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Effect of seed priming on seed vigour in *Podophyllum hexandrum* Royle: An important medicinal herb of temperate Himalayan region

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Abstract
The present investigation was conducted with an objective to study the effect of seed priming on seed vigour in *Podophyllum hexandrum* Royle. The seeds of *Podophyllum hexandrum* were subjected to seventeen priming treatments and stored thereafter, for 0, 1and 2 months. Radicle length was found maximum (4.02 cm) in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control. Plumule length was maximum i.e. 4.11 cm which was found in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control. Untreated (control) seeds showed 19.88 mg seedling dry weight. Whereas it was maximum i.e. 32.58 mg found in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control, which was followed by T_9 i.e. GA_3 100 ppm for 72 hours. Untreated (control) seeds showed seedling vigour index I (SV-I) as 169.0, whereas it was maximum (340.79) found in T_3 i.e. hydropriming for 48 hours as compared to the control and closely followed by T_{16} i.e. brassinolide 1.0 ppm 48 hours. Untreated (control) seeds registered 6.68 seedling vigour index II (SV-II). Maximum seedling vigour index II (13.97) was found in T_{16} i.e. brassinolide 1.0 ppm for 48 hours as compared to the control and followed by T_3 i.e. hydropriming for 48 hours. Henceforth, it is concluded that above seed treatments can pave the way for improving vigour of *P. hexandrum* which otherwise shows late, low, and asynchronized germination.

Keywords: Seed priming, physiology, *Podophyllum hexandrum* Royle, seed vigour

Introduction
Podophyllum hexandrum Royle, endemic to the Himalayas is an endangered medicinal plant (Chaurasia *et al*., 2012) [4] and also enlisted as an endangered plant in IUCN Red list. National Medicinal Plant Board, India has initiated efforts towards the conservation of rare, endangered, and threatened medicinal plants throughout the country (Ali and Sharma, 2013) [1]. It belongs to family Berberidaceae and is a native to the lower elevations of Himalayan countries like Afghanistan, Pakistan, India, Nepal, Bhutan, and Southwest China. In India, *Podophyllum hexandrum* is mostly found in alpine Himalayas (3000-4500 m) of Jammu and Kashmir, Himachal Pradesh, Sikkim, Uttaranchal, and Arunachal Pradesh. Despite its wider distribution in the entire Indian Himalayan range from Ladakh to Sikkim at an elevation of 3000-4200 m, the current status of *P. hexandrum* is 'endangered' (Nag *et al*., 2015) [10]. It grows in w*et al*pine meadows, in humus-rich and shaded localities or near stream banks as an undergrowth along with other herbs.

Wild plant raw material is in great demand around the world for use by pharmaceutical companies and ethnomedicinal practitioners in a variety of traditional medicines. India is one of the world's major exporters of raw herbal drugs. The domestic and international demand is met mainly through unsustainable in-situ harvesting which has become a major threat to the survival of many Himalayan plant species (Badola, 2003) [2]. There is about 100 ton annual demand of Himalayan Mayapple from international sources, with only 50-80 tonnes of this being met (Ghimire *et al*., 2006) [6]. The estimated yield could range from 330 to 490 kg/acre and over 70 kg of podophyllotoxin extract could be produced per acre cultivated land. Etoposide, a derivative of podophyllotoxin, is currently in clinical use in the treatment of many cancers (Hameed, 2014) [7].

Due to its high medicinal importance and demand, *P. hexandrum* is overexploited rendering its survival at natural sites 'endangered'. The cultivation of this species may answer the growing needs of the plant material. In nature, *P. hexandrum* propagates vegetatively by rhizome and

sexually by seeds. Therefore, a conservation strategy should be devised to increase its population number by propagating the plant through seeds in a short period, thereby compensating or reducing the harvesting pressure on the medicinally valuable rhizome. The plant raised from rhizome cutting takes 12 years to produces far-sized marketable rhizome, whereas the plants raised from seedling take an even longer time. Since it is subjected to harsh and extended winter conditions and perennates through underground parts for most of the year, the period of growth is confined only to summer months.

