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Standardization of optimum sowing time and protocols on seed germination and survival percentage of swallow root (*Decalepis hamiltonii* Wight & Arn)

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Abstract
The present investigation entitled "Standardization of optimum sowing time and protocols on seed germination and survival percentage of swallow root (*Decalepis hamiltonii* wight & Arn)" was carried out at Department of Plantation, Spices, Medicinal and Aromatic crops, Dr. YSRHU-College of Horticulture, Anantharajupeta, Annamayya District, Andhra Pradesh during 2022-2023. The seeds were sown in raised beds and polybags in September 2022, March and April, 2023 after subjecting to different seed treatments. From the experiment, it was revealed that seeds sown in the month of march + raised beds + pre seed treatment with H_2O_2 @ 0.3% for 8 hours had early germination and seeds sown in the month of march + raised beds + pre seed treatment with H_2SO_4 @ 0.3% for 10 minutes had superior performance on germination percentage whereas seeds sown in the month of march + Polybags + H_2O_2 @ 0.3% for 8 hours had superior performance on survival percentage.

Keywords: Swallow root, time of sowing, nursery raising method and pre seed treatment

Introduction
Swallow root (*Decalepis hamiltonii)* is one of the endangered woody medicinal climber belonging to the family Periploacaceae. Swallow root grows largely in rocky slopes and crevices of moist as well as dry deciduous forests, scrub jungles of southern parts of Deccan Peninsula and the Western Ghats of India (Vedavathy, 2004) [10]. The plant locally called with different regional names as "Maredukommulu" or "Nannarikommulu" or "Maredugaddalu" in Telugu, "Makaliber" in Kannada, and "Swallow root" in English. It is a climbing shrub with aromatic tuberous roots distributed in Southern parts of Peninsular India. In Andhra Pradesh, it is cultivated in Ananthapur, Kurnool, Chittoor, Prakasham, Cuddapah and Annamayya districts and in Tamil Nadu. The roots of this plant are of economic significance and used in number of medicinal and food preparations. These roots are encouraged to use in the form of powder and infusion to treat wounds and bronchial asthma (Manivannan, 2010) [6]. The roots are being used in Ayurveda, the ancient Indian system of medicine, to stimulate appetite, relieve flatulence and as a general tonic (Vedavathy, 2004) [10]. Swallow has a strong aromatic odour and its volatile oil (0.68%) which contains 2- hydroxy-4-methoxy benzaldehyde (HMB, 96%) as a major compound. 2-Hydrox Methoxy Benzaldehyde is a structural isomer of vanillin produced in the tuberous roots of *D. hamiltonii.* The roots are used in preparation of popular cool drink locally known as nannari, which has a cooling effect in summer without any toxic side effects in human beings (Vijayakumar and Pullaiah, 1998) [11].

Material and Methods
The present experiment entitled was carried out at Dr. YSRHU - College of Horticulture, Anantharajupeta, Andhra Pradesh from 2022-2023.

Treatment details
The experiment was laid out Factorial Randomized Block Design with three replications.
Factor 1: Time of sowing
Factor 2: Nursery raising method
Factor 3: Pre seed treatment

The experiment was laid out Factorial Randomized Block Design with three replications.

Factor -1 Time of sowing (S)	Factor -2 Nursery raising Method (M)	Factor -3 Pre seed treatment (T)
S_1 - September	M_1- Raised bed	T_1- H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2- KNO_3 0.5% for 24 hours
S_3 - April		T_3- H_2SO_4 0.3% for 10 minutes
		T_4- Water soaking for 48 hours

Results and Discussion

The results are discussed on days taken for germination, germination percentage and survival percentage in Table 1, Table 2 and Table 3.

1. Days taken for Germination

The data on days taken for germination as influenced by time of sowing, nursery raising method and pre seed treatment were noted significant and presented in Table 1.

