presence of a chemical substance wend lend in which is present in the leaves of this species. Polar fractions of *W. exserta* showed good antioxidant and antimicrobial activity, so these might be useful in pharmacological preparations (Tayyaba Shahzadi *et al.* 2018) [11]. The species is good for soil conservation. This tree species is Silviculture useful in re-clothing the bare hill slopes and newly exposed (clearings) as well as geologically vulnerable areas but its regeneration is very poor due to various reasons. As the species is heavily lopped for fuel wood in villages, there is a considerable need for the multiplication of the species, so as to save it from extinction. For large scale success there should be adequate means of increasing its propagation potential through seeds and vegetative means.

Material and Methods

The seed sources of the present study are located at Bhojnagar, Baddi, Patta-Bejja area of Solan district of Himachal Pradesh, India. The seeds were collected from the phenotypically superior trees in the month of May-June. The seeds were stored at different temperatures *viz*., Room temperature, 10 ± 1 ºC and 0 ± 1 ºC. Thereafter, the seeds were treated with different growth regulators- IAA, IBA, NAA, GA_3, KIN, and Ethrel and salt solutions ($MgSO_4$ and KNO_3) at different soaking periods, *viz*., No soaking, 6 hour and 12 hour. Seeds were planted in root trainers in Complete Randomized Design (CRD) Factorial. Germination studies were carried out to record different germination parameters *viz*., Onset /Initiation of germination (number of days of germination), Germination per cent and Germination capacity.

Results and Discussion

The interaction of chemical treatment, storage temperature and soaking was found to have a non-significant effect on seed germination percent, but the maximum mean value (43.33%) among treatments was found in $T_5S_3P_3$ which was tree donor with GA_3 (T_5) at S_3 (10 ± 1 ºC) and minimum (0.00%) in control (T_1).

Table 1: Interaction effect of storage temperature, soaking and chemical treatments (P x S x T) on germination percentage