Seeds of *P. hexandrum* remain dormant for about 10 months under natural conditions. Since the difficulties of germination have not favored its domestication, this can certainly be explained by a difficult propagation due to late fruiting (after 3-4 years vegetation), very capricious germination, and very slow growth (Bhadwar and Sharma, 1963) [3]. Thus, major problems for the cultivation of this plant are its long juvenile phase and poor fruit setting ability (Qazi *et al*., 2011) [7]. Seeds of *P. hexandrum* show slow, low and asynchronous germination and poor seedling performance. The structure and arrangement of embryonic envelopes act as a barrier in seed germination has been elucidated. The uptake of water by *P. hexandrum* seeds during germination shows a triphasic pattern with a reduced rate of water uptake during Phase III, due to the presence of thick-walled endosperm cells which acts as a physical barrier to the protrusion of the radicle. The existence of the multi-layered endosperm and the thick testa appears to protect the embryo during extreme environmental conditions by preventing germination until conditions are more favourable (Sreenivasulu *et al*., 2009) [13].

There is an urgent need to develop and implement regeneration/conservation strategies for the exploitation of this medicinal plant. Simultaneous development of ex situ propagation of the species concerned would encourage their cultivation, thereby considerably easing the pressure on natural habitats (Sharma *et al*., 2006) [12]. Attempts have been made to conserve this plant through the artificial breaking of seed dormancy (Qazi *et al*., 2011) [7]. One of the effective techniques of seed enhancement is priming which can be used to enhance seed quality, rapid and uniform seed emergence, and improve overall germination (McDonald, 2000 and Farooq *et al*., 2007) [8, 5].

Therefore, keeping in view the problems of highly erratic, delayed, poor and asynchronous germination of *P. hexandrum* seeds, the proposed study was undertaken with aim to improve the germination potential and vigour of seeds by using multiple approaches of seed priming.

Methodology

The present study was conducted in Plant Physiology laboratory of the Department of Basic Sciences, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni Solan (H.P.) during the period 2014-16. The details of the experiments which were conducted to achieve the objectives and methodologies are given below:

T_1: Control
T_2: Hydropriming for 24 hours
T_3: Hydropriming for 48 hours
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours
T_9: Gibberellic acid (GA_3), 100ppm for 72 hours
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours
T_{12}: Potassium nitrate 1% for 48 hours
T_{13}: Potassium nitrate 1% for 72 hours
T_{14}: Brassinolide 0.5 ppm for 48 hours
T_{15}: Brassinolide 0.5 ppm 72 hours
T_{16}: Brassinolide 1.0 ppm for 48 hours
T_{17}: Brassinolide 1.0 ppm for 72 hours

Time of Sowing 3

1. Direct (0 storage after priming)
2. After storing primed seeds for 1 month
3. After storing primed seeds for 2 months

Number of treatments: 17
Number of treatment combinations: 51
Number of replications: 3 (30 seeds each)
Experimental design: CRD (Factorial)
The experiment was conducted in seed germinator at 20 ± 2 ˚C, 80% Relative humidity, and light.

Observations Recorded

Source of seeds

Freshly harvested seeds of *Podophyllum hexandrum* Royle were procured from Rohru, (2700 - 3400 m amsl) during the last week of September. Thereafter, seeds were cleaned and air-dried. Seed characteristics *viz*. moisture content, seed viability, and solute leakage were recorded. To study the priming physiology and its implication on seed germination in *Podophyllum hexandrum* Royle, seeds were surface sterilized with the help of 0.1% mercuric chloride for 1 minute. Thereafter, seeds were thoroughly washed with distilled water thrice to remove the strains of mercuric chloride completely.

Method of storage

The primed seeds were packed in sealed in plastic envelopes which in turn were stored in plastic containers at room temperature (25 ± 2 ºC).

Conduct of experiment

The seeds of *Podophyllum hexandrum* Royle species were allowed to germinate in Petri dishes using the top paper method in seed germinator at 20 ± 2 ºC temperature, 80% relative humidity. The paper used for the experiment was Whatmann no.1.

Observational Procedure

Seedling characteristics

The normal seedlings were selected randomly and seedling characteristics were recorded.

Radicle length (cm)

Five normal seedlings were selected randomly for measurement of radicle length. The radicle length was measured from the tip of primary root to the base and the mean root length was expressed in centimetres.

Plumule length (cm)

The plumule length was measured from the base of primary leaf to the base of plumule and the mean plumule length was expressed in centimetres.