Time of Sowing

The data presented in Table 1. revealed that time of sowing had significant influence on days taken for germination. The minimum number of days taken for germination (5.39) was observed when seeds were sown in March (S_2) and maximum number of days (7.21) was observed when seeds were sown in September (S_1).

Nursery raising method

Nursery raising method also found significant influence on days taken for germination. Minimum days taken for germination (6.05) was observed in raised beds (M_1) as compared to (6.30) polybags (M_2).

Pre seed treatment

The results were found significant among different pre seed treatments on days taken for germination. Minimum number of days (5.61) taken for germination was observed in seed treatment with H_2O_2 @ 0.3% for 8 hours (T_1) followed by seed treatment with H_2SO_4 @ 0.3% for 10 minutes (T_3) while maximum number of days taken for germination (6.76) was recorded with water soaking of seeds for 48 hours (T_4).

Interaction between time of sowing and nursery raising method (S × M)

The interaction between time of sowing and nursery raising method was found to be non-significant on days taken for germination. Among the treatment combinations minimum number of days (5.24) was observed when seeds were sown in the month of March in raised bed (S_2M_1) and the maximum number of days (7.29) was observed when seeds were sown in September in polybags (S_1M_2).

Interaction between nursery raising method and pre seed treatment (M× T)

The interaction between nursery raising method and pre seed treatment also observed non-significant on days taken for germination. However, among the various interactions, minimum number of days (5.46) were recorded in pre seed treatment with H_2O_2 @ 0.3% for 8 hours and seeds sown in raised beds (M_1T_1) and the maximum number of days (6.84) were observed in polybags with water soaking of seeds for 48 hours (M_2T_4).

Interaction between time of sowing and pre seed treatment (S × T)

The interaction between time of sowing and pre seed treatment were also found non-significant on days taken for germination. Among all the treatments, minimum number of days (4.69) were observed when sowing was done in March coupled with pre seed treatment H_2O_2 @ 0.3% for 8 hours (S_2T_1) and maximum number of days (7.70) were recorded when sowing was done in September along with water soaking of seeds for 48 hours (S_1T_4).

Interaction between time of sowing, nursery raising method and pre seed treatment

The interaction between time of sowing, nursery raising method and pre seed treatment was observed non-significant on days taken for germination. Among the interactions minimum number of days (4.56) were observed when seeds were sown in March in raised beds coupled with pre sowing treatment H_2O_2 @ 0.3% for 8 hours ($S_2M_1T_1$) and the maximum number of days (7.83) were recorded when sowing was done in September in polybags with water soaking of seeds for 48 hours ($S_1M_2T_4$).

In the present study, early germination was observed when seeds were sown in the month of March. This might be probably due to the early sowing of fresh seeds which were collected in the month of February. The results were in confirmity with findings of Deka *et al*. (2015) [3] early sowing in *Cyamopsis tetragonoloba* and Ahmad *et al*. (2011) [1] in gladiolus.

From the present study, it was also noticed that early germination was noticed in raised beds. This might be attributed to raised beds provide greater soil drainage and aeration, allowing seeds to receive adequate moisture and oxygen to encourage early germination. Similar findings were also reported by Kanadal *et al.* (2022) [5] in mango.

From the perusal of the data, it was noted that H_2O_2 recorded significantly early germination among various pre seed treatments. This might be attributed to release of reactive oxygen species which involved in cell wall loosening and weakening of endosperm resulted in early germination. The results were supported with the observations made by Sushmitha *et al*. (2021) [9] in swallow root and Espin *et al*. (2012) [4] in *Pisum sativum*.

