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Presowing seed treatments affect germination and quality of rootstock in Indian ber (*Zizyphus mauritiana* Lam.)

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ABSTRACT : The effect of different pre-sowing seed treatments and sowing dates on germination and rootstock quality of ber was assessed to standardize a combination which could yield optimum germination and quality rootstock. Of the fourteen pre-sowing treatments, highest seed germination and best seedling growth was obtained in T_{10} x D_2 (seed soaking in water for 48 hours followed by 6 days storage in moist gunny bags x sowing on 15th April) and T_{13} (seed soaking in water for 72 hours followed by 6 days storage in moist gunny bags x sowing on 15th April).

Key Words : Seed treatments, Germination, Rootstock

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Indian ber (*Zizyphus mauritiana* Lam.) belonging to family Rhamnaceae is a small thorny and bushy indigenous wild fruit crop of arid and semi-arid regions of Northern India, and is popularly known as poor man's fruit. Being a very hardy plant, Indian ber is found growing successfully upto an elevation of 3000 feet, even on marginal soils, where most of the other fruit can not thrive. Yellow and red coloured round fruits of Indian ber are relished by the local inhabitants for its distinct sweet sour taste. It contains B group of vitamins (thiamin, riboflavin and niacin), ascorbic acid (70-165mg/100 g of pulp) and carotene. The cultivated ber or Chinese ber (*Zizyphus jujuba* Lam.) also belongs to the same family but is distinct from the former in having bigger and elongated fruits and having comparatively erect growth habit which is suitable for commercial production. Traditionally, the cultivated ber orchard is planted by sowing the seeds in the field at a proper distance and then budded *in situ* after attaining the buddable size. This method involves intensive care and expenditure because of difficulty in the management of large area. Moreover, during the sowing season (April-May), farmers are busy in the agricultural operation such as harvesting and threshing of wheat and sowing of cotton etc. Thus, they have little time and labour to spare for the proper maintenance of ber seedlings. The budding of seedling *in situ* is a very tedious process and the trees in orchard never attain uniform stand. Seeds are most often used to raise rootstocks for the purpose of vegetative propagation. Each fruit contains one stone embedded in the pulp at the centre of the fruit (ICUC, 2002) and ber seeds are enclosed in this stony structure. The stone may contain as many as three seeds (mostly 1-2 seeds per stone) embedded in the endocarp of the fruit (Pareek, 2001) but the presence of only one and two seeds per stone also has been reported. Ber seedlings raised from seeds are not uniform and precoucious in comparison to the trees propagated through vegetative methods. The problem in raising ber seedlings is the poor germination of seed. On account of the stony nature of the shell (endocarp) of the ber seed, the germination process become quite difficult and takes a long time, with poor germination ability. Viability of ber seed is variable depending on source, storage time and conditions, seed preparation and growing environment. Although seed viability is a varietal feature but can be manipulated to a greater extent. Keeping in view the above, the present studies were undertaken to evaluate the effect of different seed treatments on seed germination and quality of rootstock in ber to obtain most effective seed treatment could be worked out which can be replicated in the farmers field easily for better ber seed germination and quality rootstock production.