Seedling dry weight (mg)
Five normal seedlings used for measuring the seedling length were kept in the paper bag and dried in a hot air oven at 40±100C temperature for 24 hours. Thereafter, seedlings were cooled for 30 minutes and the weight of dried samples were recorded and average dry weight of ten seedlings was expressed in milligrams.

Seedling vigour index- I and II
Seedling vigour index-I and II were calculated as per the formula given by Abdul Baki and Anderson (1973).

Seedling vigour index-I = Germination percentage x Seedling length (cm)

Seedling vigour index- II = Germination percentage x Seedling dry weight (mg)

Results and Discussion

Seedling characteristics

Radicle length
The data pertaining to radicle length of seedlings which were raised from seeds of *Podophyllum hexandrum* subjected to seventeen priming treatments and stored thereafter for 0, 1 and 2 months have been presented in Table 1. Untreated (control) seeds registered 2.70 cm radicle length. Radicle length was found maximum (4.02 cm) in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control. Among treatments, the minimum length of radicle i.e. 1.42 cm was observed in T_{11} i.e. PEG 6000 (-0.5 MPa) + GA_3 100 ppm for 72 hours. Storage time also exerted a significant effect on radicle length. The maximum length of radicle was 2.40 cm recorded for 1 month storage and closely followed by 2 months storage i.e. 2.38 cm. However, the minimum length of radicle was 2.30 cm found for 0 month storage.

Table 1: Effect of priming and storage of seeds on radicle length (cm) in *Podophyllum hexandrum*

Priming treatments (T) \ Storage Duration (D)	0 month	1 month	2 months	Mean
T_1: Control	2.70	2.67	2.73	2.70
T_2: Hydropriming for 24 hours	2.60	2.27	2.37	2.41
T_3: Hydropriming for 48 hours	2.93	3.00	3.13	3.02
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours	2.43	2.10	2.37	2.30
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours	1.70	2.77	1.40	1.96
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours	1.37	1.73	1.90	1.67
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours	1.37	1.60	1.33	1.43
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours	3.73	3.93	4.40	4.02
T_9: Gibberellic acid (GA_3), 100ppm for 72 hours	3.70	3.97	4.00	3.89
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours	1.93	1.57	1.50	1.67
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours	1.70	1.50	1.07	1.42
T_{12}: Potassium nitrate 1% for 48 hours	1.30	1.47	1.53	1.43
T_{13}: Potassium nitrate 1% for 72 hours	1.33	1.70	1.97	1.67
T_{14}: Brassinolide 0.5 ppm for 48 hours	2.17	2.17	2.20	2.18
T_{15}: Brassinolide 0.5 ppm 72 hours	2.90	2.90	2.97	2.92
T_{16}: Brassinolide 1.0 ppm for 48 hours	2.93	3.13	3.17	3.08
T_{17}: Brassinolide 1.0 ppm for 72 hours	2.27	2.37	2.43	2.36
Mean	2.30	2.40	2.38	
$CD_{0.05}$				
T	0.18			
D	0.08			
T×D	0.31			

Plumule length
Data pertaining to plumule length of seedlings which were raised from seeds subjected to seventeen priming treatments and stored thereafter for 0, 1 and 2 months have been presented in Table 2. Untreated (control) seeds showed plumule length as 2.33 cm. Plumule length was maximum i.e. 4.11 cm which was found in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control. Among treatments, the minimum length of plumule was 1.66 cm which was observed for T_{11} i.e. PEG 6000 (-0.5 MPa) + GA_3 100 ppm for 72 hours. Storage time also exerted a significant effect on plumule length. The maximum length of plumule was 2.43 cm which was recorded for 2 months storage. However, the minimum length of plumule was 2.29 cm which was found for 1 month storage.