Table 1: Days taken for germination of swallow root as influenced by time of sowing, nursery raising method and pre seed treatment

Factors	Days taken for germination		
Time of Sowing			
S_1	7.21	M×T	
S_2	5.39	M_1T_1	5.46
S_3	5.93	M_1T_2	6.20
SE(m)±	0.08	M_1T_3	5.86
C.D	0.24	M_1T_4	6.68
Nursery raising Method		M_2T_1	5.76
M_1	6.05	M_2T_2	6.54
M_2	6.30	M_2T_3	6.07
SE(m)±	0.06	M_2T_4	6.84
C.D	0.20	SE(m)±	0.14
Pre seed treatment		C.D	NS
T_1	5.61	S×T	
T_2	6.37	S_1T_1	6.81
T_3	5.97	S_1T_2	7.42
T_4	6.76	S_1T_3	6.93
SE(m)±	0.09	S_1T_4	7.70
C.D	0.28	S_2T_1	4.69
S × M		S_2T_2	5.59
S_1M_1	7.13	S_2T_3	5.12
S_1M_2	7.29	S_2T_4	6.17
S_2M_1	5.24	S_3T_1	5.33
S_2M_2	5.53	S_3T_2	6.14
S_3M_1	5.77	S_3T_3	5.86
S_3M_2	6.07	S_3T_4	6.42
SE(m)±	0.12	SE(m)±	0.17
C.D	NS	C.D	NS

S_1 - September	M_1- Raised beds	T_1 - H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO_3 0.5% for 24 hours
S_3 - April		T_3 - H_2SO_4 0.3% 10 minutes
		T_4 - Water soaking for 48hours

Days taken for germination	
S×M×T	
$S_1M_1T_1$	6.76
$S_1M_1T_2$	7.31
$S_1M_1T_3$	6.86
$S_1M_1T_4$	7.57
$S_1M_2T_1$	6.84
$S_1M_2T_2$	7.52
$S_1M_2T_3$	6.99
$S_1M_2T_4$	7.83
$S_2M_1T_1$	4.56
$S_2M_1T_2$	5.36
$S_2M_1T_3$	4.93
$S_2M_1T_4$	6.13
$S_2M_2T_1$	4.83
$S_2M_2T_2$	5.83
$S_2M_2T_3$	5.26
$S_2M_2T_4$	6.21
$S_3M_1T_1$	5.06
$S_3M_1T_2$	5.93
$S_3M_1T_3$	5.76
$S_3M_1T_4$	6.33
$S_3M_2T_1$	5.60
$S_3M_2T_2$	6.26
$S_3M_2T_3$	5.96
$S_3M_2T_4$	6.46
SE(m)±	0.23
C.D	NS

S_1 - September	M1- Raised beds	T_1 - H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO_3 0.5% for 24 hours
S_3 - April		T_3 - H_2SO_4 0.3% 10 minutes
		T_4 - Water soaking for 48 hours

2. Germination percentage

Significant difference was observed on germination percentage by time of sowing, nursery raising method and pre seed treatment and were expressed in Table 2.

Time of Sowing

The data illustrated in Table 2. revealed that time of sowing were found significant on germination percentage at 10, 15 and 20 DAS. The highest germination percentage (45.73%, 62.82% and 80.74%) was observed when seeds were sown in March (S_2). The lowest germination percentage (20.19%, 25.02%, 32.85%) was recorded when seeds were sown in the month of September (S_1) at 10, 15 and 20 DAS.

Nursery raising method

It was quite evident from the data Table 2. That significant variation was observed among nursery raising method on germination percentage. The highest germination percentage (37.24%, 50.11% and 63.94%) was observed in raised beds as compared to polybags (35.59%, 47.87% and 62.23%) recorded at 10, 15 and 20 DAS.

Pre seed treatment

The results were found significant among various pre seed treatments on germination percentage as illustrated in Table 2. The highest germination percentage (39.89%, 52.45% and 66.34%) was recorded in seeds treated with H_2SO_4 @ 0.3% for 10 minutes (T_3) which was statistically at par (37.63%, 50.52% and 64.16%) with H_2O_2 @ 0.3% for 8 hours (T_1) and the lowest germination percentage (32.12%, 44.34% and 59.01%) was recorded with water soaking of seeds for 48 hours (T_4) observed at 10, 15 and 20 DAS.