RESEARCH PROCEDURE

The present studies on effect of different seed treatments on seed germination and quality of ber rootstock were carried out in the fruit plant nursery of Fruit Science Section, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, at Udheywalla during the year 2010-11 located at $32^0$40' N latitude and 74º58' E latitude at an elevation of 332 m amsl. Seeds from healthy, disease-free indian ber trees were collected and extracted for carrying out the investigations. Different presowing seed treatments involved: seed sown after cracking the hard shell (T_1), seed sown after soaking in water for 24 hours (T_2), seed sown after soaking in water for 48 hours (T_3), Seed sown after soaking in water for 72 hours (T_4), seed sown after soaking in water for 24 hours + keeping in gunny bags for 2 days (T_5), seed sown after soaking in water for 24 hours + keeping in gunny bags for 4 days (T_6), seed sown after soaking in water for 24 hours + keeping in gunny bags for 6 days (T_7), seed sown after soaking in water for 48 hours + keeping in gunny bags for 2 days (T_8), seed sown after soaking in water for 48 hours + keeping in gunny bags for 4 days (T_9), seed sown after soaking in water for 48 hours + keeping in gunny bags for 6 days (T_{10}), seed sown after soaking in water for 72 hours + keeping in gunny bags for 2 days (T_{11}), seed sown after soaking in water for 72 hours + keeping in gunny bags for 4 days (T_{12}), seed sown after soaking in water for 72 hours + keeping in gunny bags for 6 days (T_{13}), control (seed stone directly sown) (T_{14}) and seeds sown on three dates D_1: 15th March, D_2: 15th April and D_3: 15th May. Seeds were sown in well prepared raised nursery beds after treatments at spacing of 15cm x 15cm. The experiment was laid out in Randomized Block Deign and each treatment was replicated thrice. After sowing, the beds were covered with paddy straw mulch. Rest of the operations were followed as per the strict schedule of cultivated operations. Observations on seed germination were recorded till two months of sowing at monthly intervals while growth parameters (height and diameter of seedling, number of leaves, diameter of tap root, total fresh and dry root weight, fresh and dry weight of tap root) were recorded two months after seed germination. The dry weight was measured after drying the roots in oven for 25 minute at 73ºC. The data were subjected to statistical analysis as per the method suggested by Gomez and Gomez (1984).

RESEARCH ANALYSIS AND REASONING

The results of the present study as well as relevant discussions have been presented under following sub heads:

Seed germination :

The data on effect of different seed treatments on per cent ber seed germination, recorded at monthly intervals as given in Table 1 showed that per cent seed germination tended to increase with increasing the duration of water soaking

Table 1: Effect of different treatments on per cent germination of ber seed

Treatments	Germination after 1 month of sowing (%)				Germination after 2 month of sowing (%)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	0.00 (0.00)	43.33 (41.14)	23.33 (28.77)	33.33 (23.30)	36.67 (37.21)	60.00 (50.75)	46.67 (43.06)	47.78 (43.67)
T_2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.67 (23.85)	36.67 (37.21)	30.00 (33.20)	27.78 (31.42)
T_3	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.67 (30.98)	33.33 (35.20)	30.00 (33.20)	30.00 (33.13)
T_4	0.00 (0.00)	30.00 (33.20)	0.00 (0.00)	30.00 (11.06)	23.33 (28.77)	50.00 (44.98)	33.33 (34.99)	35.55 (36.25)
T_5	0.00 (0.00)	10.00 (6.14)	0.00 (0.00)	10.00 (2.05)	16.67 (23.85)	40.00 (39.22)	33.33 (34.99)	30.00 (32.69)
T_6	0.00 (0.00)	23.33 (28.77)	16.67 (23.85)	20.00 (17.54)	30.00 (33.20)	36.67 (37.21)	43.33 (41.05)	36.67 (37.15)
T_7	0.00 (0.00)	23.33 (28.77)	20.00 (26.55)	21.67 (18.44)	33.33 (35.20)	40.00 (39.22)	50.00 (44.98)	41.11 (39.80)
T_8	0.00 (0.00)	30.00 (33.20)	16.67 (23.85)	23.34 (19.01)	26.67 (30.98)	50.00 (44.98)	36.67 (37.21)	37.78 (37.73)
T_9	0.00 (0.00)	43.33 (41.14)	26.67 (30.98)	35.00 (24.04)	40.00 (39.22)	63.33 (52.75)	53.33 (46.90)	52.22 (46.30)
T_{10}	0.00 (0.00)	56.67 (48.83)	43.33 (41.14)	50.00 (29.99)	53.33 (46.90)	76.67 (61.70)	60.00 (50.83)	63.33 (53.14)
T_{11}	0.00 (0.00)	30.00 (33.20)	20.00 (26.55)	25.00 (19.98)	40.00 (39.13)	50.00 (44.98)	50.00 (44.98)	46.67 (43.03)
T_{12}	0.00 (0.00)	63.33 (52.75)	26.67 (30.98)	45.00 (27.91)	46.67 (43.06)	70.00 (56.77)	53.33 (46.90)	56.67 (48.91)
T_{13}	0.00 (0.00)	70.00 (56.98)	26.67 (30.98)	48.34 (29.32)	46.67 (43.06)	73.33 (58.98)	53.33 (46.90)	57.78 (49.65)
T_{14}	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.00 (18.42)	33.33 (35.20)	23.33 (28.77)	22.22 (27.47)
Mean	0.00 (0.00)	38.48 (28.86)	24.45 (18.83)		31.91 (33.85)	50.95 (45.65)	42.62 (40.57)	
$C.D._{0.5\%}$		Treatment	3.10				4.21	
		Sowing date	1.44				1.95	
		Treatment x sowing date	5.38				7.30	