Treatments	**No soaking (P_1)**				**6 Hrs. (P_2)**				**12 Hrs. (P_3)**				
Chemicals (T)	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**Mean**
Control (T_1)	9.00 (17.02)	0.00 (0.00)	0.00 (0.00)	3.00 (5.67)	7.33 (12.71)	2.33 (6.64)	6.67 (2.71)	5.44 (7.35)	0.00 (0.00)	2.00 (6.65)	12.33 (20.04)	4.78 (8.90)	4.41 (7.31)
Water (T_2)	16.33 (23.32)	15.67 (22.71)	0.00 (0.00)	10.67 (15.01)	9.00 (14.37)	15.67 (19.22)	7.00 (15.32)	10.56 (16.30)	3.67 (8.06)	9.67 (14.5)	16.33 (19.74)	9.89 (14.12)	10.37 (15.15)
100 ppm IAA (T_3)	27.00 (30.37)	32.33 (34.56)	17.67 (20.28)	25.67 (28.30)	13.33 (21.29)	25.33 (25.32)	18.33 (24.95)	19.00 (23.82)	21.67 (27.09)	21.67 (25.85)	30.00 (32.71)	24.45 (28.55)	23.04 (26.89)
100 ppm IBA (T_4)	40.00 (39.23)	38.00 (37.98)	41.00 (39.81)	39.67 (39.01)	36.33 (37.06)	29.67 (32.79)	23.67 (28.10)	29.89 (32.65)	22.67 (28.06)	28.67 (31.07)	28.67 (31.63)	26.67 (30.25)	32.08 (33.97)
100 ppm GA $_3$ (T_5)	42.00 (40.39)	39.00 (38.63)	44.00 (41.54)	41.67 (40.19)	40.00 (39.21)	39.00 (38.50)	36.33 (37.03)	38.44 (38.25)	25.67 (30.34)	37.00 (37.34)	43.33 (41.07)	35.33 (36.25)	38.48 (38.23)
100 ppm NAA (T_6)	23.33 (27.47)	36.00 (36.78)	25.00 (29.22)	28.11 (31.16)	25.00 (27.33)	27.00 (31.27)	23.00 (26.26)	25.00 (28.29)	22.00 (26.92)	24.33 (27.09)	40.00 (39.21)	28.78 (31.07)	27.30 (30.17)
100 ppm Kinetin (T_7)	23.33 (28.67)	26.00 (30.46)	0.00 (0.00)	16.44 (19.71)	11.00 (18.64)	20.00 (26.45)	11.00 (19.10)	14.00 (21.40)	15.67 (21.51)	17.67 (24.43)	25.33 (28.91)	19.56 (24.95)	16.67 (22.02)
100 ppm Ethrel (T_8)	21.67 (26.44)	25.00 (29.69)	0.00 (0.00)	15.56 (18.71)	11.67 (16.45)	22.00 (26.66)	9.00 (17.22)	14.22 (20.11)	16.67 (22.54)	13.33 (13.08)	25.33 (30.16)	18.44 (21.93)	16.07 (20.25)
1% KNO_3 (T_9)	35.00 (36.24)	35.67 (36.65)	18.00 (25.03)	29.56 (32.64)	19.33 (24.96)	27.00 (30.94)	27.00 (31.02)	24.44 (28.97)	22.00 (27.81)	23.67 (28.22)	36.67 (37.21)	27.45 (31.08)	27.15 (30.90)
1% $MgSO_4$ (T_{10})	25.00 (29.74)	30.00 (33.19)	0.00 (0.00)	18.33 (20.98)	9.67 (14.09)	18.33 (25.00)	12.33 (18.09)	13.44 (19.06)	8.00 (14.99)	20.33 (25.52)	26.6 (30.67)	18.33 (23.73)	16.70 (21.25)
Mean	26.17 (29.84)	27.77 (30.07)	14.57 (15.59)		18.27 (22.60)	22.63 (26.28)	16.83 (21.98)		15.80 (20.73)	19.83 (23.38)	28.47 (31.13)		

$CD_{(0.05)}$	T=5.02	S=2.75	P=NS	T*S=NS	S*P=3.36	T*P=NS	T*S*P=NS

Figures in parentheses indicate the arc sine transformed values

The minimum value was 9.33days which was found under T_{10} S_1 P_2 and $T_3S_3P_1$ and the mean maximum value (16.00 days) was found under $T_1S_3P_3$ (which was control with the storage temperature of 0 ± 1 s ºC with 12hrs soaking period with KNO_3), $T_7S_2P_2$ (Kinetin) and $T_8S_2P_2$ (Ethrel) with 6hrs soaking time and at storage temperature of 10 ± 1 ºC and it was found at par with values 15.33 days for each $T_3S_2P_1$, $T_{10}S_2P_2$, $T_{10}S_2P_3$, $T_3S_2P_1$ and $T_5S_2P_2$ with storage temperature of 10 ± 1 ºC and $T_{10}S_3P_2$ with storage temperature 10 ± 1 ºC and treatment of $MgSO_4$, respectively. Effect of storage temperature and chemical treatments (interaction) on initiation of germination was significant. The higher value of interaction for initiation of germination (15.11days) on the basis of mean was found to be at par with 14.89 in both $MgSO_4$ ($T_{10}S_2$) as well as GA_3 (T_5S_2) and 14.67 in IBA (T_4S_1 and T_4S_3), NAA (14.44) (T_6S_1) and (T_6S_2), 14.22in Kinetin (T_7S_1 and T_7S_2) in seed stored at room temperature (S_1) and 10 ± 1 ºC (S_2) respectively. The results of experiment are in accordance with the studies conducted by Sivakumar *et al.* (2006) [9] on seeds of *Aegle marmelos* stored at ambient and 10-12ºC temperature showed higher germination per cent with 12 months storage, whereas, seeds stored under low temperature (0 to -5 ºC) were found to be deleterious. Similar studies were conducted by Amri (2011) [1] indicated the effect of temperature regime on highest seed germination (35%) of *Terminalia sericea* at 25 °C indicating the optimum temperature was 25 °C. Sharma *et al.* (2011) [8] observed that high moisture content (18.90%) and high temperature (30 ºC) showed maximum germination (about 97%) within shortest time period (about 9 days) in seeds of *Aegle marmelos*. The present study showed that storage of short-period, seeds overcome some degree of dormancy. Rudolf (1974) [6], Hartmann *et al.* (2009) [2] and Takos (1999) [10] also referred this reason and suggested a short period of cold stratification before spring sowing.