Interaction between time of sowing and nursery raising method (S × M)

The interaction between time of sowing and nursery raising method were found significant influence on germination percentage at 10, 15 and 20 DAS. Among the treatments tested, the highest germination percentage (47.32, 64.40 and 81.23) was recorded when seeds sown in the month of march in raised beds (S_2M_1) at 10, 15 and 20 DAS, while, the lowest germination percentage (19.52%, 24.35% and 32.27%) was observed at 10, 15 and 20 DAS when the seeds were sown in September in polybags (S_1M_2).

Interaction between nursery raising method and pre seed treatment (M×T)

The combined effect of nursery raising method and pre seed treatment were found non-significant with respect to germination percentage at 10 DAS while significant effect was visible at 15 and 20 DAS. Among the treatments, the highest germination percentage (40.78%, 54.00% and 67.42%) recorded at 10, 15 and 20 DAS were found superior with pre seed treatment of H_2SO_4 @ 0.3% for 10 min and were sown in raised beds (M_1T_3) and the least germination percentage (35.13%, 47.24% and 62.96%) was observed with water soaking of seeds for 48 hours and were sown in polybags (M_2T_4).

Interaction between time of sowing and pre seed treatment (S×T)

The interaction between time of sowing and pre seed treatment were found to be significant at 10 and 20 DAS except at 15 DAS. The highest germination percentage (49.86%, 66.53 and 82.63%) was recorded with treatment

H_2SO_4 @ 0.3% for 10 min sown in the month of march (S_2T_3) and the lowest germination percentage (17.27%, 21.60% and 27.63%) was observed with water soaking of seeds for 48 hours and were sown in September (S_1T_4) at 10, 15 and 20 DAS.

Interaction between time of sowing, nursery raising method and pre seed treatment (S×M×T)

The data depicted in Table 2. Suggested that interaction between time of sowing, nursery raising method and pre seed treatment were found non-significant on germination percentage. Among the various treatment combinations, the highest germination percentage (51.58%, 68.58% and 83.58%) was reported in combination of pre seed treatment with H_2SO_4 @ 0.3% for 10 min and were sown in raised beds in the month of march ($S_2M_1T_3$) and the lowest germination percentage (16.79%, 21.46% and 27.46%) at 10, 15 and 20 DAS were found in water soaking of seeds for 48 hours and were sown in polybags in the month of September ($S_1M_2T_4$).

The present study clearly suggested that highest germination percentage was obtained when seeds were sown in the month of March. In general, the availability of *Decalepis hamiltonii* seeds were commenced from February onwards from the wild sources. Hence, sowing of freshly collected seeds might have encouraged the germination tendency. Further, more favorable environmental conditions and optimum soil temperature also tends to enhance the germination percentage of seeds. The lowest germination percentage was found in September sowing might be due to loss in viability of the seeds. The results were in confirmation with the findings of Singh *et al*. (2021) [8] in *Terminalia chebula* and Buckervicience *et al*. (2021) [2] in rapeseed.

The present study was also confirmed that highest germination percentage was obtained when seeds were sown in raised beds. This might be due to the reason that loose and well aerated soil allows better oxygen penetration thereby improved the germination percentage. Besides, raised beds also helped to drain out the excess water applied to the plants.

In the present investigation, among various pre seed treatment tried, H_2SO_4 0.3% exerted significantly maximum germination percentage. This might be due to the fact that H_2SO_4 had the ability to soften the seed coat and allows water and oxygen to penetrate more effectively. Similar findings were observed in Olatunji *et al*. (2012) [7] in *Acacia auriculiformis* and Soliman *et al*. (2013) [15] in *cassia fistula*.

Table 3 Survival percentage

The data on survival percentage as influenced by time of sowing, nursery raising method and pre seed treatment were noted significant and presented in Table 3.