Figures in parenthesis are angular transformed values

treatments which was further improved by storing the water soaked seeds in moist gunny bags. The treated seed germination increased with water soaking duration upto a certain duration and declined thereafter which could be due to the harmful effect of extended pre-soaking due to the restriction of oxygen supply during some critical metabolic stage of germination (Kramer, 1983). Under different treatments, after one month time, the highest seed germination (50.00%) was recorded in T_{10} (seed soaking in water for 48 hours and 6 days storage in moist gunny bags) which was statistically at par (48.34% germination) in T_{13} (seed soaking in after for 72 hours and 6 days storage in moist gunny bags). The seeds failed to germinate upto one month under treatments T_2 (seed soaking in water for 24 hours), T_3 (seed soaking in water for 48 hours), T_4 (seed soaking in water for 72 hours), T_5 (seed soaking in water for 24 hours and 2 days storage in moist gunny bags) and T_{14} (control). Of the different sowing dates, highest germination (38.48%) of ber seeds was obtained in D_2 (15th April) followed by D_3 (15th May) sowing, however, seeds could not germinate upto one month when sown on D_1 (15th March). Among the interaction of different seed treatments and sowing dates, highest germination (70.00%) of ber seeds was obtained in T_{13} (water soaking for 72 hours and 6 days storage in moist gunny bags) followed by 63.33 per cent seed germination in T_{12} (water soaking for 72 hours and seed storage for 4 days in moist gunny bags) and 56.67 per cent seed germination in T_{10} (water soaking for 48 hours and 6 days storage in moist gunny bags). No seed could germinate under all the seed treatments sown on 15th March, under treatments T_2, T_3 and T_{14} in 15th March and 15th April sowing and under treatments T_4 and T_5 in 15th April sowing of ber seeds. Observation on ber seed germination recorded after two months of sowing (Table 1 and Fig 1) revealed that T_{10} (water soaking for 48 hours and 6 days storage in moist gunny bags) yielded highest (63.33%) seed germination which was statistically at par with seed germination in T_{13} (57.78%) and T_{12} (56.67%). The lowest germination was observed under T_{14} (22.22%). Among three sowing dates, highest ber seed germination (50.95%) was recorded in D_2

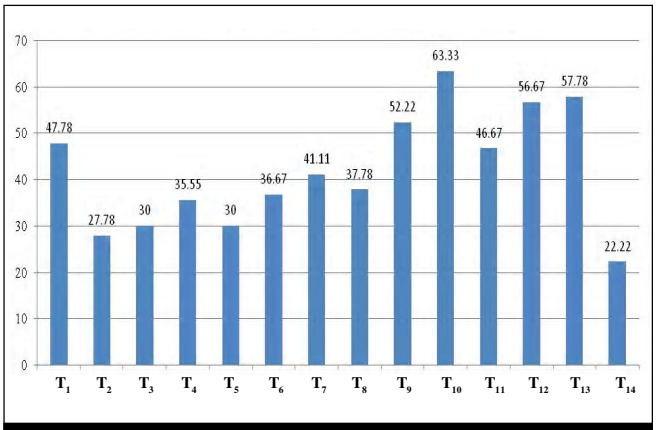

Fig. 1: Per cent ber seed germination after 2 month of sowing under different treatments

Table 2: Effect of different seed treatments on days taken for germination, number of plantlets per seed and number of leaves per seedling in ber