Table 2: Interaction effect of storage temperature, soaking and chemical treatments on initiation of germination of *Wendlandia exserta* seeds.

	No soaking (P_1)				6 Hrs. (P_2)				12 Hrs. (P_3)				
Chemicals (T)	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**Mean**
Control (T_1)	14.67 (3.95)	15.33 (4.04)	0.00 (1.00)	10.00 (3.00)	9.33 (2.91)	14.67 (3.95)	5.33 (2.04)	9.78 (2.97)	0.00 (1.00)	14.00 3.87)	16.00 (4.12)	10.00 3.00)	9.93 (2.98)
Water (T_2)	14.00 (3.87)	0.00 (1.00)	0.00 (1.00)	4.67 (1.96)	14.67 (3.95)	15.33 (4.04)	16.00 (4.12)	15.33 (4.04)	10.67 (3.08)	14.00 (3.87)	14.67 (3.95)	13.11 (3.64)	11.04 (3.21)
100 ppm IAA (T_3)	14.67 (3.95)	15.33 (4.04)	9.33 (2.91)	13.11 (3.64)	14.67 (3.95)	14.00 (3.87)	14.00 (3.87)	14.22 (3.90)	14.67 (3.95)	14.00 (3.87)	14.67 (3.95)	14.45 (3.93)	20.59 (3.82)
100 ppm IBA (T_4)	14.00 (3.87)	0.00 (1.00)	14.00 (3.87)	9.33 (2.91)	14.00 (3.87)	10.67 (3.08)	15.33 (4.04)	13.33 (3.66)	14.00 (3.87)	14.67 (3.95)	14.67 (3.95)	14.45 (3.93)	12.37 (3.50)
100 ppm GA_3 (T_5)	14.00 (3.87)	15.33 (4.04)	14.00 (3.87)	14.44 (3.93)	14.00 (3.87)	15.33 4.04)	14.00 (3.87)	14.44 (3.93)	14.67 (3.95)	14.00 (3.87)	14.00 (3.87)	14.22 (3.90)	14.37 (3.91)
100 ppm NAA (T_6)	14.67 (3.95)	14.00 (3.87)	14.00 (3.87)	14.22 (3.90)	14.67 (3.95)	14.67 (3.95)	14.00 (3.87)	14.45 3.93()	14.00 3.87)	14.67 (3.95)	14.00 (3.87)	14.22 (3.90)	14.29 (3.91)
100 ppm Kinetin (T_7)	14.00 (3.87)	14.00 (3.87)	0.00 (1.00)	9.33 (2.91)	14.00 (3.87)	14.00 (3.87)	16.00 (4.12)	14.67 (3.95)	14.67 (3.95)	14.67 (3.95)	14.67 (3.95)	14.67 (3.95)	12.89 (3.61)
100 ppm Ethrel (T_8)	14.67 (3.95)	14.00 (3.87)	0.00 (1.00)	9.56 (2.94)	15.33 (4.04)	14.00 (3.87)	16.00 (4.12)	15.11 (4.01)	15.33 (4.04)	4.67 (1.96)	14.67 (3.95)	11.56 (3.31)	12.07 (3.42)
1% KNO_3 (T_9)	14.00 (3.87)	14.00 (3.87)	16.00 (4.12)	14.67 (3.95)	14.67 (3.95)	15.33 4.04)	14.67 (3.95)	14.89 (3.98)	14.67 (3.95)	14.67 (3.95)	14.00 (3.87)	14.45 (3.93)	14.67 (3.95)
1% $MgSO_4$ (T_{10})	14.67 (3.95)	14.00 (3.87)	0.00 (1.00)	9.56 (2.94)	9.33 (2.91)	15.33 (4.04)	15.33 (4.04)	13.33 (3.66)	14.67 (3.95)	15.33 (4.04)	15.33 (4.04)	15.11 (4.00)	12.67 (3.54)
Mean	14.33 (3.91)	11.60 (3.35)	6.73 (2.36)		13.47 (3.73)	14.33 (3.88)	14.07 (3.81)		12.73 (3.56)	13.47 (3.73)	14.67 (3.95)		