Time of Sowing

The data illustrated in Table 3. revealed that time of sowing was found significant on survival percentage at 60 DAS. The maximum survival percentage (98.33%) was observed when seeds were sown in March (S_2). While the lowest survival percentage (94.88%) was recorded when the seeds were sown in September (S_1) at 60DAS.

Nursery raising method

The appraisal of the data presented in the Table 3. revealed that the nursery raising method was recorded significant on survival percentage at 60 DAS. The maximum survival percentage (97.64%) was observed in polybags as compared to raised beds (96.67%) at 60 DAS.

Pre seed treatment

The results were found significant among various pre seed treatments on survival percentage as presented in Table 3. The maximum survival percentage (97.91%) was recorded in pre seed treatment with H_2O_2 @ 0.3% for 8 hours (T_1) at 60 DAS which was statistically at par (97.52%) with pre seed treatment H_2SO_4 @ 0.3% for 10 minutes (T_3) and lowest survival percentage (96.09%) was recorded with water soaking of seeds for 48 hours (T_4) at 60 DAS.

Interaction between time of sowing and nursery raising method (S × M)

The interaction between time of sowing and nursery raising method were found non-significant on survival percentage at 60 DAS. Among all the treatments, maximum survival percentage (98.90%) was recorded when seeds were sown in March in polybags (S_2M_2) and minimum survival percentage (94.17%) was recorded when seeds were sown in September in raised beds (S_1M_1) at 60 DAS.

Interaction between nursery raising method and pre seed treatment (M×T)

The interaction between nursery raising method and pre seed treatment were found to be non-significant on survival percentage. Among all the treatments the maximum survival percentage (98.21%) was recorded when seeds were sown in polybags with pre seed treatment H_2O_2 @ 0.3% for 8 hours (M_2T_1) and minimum survival percentage (95.30%) was observed in raised beds with water soaking of seeds for 48 hours sown (M_1T_4) at 60 DAS.

Interaction between time of sowing and pre seed treatment (S×T)

The interaction between time of sowing and pre seed treatment were found statistically non-significant at 60 DAS. The maximum survival percentage (98.98) was recorded when seeds were sown in march along with pre seed treatment with H_2O_2 @ 0.3% for 8 hours (S_2T_1) and the minimum survival percentage (93.31) was observed when seeds were sown in September with water soaking of seeds for 48 hours (S_1T_4) at 60 DAS.

Interaction between time of sowing, nursery raising method and pre seed treatment (S×M×T)

The interaction between time of sowing, nursery raising method and pre seed treatment were observed non-significant on survival percentage. Among the treatments tested, the maximum survival percentage (99.41) was observed when seeds sown in March in polybags with pre sowing treatment H_2O_2 @ 0.3% for 8 hours ($S_2M_2T_1$). While minimum survival percentage (92.24) at 60 DAS was found when seeds were sown in September in raised beds with water soaking of seeds for 48 hours ($S_1M_1T_4$).

In the present experiment, March had shown maximum survival percentage. This might be due to the favorable weather conditions existed during the nursery stage of swallow root, whereas, in September because of inconsistent moisture levels present in the soil as well as the heavy rainfall precipitated during the time caused minimum establishment of germinated seeds. These findings were in support with the results obtained by Missanjio *et al*. (2014) [13] in *Acacia polyacantha* and Mohamed *et al*. (2021) [12] in *Acacia nilotica*.

Table 2: Germination percentage of swallow root as influenced by time of sowing, nursery raising method and pre seed treatment at 10th, 15th & 20 DAS