Table 2: Effect of priming and storage of seeds on plumule length (cm) in *Podophyllum hexandrum*

Priming treatments (T) \ Storage Duration (D)	0 month	1 month	2 months	Mean
T_1: Control	2.30	2.30	2.40	2.33
T_2: Hydropriming for 24 hours	1.77	1.80	1.77	1.78
T_3: Hydropriming for 48 hours	2.67	2.80	2.77	2.74
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours	1.40	1.40	1.40	1.40
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours	1.30	1.50	1.60	1.47
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours	2.10	1.63	2.17	1.97
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours	2.10	1.97	2.30	2.12
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours	4.10	4.03	4.20	4.11
T_9: Gibberellic acid (GA_3), 100ppm for 72 hours	4.13	4.07	4.10	4.10
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours	2.00	1.60	2.17	1.92
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours	1.50	1.67	1.80	1.66

T_{12}: Potassium nitrate 1% for 48 hours	1.80	1.73	1.93	1.82
T_{13}: Potassium nitrate 1% for 72 hours	1.80	1.83	1.80	1.81
T_{14}: Brassinolide 0.5 ppm for 48 hours	2.20	2.27	2.30	2.26
T_{15}: Brassinolide 0.5 ppm 72 hours	2.90	2.93	3.03	2.96
T_{16}: Brassinolide 1.0 ppm for 48 hours	2.93	2.93	3.07	2.98
T_{17}: Brassinolide 1.0 ppm for 72 hours	2.47	2.43	2.50	2.47
Mean	2.32	2.29	2.43	
$CD_{0.05}$				
T	0.16			
D	0.07			
T×D	NS			

Seedling dry weight

Table 3 reveals the data pertaining to the dry weight of seedlings which were raised from seeds subjected to seventeen priming treatments and stored thereafter for 0, 1 and 2 months. Untreated (control) seeds showed 19.88 mg seedling dry weight. Whereas it was maximum i.e. 32.58 mg found in T_8 i.e. GA_3 100 ppm for 48 hours as compared to the control, which was followed by T_9 i.e. GA_3 100 ppm for 72 hours. Among treatments, the minimum seedling dry weight was 14.97 mg in T_5 i.e. PEG 6000 (-0.5 MPa) for 72 hours. Storage time also exerted a significant effect on seedling dry weight. The maximum seedling dry weight was 23.26 mg recorded for 2 months storage and this was followed by 22.97 mg dry weight as found for 1 month storage. However, the minimum seedling dry weight was 22.53 mg found for 0 month storage.

Table 3: Effect of priming and storage of seeds on seedling dry weight (mg) in *Podophyllum hexandrum*

Priming treatments (T) \ Storage Duration (D)	0 month	1 month	2 months	Mean
T_1: Control	19.67	19.70	20.28	19.88
T_2: Hydropriming for 24 hours	19.78	19.70	19.78	19.75
T_3: Hydropriming for 48 hours	23.37	23.56	23.63	23.52
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours	19.44	18.67	19.41	19.17
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours	14.82	15.15	14.93	14.97
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours	23.56	22.63	23.31	23.17
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours	23.75	25.30	25.82	24.95
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours	31.43	31.96	34.36	32.58
T_9: Gibberellic acid (GA_3), 100ppm for 72 hours	31.66	32.15	32.82	32.21
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours	22.82	24.85	22.60	23.42
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours	19.37	20.11	18.52	19.33
T_{12}: Potassium nitrate 1% for 48 hours	19.17	19.70	21.19	20.02
T_{13}: Potassium nitrate 1% for 72 hours	19.52	20.88	21.61	20.67
T_{14}: Brassinolide 0.5 ppm for 48 hours	23.18	23.18	23.91	23.43
T_{15}: Brassinolide 0.5 ppm 72 hours	24.88	25.11	25.66	25.22
T_{16}: Brassinolide 1.0 ppm for 48 hours	25.06	25.17	25.74	25.32
T_{17}: Brassinolide 1.0 ppm for 72 hours	21.44	22.67	21.79	21.97
Mean	22.52	22.97	23.26	
$CD_{0.05}$				
T	0.45			
D	0.19			
T×D	0.78			

Seedling vigour index I (SV-I)

Data pertaining to seedling vigour index I (SV-I) of *Podophyllum hexandrum* which were subjected to seventeen priming treatments and stored thereafter for 0, 1 and 2 months have been presented in Table 4. Untreated (control) seeds showed seedling vigour index I (SV-I) as 169.0, whereas it was maximum (340.79) found in T_3 i.e. hydropriming for 48 hours as compared to the control and closely followed by T_{16} i.e. brassinolide 1.0 ppm 48 hours. Among treatments, the minimum seedling vigour index I (SV-I) 40.47 was observed in T_{11} i.e. PEG 6000 (-0.5 MPa) + GA_3 100 ppm for 72 hours. Storage time also exerted a significant effect on seedling vigour index I (SV-I). The maximum seedling vigour index I (202.22) was recorded for 2 months storage which was followed by 1 month storage (177.83). However, the minimum SV-I (155.15) was found for 0 month storage.