Treatments	Days taken for germination				Number of plantlets / seed				Number of leaves per seedling			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	37.67	24.67	25.67	29.34	1.00	1.00	1.00	1.00	69.33	76.67	72.00	72.67
T_2	46.00	32.33	38.00	38.78	1.00	1.00	1.00	1.00	66.67	73.67	68.00	69.45
T_3	44.67	31.67	35.67	37.34	1.00	1.33	1.00	1.11	66.67	74.67	68.33	69.89
T_4	46.67	29.00	32.67	36.11	1.00	1.00	1.00	1.00	67.67	75.00	68.33	70.33
T_5	43.33	31.00	34.33	36.22	1.00	1.00	1.33	1.11	67.67	74.00	68.33	70.00
T_6	42.00	28.67	29.33	33.33	1.00	1.00	1.00	1.00	68.00	75.67	71.00	71.56
T_7	39.67	26.67	28.33	31.56	1.00	1.33	1.00	1.11	68.67	75.67	71.33	71.89
T_8	42.33	28.00	29.33	33.22	1.00	1.33	1.00	1.11	68.00	75.67	71.33	71.67
T_9	34.33	24.67	25.67	28.22	1.00	1.00	1.33	1.11	69.67	76.67	72.33	72.89
T_{10}	32.00	20.67	22.00	24.89	1.00	1.00	1.00	1.00	73.33	81.67	76.33	77.11
T_{11}	38.67	26.00	27.00	30.57	1.00	1.00	1.00	1.00	69.33	76.00	72.00	72.44
T_{12}	33.33	21.33	23.67	26.11	1.00	1.00	1.00	1.00	69.67	78.33	74.00	74.00
T_{13}	32.33	21.00	23.67	25.66	1.00	1.00	1.00	1.00	69.67	78.33	74.33	74.11
T_{14}	48.33	35.00	36.00	39.78	1.00	1.33	1.00	1.11	66.33	73.67	68.00	69.33
Mean	40.10	27.19	29.38		1.00	1.10	1.05		68.62	76.12	71.12	
C.D.$_{0.5\%}$	Treatment			0.55			NS				0.55	
	Sowing date			0.06			NS				0.26	
	Treatment x sowing date			0.96			NS				0.96	

sowing followed by D_3 (42.62%) sowing, while it was lowest in D_1 (31.91%) sowing. Among the interaction of different seed treatments and sowing dates, after two months of sowing, highest seed germination (76.67%) of ber seeds was recorded under T_{10} x D_2 and was statistically at par with T_{13} x D_2 (73.33%) and T_{12} x D_2 (70.00%). Germination in T_1 (cracking the hard shell) was better than T_{14} (control) Similarly, Kajal (1983) reported increased seed germination (71.83%) with stone cracking than control in ber. The variation in seed germintion under different treatments is mainly due to variation in the seed coat hardness and different environmental conditions provided for seed germination. With the time, the seed coat become loose and cause little hinderance whereas, in fresh seed, germination may have reduced due to hard seed coat. The findings of present study are in conformity with the results of Singh *et al.* (2001) who obtained 78.50 per cent germination in *Zizyphus rotundifolia* seeds while soaked in water for 48 hours and kept in moist gunny bags thereafter for 4 days. Hussain *et al.* (1990) also reported higher seed germination in three peach cultivars while sown after one week of water soaking treatment as compared to those seeds which were soaked in water for 2, 3, or 4 days.

Days taken for germination, number of plantlets per seed and number of leaves per seedling :