Germination percentage							
Factors	**10 DAS**	**15 DAS**	**20 DAS**		**10 DAS**	**15 DAS**	**20 DAS**
Time of sowing							
S_1	20.19	25.02	32.85	M×T			
S_2	45.73	62.82	80.74	$M1T_1$	38.45	51.56	65.39
S_3	43.34	59.14	75.88	M1T2	36.97	50.08	63.67
SE(m)±	0.22	0.22	0.17	M1T3	40.78	54.00	67.42
C.D	0.63	0.63	0.49	M1T4	32.80	44.80	59.31
Nursery raising Method				M_2T_1	36.81	49.47	62.96
M1	37.24	50.11	63.94	M_2T2	35.13	47.24	62.05
M_2	35.59	47.87	62.23	M_2T3	39.01	50.90	65.21
SE(m)±	0.18	0.18	0.14	M_2T4	31.43	43.88	58.67
C.D	0.52	0.52	0.20	SE(m)±	0.36	0.36	0.28
Pre seed treatment				C.D	NS	1.03	0.77
T_1	37.63	50.52	64.16	S×T			
T2	36.05	48.66	62.85	$S1T_1$	21.20	26.37	33.92
T3	39.89	52.45	66.34	S1T2	19.80	24.47	33.22
T4	32.12	44.34	59.01	S1T3	22.47	27.64	36.67
SE(m)±	0.26	0.26	0.20	S1T4	17.27	21.60	27.63
C.D	0.73	0.73	0.56	S_2T_1	47.14	63.64	80.92
S × M				S_2T_2	45.96	62.62	80.29
S_1M_1	20.85	25.69	33.44	S_2T3	49.86	66.53	82.63
S_1M_2	19.52	24.35	32.27	S_2T4	39.97	58.47	78.14
S_2M_1	47.32	64.40	81.23	$S3T_1$	44.55	61.55	77.58
S_2M_2	45.15	61.23	79.82	S3T2	42.38	58.88	75.05
S_3M_1	43.57	60.24	77.16	S_3T3	47.35	63.18	79.68
S_3M_2	42.12	58.03	74.62	S_3T_4	39.10	52.94	71.28
SE(m)±	0.32	0.31	0.24	SE(m)±	0.45	0.63	0.34
C.D	0.90	0.90	0.69	C.D	1.27	N. S	0.98

S_1 - September	M1- Raised beds	T_1 - H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO_3 0.5% for 24 hours
S_3 - April		T_3 - H_2SO_4 0.3% 10 minutes
		T_4 - Water soaking for 48hours

Germination percentage			
S×M×T	**10 DAS**	**15 DAS**	**20 DAS**
$S_1M_1T_1$	21.61	26.95	34.55
$S_1M_1T_2$	20.94	25.28	33.68
$S_1M_1T_3$	23.11	28.77	37.77
$S_1M_1T_4$	17.75	21.75	27.75
$S_1M_2T_1$	20.79	25.79	33.36
$S_1M_2T_2$	18.66	23.66	32.76
$S_1M_2T_3$	21.83	26.50	35.50
$S_1M_2T_4$	16.79	21.46	27.46
$S_2M_1T_1$	48.86	65.19	81.86
$S_2M_1T_2$	47.62	64.62	80.96
$S_2M_1T_3$	51.58	68.58	83.58
$S_2M_1T_4$	41.20	59.20	78.54
$S_2M_2T_1$	45.42	62.08	80.08
$S_2M_2T_2$	44.29	60.62	79.62
$S_2M_2T_3$	48.14	64.48	81.81
$S_2M_2T_4$	38.74	57.74	77.74
$S_3M_1T_1$	44.88	62.55	79.55
$S_3M_1T_2$	42.34	60.34	76.34
$S_3M_1T_3$	47.64	64.64	80.98
$S_3M_1T_4$	39.43	53.43	71.77
$S_3M_2T_1$	44.21	60.55	75.55
$S_3M_2T_2$	42.43	57.43	73.76
$S_3M_2T_3$	47.05	61.72	78.38
$S_3M_2T_4$	38.77	52.44	70.77
SE(m)±	0.63	0.52	0.49
C.D	NS	NS	NS

S_1 - September	M_1- Raised beds	T_1 - H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO_3 0.5% for 24 hours
S_3 - April		T_3 - H_2SO_4 0.3% 10 minutes
		T_4 - Water soaking for 48 hours

Similarly, sowing of seeds in polybags had recorded maximum survival percentage. This might be due to the reason that almost all the germinated seeds survived well in the nursery stage due to the favorable microclimate existed in the polybags. Similar findings were observed in Santhi *et al*. (2018) [14] in *Delonix regia*.