$CD_{(0.05)}$	T=0.26	S=0.14	P=0.14	T*S=0.45	S*P=0.24	T*P=0.45	T*S*P=0.77

Figures in parentheses indicate the square root transformed values

The interaction between soaking period and various chemicals treatments was found to have a significant effect on the initiation of germination, the values varied from minimum (4.67 days) in water soaked seeds (T_2P_1) to maximum in 100 ppm water (15.33 days) at the soaking period of 6 Hrs. (P_2). The higher value of interaction on initiation of seed germination (15.33 days) on the basis of mean was (T_2P_2) found to be at par with treatments GA_3 (14.44 days) and NAA (14.22 days) without soaking respectively. Effect of storage temperature and soaking period (P x S) on initiation of germination was significantly found to effect the initiation of seed germination with the highest value of 14.67 days at storage temperature of 0 ± 1 ºC with 12 Hrs. soaking period (P_3S_3) and it was found at par with most of the interactions except P_1S_3, P_1S_2 and P_3S_1. Three way interaction of treatment, storage temperature and soaking periods was found to have a significant effect on germination energy and it was observed significantly higher in $T_7S_3P_2$ which was 77.05 per cent under storage temperature of 0 ± 1 ºC with soaking period of 6hrs and it was found significantly at par with $T_8S_3P_2$, $T_6S_1P_1$, which were (64.85%) and (66.51%) under storage temperatures (0 ± 1 ºC) and room temperature with 6 Hrs. (P_3) soaking period and without soaking (P_1). The minimum value for germination energy which was zero under $T_1S_2P_1$ and $T_1S_3P_1$, which was in control without soaking with storage temperatures of 10 ± 1 ºC and 0 ± 1 ºC, $T_2S_3P_1$, and $T_7S_3P_1$ and $T_{10}S_3P_1$ were with (0 ± 1 ºC) storage temperatures without soaking under treatments (IAA), (Kinetin) and ($MgSO_4$). In present investigation higher soaking doesn't give any considerable impact. It may be due to very small size of the seeds. The results on control are good which might be due to the reason that the seed of *Wendlandia exserta* are minute which don't require soaking treatment for germination. The results were in contradiction for germination per cent but for other parameters the results were in favour with observation made by Rambabu (2005) [5] in *Gvotia rottleriformis* where he reported that 8 days treatment of 3000 ppm GA_3 is far better than 4 days seed treatment with equal concentration of GA_3. Pre-sowing seed treatments involved soaking seeds in cold and hot water for 12 and 24 Hrs. and soaking in different concentrations (0, 100, 200, 400 and 800 mg/l) of gibberellic acid for 24 hrs. Soaking of seeds in cold or hot water for up to 24 Hrs. did not achieve more than 45% germination, while seeds treated with gibberellic acid achieved <20% germination rates (Thokozani *et al.*, 2011) [12]. While working with *Hippophae tibetana*, Sankhayan *et al.* (2004) [7] has also reported that the germination parameters value do change with the different treatment duration of growth regulators.