A perusal of data (Table 2) indicates that the number of days taken for germination and number of leaves per seedling were influenced significantly by different presowing treatments and sowing dates individually as well collectively, however, they fail to exert any significant effect on number of seedlings per seed. The number of leaves tended to increase with the duration of seed soaking in water and keeping in moist gunny bags. Among different treatments, lowest number of days (24.89) to start germination and highest number of leaves per seedling (77.11) were observed in T_{10} followed by T_{13} (25.66 days and 74.11 leaves per seedling). Maximum number of days taken to seed germination (39.78) and minimum number of leaves per seedling were recorded in T_{14} (control). Of three sowing dates tested in the present studies, the sowing of seed on 15th April (D_2) took the least time for seed germination (27.19 days) and produced maximum number of leaves per seedling (76.12) while the reverse trend were observed in seeds sown on 15th March (D_1). The interaction data reveal that minimum number of days taken to initiate germination (20.67) and maximum number of leaves per seedling were observed in T_{10} while sown on 15th April. Maximum number of days (48.33) to initiate germination and minimum number of leaves per seedling (63.33) were recorded in T_{14} x D_2. In the similar study, Singh *et al.* (2004) also observed extended germination period (13-51 days) of ber seeds. The reasons for the extended seed germination period could be the higher soil temperature during this time and requirement of after ripening period for seed germination (Singhrot and Makhija, 1979). The seed treatment with water soaking and storage in moist gunny

Table 3: Effect of different seed treatments on seedling height, seedling diameter and tap root diameter of ber seedling

Treatment	Seedling height				Seedling diameter				Tap root diameter			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	36.43	45.67	39.57	40.56	0.49	0.62	0.52	0.54	0.44	0.63	0.53	0.53
T_2	31.57	43.93	37.57	37.69	0.40	0.51	0.43	0.45	0.36	0.52	0.42	0.44
T_3	32.27	44.30	37.70	38.09	0.41	0.52	0.43	0.45	0.37	0.54	0.43	0.44
T_4	32.73	44.40	38.17	38.43	0.42	0.53	0.46	0.47	0.37	0.56	0.44	0.46
T_5	32.40	44.30	37.93	38.21	0.41	0.53	0.46	0.47	0.37	0.56	0.43	0.45
T_6	33.67	44.63	38.50	38.93	0.45	0.58	0.49	0.51	0.42	0.60	0.49	0.50
T_7	34.27	45.40	39.20	39.62	0.46	0.59	0.53	0.53	0.44	0.61	0.51	0.52
T_8	34.17	45.30	38.67	39.38	0.45	0.59	0.50	0.51	0.43	0.60	0.50	0.51
T_9	36.13	46.00	39.87	40.67	0.51	0.63	0.54	0.56	0.47	0.63	0.53	0.54
T_{10}	37.50	47.73	43.00	42.74	0.59	0.70	0.62	0.64	0.55	0.68	0.59	0.60
T_{11}	34.27	45.50	39.37	39.71	0.46	0.59	0.52	0.52	0.45	0.61	0.52	0.53
T_{12}	37.00	46.40	42.10	41.83	0.55	0.68	0.60	0.61	0.51	0.67	0.57	0.58
T_{13}	37.07	46.53	42.27	41.96	0.55	0.68	0.61	0.61	0.52	0.67	0.57	0.59
T_{14}	29.87	42.77	37.27	36.64	0.39	0.51	0.41	0.44	0.36	0.51	0.42	0.43
Mean	34.24	45.20	39.37		0.47	0.59	0.51		0.43	0.60	0.50	
$C.D._{0.5\%}$	Treatment			0.40			0.005				0.007	
	Sowing date			0.19			0.002				0.003	
	Treatment x sowing date			0.70			0.008				0.012	

Table 4 : Effect of different seed treatments on total fresh and dry root weight of ber seedlings