Table 4: Effect of seed priming and storage on seedling vigour I (SV-I) in *Podophyllum hexandrum*

Priming treatments (T) \ Storage Duration (D)	0 month	1 month	2 months	Mean
T_1: Control	162.40	160.39	184.24	169.01
T_2: Hydropriming for 24 hours	157.68	159.36	196.57	171.20
T_3: Hydropriming for 48 hours	273.75	345.20	403.42	340.79
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours	119.26	118.23	133.50	123.66
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours	45.77	67.80	41.56	51.71
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours	87.95	93.65	122.00	101.20
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours	62.40	81.64	101.34	81.79
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours	273.31	315.43	347.50	312.08

T_9: Gibberellic acid (GA_3), 100ppm for 72 hours	236.44	256.18	253.50	248.71
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours	66.87	59.35	73.34	66.52
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours	39.11	47.15	35.14	40.47
T_{12}: Potassium nitrate 1% for 48 hours	130.65	135.11	149.32	138.36
T_{13}: Potassium nitrate 1% for 72 hours	115.01	141.33	137.56	131.30
T_{14}: Brassinolide 0.5 ppm for 48 hours	150.24	160.42	234.99	181.88
T_{15}: Brassinolide 0.5 ppm 72 hours	244.24	310.90	364.66	306.60
T_{16}: Brassinolide 1.0 ppm for 48 hours	283.13	340.62	379.53	334.43
T_{17}: Brassinolide 1.0 ppm for 72 hours	189.33	230.40	279.57	233.10
Mean	155.15	177.83	202.22	
$CD_{0.05}$				
T	8.16			
D	3.43			
T×D	14.13			

Seedling vigour index II (SV-II)

Data pertaining to seedling vigour index II (SV-II) of seeds of *Podophyllum hexandrum* which were subjected to seventeen priming treatments and stored thereafter for 0, 1 and 2 months have been presented in Table 5. Untreated (control) seeds registered 6.68 seedling vigour index II (SV-II). Maximum seedling vigour index II (13.97) was found in T_{16} i.e. brassinolide 1.0 ppm for 48 hours as compared to the control and followed by T_3 i.e. hydropriming for 48 hours. Among treatments, the minimum seedling vigour index II (2.24) was observed in T_5 i.e. PEG 6000 (-0.5 MPa) for 72 hours. Storage time also exerted a significant effect on seedling vigour index II (SV-II). The maximum seedling vigour index II 9.41 was recorded for 2 months storage, which was followed by 1 month storage (8.41). However, the minimum seedling vigour index II (SV-II) was 7.33 found for 0 month storage.

Table 5: Effect of seed priming and storage on Seedling vigour index II (SV-II) in *Podophyllum hexandrum*

Storage Duration (D) / **Priming treatments (T)**	**0 month**	**1 month**	**2 months**	**Mean**
T_1: Control	6.39	6.36	7.28	6.68
T_2: Hydropriming for 24 hours	7.14	7.72	9.41	8.09
T_3: Hydropriming for 48 hours	11.42	14.02	16.16	13.87
T_4: Polyethylene glycol (PEG 6000), -0.5 MPa for 48 hours	6.05	6.31	6.88	6.41
T_5: Polyethylene glycol (PEG 6000), -0.5 MPa for 72 hours	2.26	2.41	2.07	2.24
T_6: Polyethylene glycol (PEG 6000), -1.0 MPa for 48 hours	5.98	6.30	6.99	6.42
T_7: Polyethylene glycol (PEG 6000), -1.0 MPa for 72 hours	4.27	5.79	7.20	5.75
T_8: Gibberellic acid (GA_3), 100ppm for 48 hours	10.97	12.66	13.88	12.50
T_9: Gibberellic acid (GA_3), 100ppm for 72 hours	9.56	10.25	10.27	10.03
T_{10}: Polyethylene glycol (PEG 6000), -0.5 MPa + GA_3 100ppm for 48 hours	3.88	4.66	4.52	4.35
T_{11}: Polyethylene glycol (PEG 6000), -0.5 MPa + $GA_3$100ppm for 72 hours	2.37	2.99	2.27	2.54
T_{12}: Potassium nitrate 1% for 48 hours	8.08	8.32	9.13	8.51
T_{13}: Potassium nitrate 1% for 72 hours	7.17	8.35	7.89	7.80
T_{14}: Brassinolide 0.5 ppm for 48 hours	7.98	8.39	12.49	9.62
T_{15}: Brassinolide 0.5 ppm 72 hours	10.48	13.38	15.59	13.15
T_{16}: Brassinolide 1.0 ppm for 48 hours	12.09	14.14	15.67	13.97
T_{17}: Brassinolide 1.0 ppm for 72 hours	8.58	10.88	12.35	10.60
Mean	7.33	8.41	9.41	
$CD_{0.05}$				
T	0.21			
D	0.09			
T×D	0.37			