Table 3: Interaction effect of storage temperature, soaking and chemical treatments (T x S x P) on germination energy.

Treatments	**Soaking Period and Storage Temperature**												**Mean**
	No soaking (P_1)				**6 Hrs. (P_2)**				**12 Hrs. (P_3)**				
Auxin & Nutrient	**S_1**	**S_2**	**S_3**	**M**	**S_1**	**S_2**	**S_3**	**M**	**S_1**	**S_2**	**S_3**	**M**	
T_1	47.30 (43.33)	0.00 (0.00)	0.00 (0.00)	15.77 (14.44)	27.30 (26.41)	16.67 (15.00)	16.67 (15.00)	20.21 (18.80)	0.00 (0.00)	33.33 (30.00)	42.63 (40.70)	25.32 (23.57)	20.43 (18.94)
T_2	48.57 (44.18)	45.52 (42.31)	0.00 (0.00)	31.37 (28.83)	27.11 (26.41)	34.13 (30.46)	46.83 (43.12)	36.02 (33.33)	23.33 (18.93)	40.87 (34.55)	32.54 (29.55)	32.25 (27.67)	33.22 (29.95)
T_3	50.33 (45.17)	46.46 (42.93)	30.94 (28.61)	42.57 (38.90)	39.82 (39.10)	9.63 (10.84)	41.36 (39.93)	30.27 (29.96)	39.52 (38.88)	56.93 (39.04)	50.74 (45.56)	49.07 (44.49)	40.64 (37.78)
T_4	47.11 (43.34)	49.52 (44.73)	37.78 (37.88)	44.80 (41.98)	43.81 (41.37)	42.33 (40.53)	56.09 (48.65)	47.41 (43.52)	40.08 (39.28)	30.68 (33.62)	43.65 (41.25)	38.14 (38.05)	43.45 (41.18)

T_5	40.65 (39.60)	41.31 (39.94)	54.56 (42.42)	42.51 (40.65)	35.81 (36.74)	47.61 43.63()	37.74 (37.78)	40.39 (39.39)	51.62 (46.00)	47.59 (43.60)	33.61 (35.34)	44.28 (41.65)	42.39 (40.56)
T_6	66.51 (54.91)	45.93 (42.64)	44.17 (41.64)	52.20 (46.40)	59.17 (55.67)	58.31 (49.79)	52.06 (46.19)	56.51 (50.55)	50.65 (45.39)	44.87 (42.04)	61.12 51.55()	52.21 (46.33)	53.64 (47.76)
T_7	37.78 (37.91)	42.97 (40.83)	0.00 (0.00)	26.92 (26.25)	45.83 (42.58)	56.78 (48.93)	77.05 (61.55)	59.89 (51.02)	45.71 (42.53)	44.85 (42.04)	53.43 (46.99)	48.00 (43.86)	44.94 (40.37)
T_8	45.40 (42.32)	53.08 (46.80)	0.00 (0.00)	32.83 (29.71)	31.11 (28.72)	43.73 (41.03)	64.85 (54.17)	46.56 (41.31)	59.05 (50.22)	8.33 (10.00)	46.29 (42.85)	37.89 (34.35)	39.10 (35.12)
T_9	45.67 (42.49)	44.61 (41.90)	54.22 (47.44)	48.17 (43.95)	43.62 (41.20)	45.75 (42.48)	40.28 (39.39)	43.22 (41.02)	49.01 44.42()	57.02 49.06()	42.06 (40.39)	41.37 (44.62)	46.92 (43.20)
T_{10}	43.33 (41.14)	51.28 (45.74)	0.00 (0.00)	31.54 (28.96)	28.61 (27.28)	47.33 (43.49)	22.67 (23.73)	32.87 (31.50)	36.39 (31.78)	51.67 (50.67)	47.94 (43.82)	49.33 (42.09)	36.58 (34.18)
Mean	47.27 (43.44)	42.07 (38.78)	21.27 (19.80)	36.87 (34.01)	39.22 (36.55)	40.23 (36.62)	45.56 (40.95)	41.33 (37.95)	39.54 (35.74)	41.62 (38.46)	45.40 (41.80)	42.18 (34.18)	