Treatments	Total fresh weight of roots				Total dry weight of roots			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	2.37	2.66	2.51	2.51	2.03	2.32	2.16	2.17
T_2	1.78	1.99	1.79	1.85	1.14	1.42	1.34	1.30
T_3	1.85	2.06	1.93	1.95	1.26	1.55	1.40	1.40
T_4	2.04	2.21	2.20	2.15	1.62	1.88	1.72	1.74
T_5	1.98	2.18	2.07	2.08	1.48	1.78	1.63	1.63
T_6	2.05	2.29	2.20	2.18	1.90	2.12	2.03	2.02
T_7	2.31	2.47	2.43	2.40	1.99	2.21	2.08	2.09
T_8	2.25	2.46	2.41	2.37	1.91	2.18	2.02	2.03
T_9	2.43	2.71	2.64	2.59	2.13	2.34	2.35	2.27
T_{10}	2.68	2.89	2.86	2.81	2.45	2.87	2.78	2.70
T_{11}	2.31	2.50	2.43	2.41	2.02	2.23	2.15	2.14
T_{12}	2.58	2.87	2.76	2.74	2.25	2.51	2.43	2.40
T_{13}	2.60	2.91	2.84	2.78	2.33	2.58	2.45	2.45
T_{14}	1.36	1.43	1.41	1.40	0.61	0.84	0.78	0.74
Mean	2.19	2.40	2.32		1.80	2.06	1.95	
C.D. (0.5%)	Treatment	0.05				0.05		
	Sowing date	0.02				0.02		
	Treatment x sowing date	0.09				N.S.		

Table 5: Effect of different seed treatments on length, fresh and dry weight of tap root of ber seedlings

Treatments	Tap root length (cm)				Tap root fresh weight (g)				Tap root dry weight (g)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	24.73	34.00	33.70	30.81	1.85	2.07	1.98	1.96	1.78	1.93	1.83	1.85
T_2	16.40	21.50	21.10	19.67	1.72	1.80	1.76	1.76	1.40	1.46	1.50	1.45
T_3	16.33	21.93	21.10	19.79	1.73	1.82	1.79	1.78	1.58	1.64	1.63	1.62
T_4	16.43	24.77	21.40	20.87	1.75	1.87	1.82	1.81	1.60	1.71	1.66	1.66
T_5	16.33	23.20	21.27	20.27	1.74	1.85	1.81	1.80	1.59	1.71	1.65	1.65
T_6	19.37	27.37	21.97	22.90	1.79	1.93	1.81	1.84	1.63	1.75	1.67	1.68
T_7	19.87	27.97	27.37	25.07	1.83	1.97	1.91	1.90	1.66	1.81	1.75	1.74
T_8	19.23	27.77	25.43	24.14	1.81	1.97	1.84	1.87	1.65	1.80	1.66	1.70
T_9	26.23	34.70	34.60	31.84	1.99	2.10	2.04	2.04	1.82	1.94	1.86	1.87
T_{10}	28.77	36.77	36.00	33.85	2.25	2.38	2.26	2.30	1.94	2.13	1.96	2.01
T_{11}	25.50	29.83	30.60	28.64	1.83	2.04	1.94	1.93	1.67	1.82	1.79	1.76
T_{12}	26.47	35.17	34.77	32.14	2.03	2.15	2.09	2.09	1.83	1.95	1.89	1.89
T_{13}	26.67	35.60	35.60	32.62	2.04	2.15	2.12	2.10	1.84	1.96	1.90	1.90
T_{14}	16.23	20.20	20.50	18.98	0.98	1.06	1.03	1.02	0.58	0.71	0.66	0.65
Mean	21.33	28.63	27.53		1.81	1.94	1.87		1.61	1.74	1.67	
C.D. (0.5%)	Treatment	0.45				0.03				0.02		
	Sowing date	0.21				0.01				0.01		
	Treatment x sowing date	0.78				0.05				0.04		

bags have facilitated in either breaking or softening the hard seed coat which resulted in quick germination.

Seedling height (cm), seedling diameter (cm) and tap root diameter (cm) :