Conclusion

Based on the findings of present investigation it may be concluded that seeds of *Podophyllum hexandrum* subjected to GA_3 100 ppm for 48 hours resulted in maximum radicle length (4.02 cm), plumule length (4.11 cm) and seedling dry weight (32.58 mg) in T_8. The maximum seedling vigour index I (SV-I) of 340.79 was found in T_3 i.e. hydropriming for 48 hours as compared to the control and closely followed by T_{16} i.e. brassinolide 1.0 ppm 48 hours whereas the maximum seedling vigour index II (13.97) was found in T_{16} i.e. brassinolide 1.0 ppm for 48 hours as compared to the control and followed by T_3 i.e. hydropriming for 48 hours. Therefore, it was inferred that above seed treatments can pave the way for improving vigour of *P. hexandrum*.

References

1. Ali M, Sharma V. An Urgent Need for Conservation of *Podophyllum hexandrum* (Himalyan Mayapple) – An economically important and threatened plant of cold desert of Ladakh, India. The Journal of Biological Chemical Research 2013;30(1):741-747.
2. Badola HK, Aitken S. The Himalayas of India: A treasury of medicinal plants under siege. *Biodiversity* 2003;4(3):3-13.
3. Bhadwar RL, Sharma BK. A note on germination of Podophyllum seeds. *Indian Forester* 1963;89:445-447.
4. Chaurasia OP, Ballabh B, Tayade A, Kumar R, Kumar GP, Singh SB. *Podophyllum* L.: An endangered and anti-cancerous medicinal plant- An overview. Indian Journal of Traditional Knowledge 2012;11(2):234-241.

5. Farooq M, Basra SMA, Ahmad N. Improving the performance of transplanted rice by seed priming. Plant Growth Regulation 2007;51:129-137.
6. Ghimire SK, Mckey D, Thomas AY. Himalayan medicinal plant diversity in an ecologically complex high altitude anthropogenic landscape, Dolpo, Nepal. Environmental Conservation 2006;33:1.
7. Hameed I, Ullah A, Murad W, Khan S. Podophyllum hexandrum Royle. Scholarly Journal of Agricultural Science 2014;4(6):331-338.
8. McDonald MB. Seed priming. In: Seed technology and its biological basis. Black M and Bewley J D. (Eds) Sheffield Academic Press, Sheffield, UK 2000.
9. Moore RP. Tetrazolium staining for assessing seed quality, In Seed Ecology, W. Heydecker ed. University Park Pennsylvania state university press 1973.
10. Nag A, Ahuja PS, Sharma RK. Genetic diversity of high-elevation populations of an endangered medicinal plant. *AoB Plants* 2015;7:1-15.
11. Qazi PH, Rashid A, Shawl SA. Podophyllum hexandrum-A versatile medicinal plant. International Journal of Pharmancy and Pharmaceutical Sciences 2011;3:261-268.
12. Sharma RK, Sharma S, Sharma SS. Seed germination behaviour of some medicinal plants of Lahaul and Spiti cold desert (Himachal Pradesh): implications for conservation and cultivation. Current science 2006;90(8):1113-1118.
13. Sreenivasulu Y, Chanda SK, Ahuja PS. Endosperm delays seed germination in *Podophyllum hexandrum* Royle – an important medicinal herb. International Seed Testing Association 2009;37:10-16.
14. Shahi P, Mandal RA, Mathema AB. Assessing the impact of climate change on medicinal herbs in Humla district. Int. J Geogr. Geol. Environ 2020;2(2):11-17.