Likewise, pre seed treatment with H_2O_2 encouraged maximum survival percentage of swallow root. This might be because of the induced elevation of enzyme activity due to H_2O_2 and also the oxidative stress protection provided by the intracellular antioxidant balance in the cell helped the plant resistance against the pathogens as well as the production of healthy seedlings. Similar findings were reported by Sushmitha *et al.* (2021) [9] in Swallow root.

Table 3: Survival percentage of swallow root as influenced by time of sowing, nursery raising method and pre seed treatment at 60 DAS

Survival percentage			
Factors	**60 DAS**		**60 DAS**
Time of sowing			
S_1	94.88	M×T	
S_2	98.33	M_1T_1	97.05
S_3	98.26	M_1T2	96.73
SE(m)±	0.17	M1T3	97.62
C.D	0.50	M1T4	95.30
Nursery raising Method		M_2T_1	98.21
M_1	96.67	M_2T2	97.48
M_2	97.64	M_2T3	97.98
SE(m)±	0.14	M_2T4	96.88
C.D	0.40	SE(m)±	0.28
Pre seed treatment		C.D	N. S
T_1	97.91	S×T	
T2	97.10	$S1T_1$	95.27
T3	97.52	S1T2	94.82
T4	96.09	S1T3	96.10
SE(m)±	0.20	S1T4	93.31
C.D	0.57	S_2T_1	98.98
S × M		S_2T2	98.19
S_1M_1	94.17	S_2T_3	98.74
S_1M_2	95.58	S_2T_4	97.43
S_2M1	97.76	S_3T_1	98.53
S_2M_2	98.90	S_3T_2	98.30
S_3M_1	98.09	S_3T_3	98.67
$S3M_2$	98.43	S_3T_4	97.54
SE(m)±	0.25	SE(m)±	0.35
C.D	N. S	C.D	N. S

S_1 - September	M_1- Raised beds	T_1 - H_2O_2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO_3 0.5% for 24 hours
S_3 - April		T_3 - H_2SO_4 0.3% for 10 minutes
		T_4 - Water soaking for 48 hours

S_1 - September	M_1- Raised beds	T_1 - H2O2 0.3% for 8 hours
S_2 - March	M_2- Polybags	T_2 - KNO3 0.5% for 24 hours
S_3 - April		T_3 - H2SO4 0.3% for 10 minutes
		T_4 - Water soaking for 48 hours

Survival percentage	
S×M×T	**60 DAS**
$S_1M_1T_1$	94.51
$S_1M_1T_2$	94.32
$S_1M_1T_3$	95.60
$S_1M_1T_4$	92.24
$S_1M_2T_1$	96.04
$S_1M_2T_2$	95.32
$S_1M_2T_3$	96.60
$S_1M_2T_4$	94.39
$S_2M_1T_1$	98.74
$S_2M_1T_2$	97.62
$S_2M_1T_3$	98.17
$S_2M_1T_4$	96.52
$S_2M_2T_1$	99.21
$S_2M_2T_2$	98.76
$S_2M_2T_3$	99.41
$S_2M_2T_4$	98.33
$S_3M_1T_1$	98.48
$S_3M_1T_2$	98.23
$S_3M_1T_3$	98.52
$S_3M_1T_4$	97.13
$S_3M_2T_1$	98.59
$S_3M_2T_2$	98.37
$S_3M_2T_3$	98.82
$S_3M_2T_4$	97.94
SE(m)±	0.49
C.D	N. S