$CD_{0.05}$	T=7.03	S=NS	P=3.85	T*S=NS	S*P=6.67	T*P=NS	T*S*P=21.09

Figures in parentheses indicate the square root transformed values

The interaction effect between storage temperature and soaking period (S x P) was found to have a significant effect on germination energy with the mean maximum value of 47.27 per cent which was observed in no soaking at room temperature of 0 ± 1 ºC (P_1S_1) which was found at par with (45.56) and (45.40%) which was 6hrs and 12hrs soaking under the 0 ± 1 ºC storage temperature (P_2S_3) and (P_3S_3). The minimum value (21.27%) of mean for germination energy under the interaction was obtained in 0 ± 1 ºC temperature of without soaking treatment (P_1S_3) respectively. The observations are in agreement with the findings of many workers like Rambabu *et al.* (2005) [5], Lavania *et al.* (2006) [4] who found significant increase in germination per cent with the treatment of GA_3. Sankhyan *et al.* (2004) [7] studied the effect of growth regulators (IAA, IBA, GA_3, Kinetin, NAA and Ethrel) and salt solutions (KCl, KNO_3, $ZnSO_4$, KH_2PO_4, $FeSO_4$ and $MgSO_4$) on the germination of seed of *Hippophae tibetana* Schlecht. They found that the treatment with 100ppm GA_3 or IAA produced highest germination success. KNO_3 can relieve the requirement of alternating temperature in *Lepidium* seeds but the nature of this salt is not known (Toole *et al.*, 1955) [13]. Hemberg, (1949) [3] reported that the increase in GA_3 content on large scale in the embryo axis than in the cotyledon, thereby helping in breaking seed dormancy and enhancing the rate. Synthesis of specific proteins responsible for faster cell division and subsequent growth of the embryo and causing faster and vigorous germination. It helps in seed metabolism process during germination possibly through production of enzymes and coenzymes which in terms mediates in the synthesis of specific proteins required for cell division and subsequent growth. Amri (2011) [1] found significant effects of temperature regime, photoperiod and gibberellic acid but pre-treatments with KNO_3 had non-significant effect and generally had the lowest percentage of seed germination in *Terminalia sericea*.

Conclusion

It can be concluded from the present study that the mean value for seed germination at storage temperature (10 ± 1 ºC) was found higher for all the treatments i.e., the treatment with GA_3 without soaking under 10 ± 1 ºC gave higher germination percentage. The seeds took minimum 11.82 days for germination at 0 ± 1 ºC and 10.89 days (for no-soaking). Regarding the interaction effect of storage temperature with soaking period for germination per cent with maximum value of 28.47% (12 Hrs. soaking at 0 ± 1 ºC). For initiation of germination, the interaction of storage temperature with various treatments, storage temperature with soaking period and chemical treatment, storage temperature with soaking time was significant with minimum values in control at 0 ± 1 ºC, 6.73 days under control at 0 ± 1 ºC (with no soaking) and 9.33 days in $MgSO_4$ for 6hrs soaking at room temperature and IAA at 0 ± 1 ºC with no soaking. The interaction of storage temperature with soaking period and treatment, storage temperature with soaking periods was significant for germination energy with maximum value 47.27 per cent (no soaking at room temperature) and 77.05% in Kinetin at 0 ± 1ºC with 6hrs soaking. For germination energy, the maximum mean value was observed at room temperature whereas among treatments NAA was found better. It can be concluded that more work is needed to study the species growth/germination behavior, so as to multiply it and prevent the risk of extinction.

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