The data pertaining to seedling height (cm), seedling diameter (cm) and tap root diameter (cm) of ber seedlings as affected significantly by different treatments and sowing dates and presented in Table 3. There was a positive correlation between duration of seed soaking in water and keeping in moist gunny bags and root-shoot parameters of ber seedlings. Longest (42.74 cm) and thickest (0.64 cm) seedlings and thickest tap root diameter (0.60 cm) were recorded in T_{10} treated plants followed by T_{13} (41.96 cm, 0.61 cm 0.59 cm, respectively), while T_{14} (control) resulted in minimum height (36.64 cm) and diameter (0.44 cm) of the ber seedlings. Among different sowing dates, longest (45.20 cm) and thickest (0.59 cm) ber seedlings were obtained in seeds sown on D_2 followed by D_3 (39.37 cm long and 0.50 cm thick seedlings) and D_1 (34.24 cm long and 0.47 cm thick seedlings) sowings. Among the interaction effects, the longest seedlings (47.73 cm), thickest stem (0.70 cm) and tap root diameter (0.68 cm) were observed in T_{10} x D_2, closely followed by T_{13} x D_2 (46.53 cm seedling height, 0.68 cm stem diameter and 0.67 cm tap root diameter) and minimum seedling height (29.87 cm), seedling diameter (0.39 cm) and tap root diameter (0.36 cm) was obtained in T_{14} x D_3 and minimum tap root diameter (0.67 cm) was observed under T_{14} x D_1. Ber seedling growth has been reported to remains poor when budded after September (Singhrot and Makhija, 1979).

Total fresh and dry root weight (g) of ber seedlings :

The perusal of data (Table 4) indicates significant variation for total fresh and dry root weight (g) under different seed treatments and sowing dates. Among different treatments, prolonging the duration of seed soaking in water and keeping in moist gunny bags significantly increased fresh weight of roots registering the highest value for fresh weight (2.81g) and dry weights (2.70 g) of roots in T_{10} followed by T_{13} (2.78 g fresh and 2.45 g dry root weight) and T_{12} (2.74 g and 2.40 g fresh and dry root weight, respectively). Minimum fresh root weight (1.40 g) and dry root weight (0.74 g) were observed under T_{14}. Of the three sowing dates, maximum fresh root weight (2.40 g) and dry root weight (2.06 g) were obtained in D_2 followed by D_3 (2.32 g fresh and 1.95 g dry root weight) and D_1 (2.19 g fresh and 1.80 g dry root weight) sowings. Among the various interactions (T x D), highest fresh (2.91 g) and dry weights (2.87 g) of roots was observed under T_{13} x D_2 and T_{10} x D_2, respectively, however, both were statistically at par in respect of fresh root weight. Minimum fresh (1.36 g) and dry (0.74 g) root weight were recorded under T_{14} x D_1. These results are in line with the work done by Jett *et al*. (1996) who reported that root growth rates of matric primed seeds were significantly higher than either osmotic or non-primed seedlings at most temperatures. Singh *et al.* (2001) also reported highest seedling height and stem diameter of ber seedlings while sown after soaking seeds in water for 48 hours and 4 days storage in moist gunny bags recorded after 3 months of sowing. The better seedling growth might have resulted from the higher manufacture of food (photosynthates) which were translocated towards the roots causing overall increase in growth.

Length(cm) and fresh and dry weight (g) of tap root :

As evident from the data (Table 5), different seed treatments and sowing dates significantly influenced the length and fresh and dry tap root weight of ber seedlings. Longest roots (33.85 cm), highest fresh tap root weight (2.30 g) and dry root weight (2.01 g) was recorded under T_{10} followed by T_{13} (32.62 cm tap root length, 2.10 g fresh root weight and 1.90 g dry tap root weight). The lowest value for tap root length (18.89 cm), fresh tap root weight (0.98 g) and dry root weight (0.65 g) were observed under control (T_{14}). Of the three sowing dates, maximum tap root length (28.63 cm), fresh weight (1.94 g) and dry weight (1.74 g) were recorded in seeds sown on D_2 followed by D_3 (27.53 cm tap root length, 1.87 g fresh tap root weight and 1.67 g dry tap root weight. The lowest values for tap root length (21.33 cm), fresh tap root weight (1.81 g) and dry tap root weight (1.67 g) were recorded in D_1 (15th March) date of sowing. Among the interaction effect of seed treatment and sowing dates maximum tap root length (36.77 cm), fresh tap root weight (2.38 g) and dry tap root weight (2.13 g) were observed under T_{10} x D_2 followed by T_{13} x D_2 (35.60 cm tap root length, 2.15 g fresh tap root weight and 1.69 g dry tap root weight), while lowest values for tap root length (16.23 cm), fresh tap root weight (0.98 g) and dry tap root weight (0.58 g) were registered in T_{14} x D_1.

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