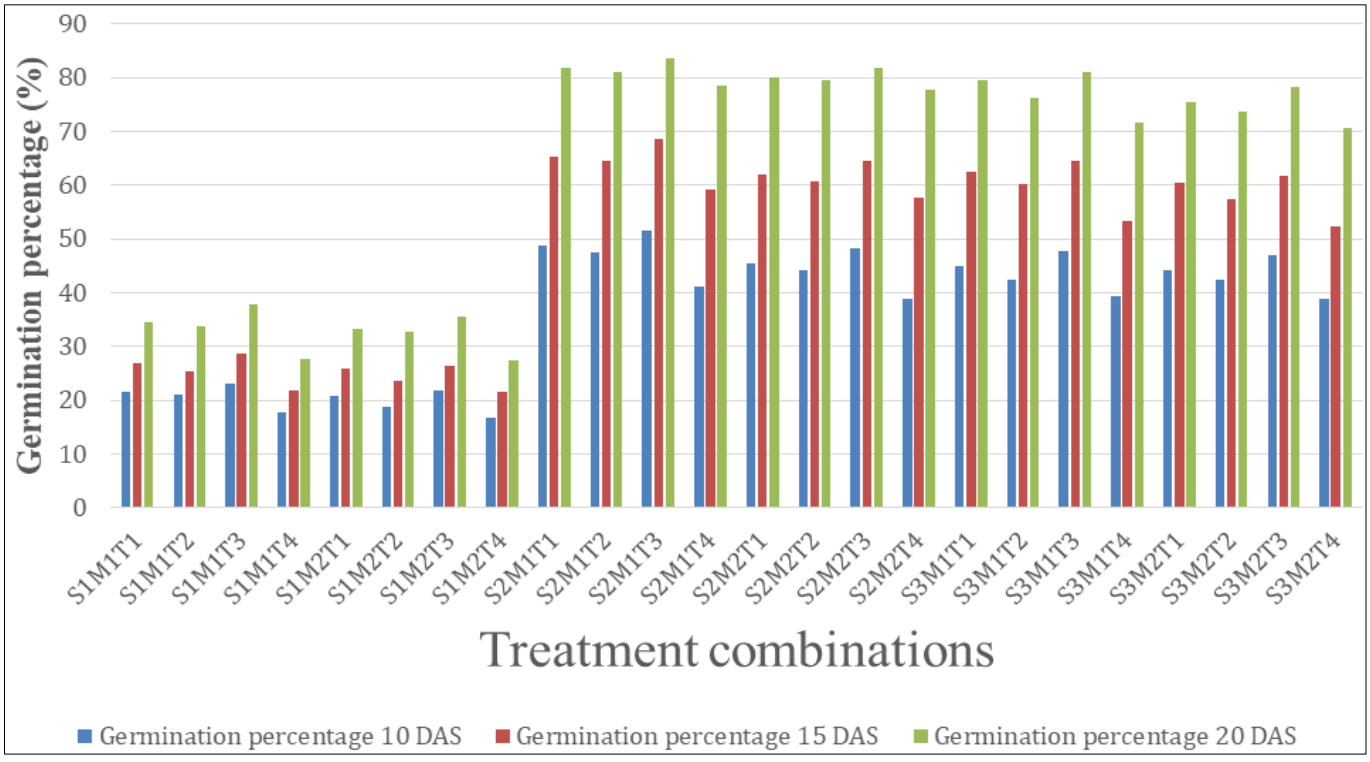

Fig 1: Germination percentage of swallow root as influenced by time of sowing, nursery raising method and pre seed treatment at 10, 15 & 20 DAS

Conclusion

- Based on the study, it may be concluded that, seeds sown in the month of March had highest germination and survival percentage.
- Among the nursery raising methods, seeds sown in raised beds had highest germination percentage, whereas seeds sown in polybags had highest survival percentage.

Among all the interaction combinations, seeds sown in march + seeds sown in raised beds + pre seed treatment H_2SO_4 had exerted maximum germination percentage, whereas seeds sown in the month of September + seeds sown in polybags + pre seed treatment with H_2O_2 had noted highest survival percentage.

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