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Genetic Variability in Soapnut (Sapindus Mukorossi Gaerten.) among different seed sources in Himachal Pradesh

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Abstract
An experiment was conducted to select better seed sources for improved genetic material and quality production of soapnut (*Sapindus mukorossi*). Genetic variability was evaluated for different traits viz., morphometric traits, germination parameters, percent seed oil and progeny performance traits were carried out among different twenty four seed sources from Himachal Pradesh. The study revealed significant variation among different seed sources. Seed sources which have higher seed weight and seed diameter showed better performance over others, those seed having lower seed weight and seed diameter comparatively. Banjar seed source was found to be superior and best, followed by Garsa seed source, for all morphometric traits, germination parameters, percentage seed oil content and progeny performance traits over all other seed sources studied. Positive significant genotypic and phenotypic correlation was found between all traits, which suggest that selection for any one of these will be reliable for others also. Highly positive significant genotypic and phenotypic correlation was shown by all traits. High heritability with low genetic advance is associated with seed diameter. All traits were more over genetically controlled as revealed by high heritabilities.

Keywords: *Sapindus mukorossi,* morphometric traits, germination, oil content and progeny performance traits

1. Introduction
Sapindus mukorossi or Soapnut tree (Ritha) is an important multipurpose tree of North India, belonging to family Sapindaceae. The tree is native to China and Japan and much cultivated in North India, in moister tracts along the foot hills of Himalayas from Ravi eastward up to 1500 m elevation. The tree is also found wild in the valleys of North Western Himalayas, Assam and West Bengal. It is also planted in avenues. In Nagaland, it is cultivated extensively for use in small scale industries. The tree is cultivated in many parts of India as ornamental and for saponaceous fruits. In *Sapindus mukorossi*, the seed have mechanical dormancy due to hard seed coat (Troup, 1921) [19].

The dried fruits of 'Ritha' are most valuable part of the plant. Its fleshy portion contains saponin, which is used in preparation of washing soap and as such is used for preparation of quality shampoos. The fruit is of considerable importance for its medical value as well. As per Ayurveda, Unani and Tibetan system of medication, it is useful in treating in number of human maladies like bad cold, facial pimples, irregularities in salivation, chlorosis, epilepsy, constipation, nausea, etc. It is also used as expectorant and antihelminthic in small doses. The Central Drug Research Institute, Lucknow, has recently developed a contraceptive cream out of ritha fruit. The same is marketed under the trade name "Consap" (Bahar and Singh, 2007) [3].

Saponin chemically extracted from *Sapindus mukorossi* has properties such as micellar concentration, emulsification and hemolytic activities. Emulsification activity for water-kerosene and various plant oils are excellent in comparison with synthetic surfactant like sodium dodecyl sulfate (SDS). Hence crude Ritha is used as an economical bio-surfactant (Ghagi *et al*, 2011) [10]. Extraction of saponins from the pericarp of *Sapindus mukorossi* is used as compatibilizer in nanocomposites. Saponin increase mechanical properties and decrease roughness of nanofibrels (Cherian *et al*., 2012) [6]. Considering vast semi-wild distribution of soapnut, it is expected to have considerable genetic variation. Sufficient information on such aspect is lacking in this species despite of its many uses. Environmental factors in combination with genetic and physiological factors play an important role in determination of plant potential for seed quality. These characters appear to be under strong genetic control (Roy *et al*. 2004) [16].

Among various factors responsible for successful plantation programme, use of quality seeds in terms of genetic and physical attributes is of paramount importance. The seed size have been found to have a marked bearing on the quality of the nursery stock in numerous species and *Sapindus mukorossi* need not necessarily provide an exception to this. It is therefore, worthwhile to determine the optimum seed size for improving the physical quality of the seedlings/growing stock. So far, only few records of seed source variation of soapnut exist where an attempt was made to examine and identify the superior seed source for production of quality seedling (Bahar and Singh, 2007) [3]. Although, the plant is cultivated extensively for small scale industries in some part of country, however, commercial plantation for seed production is relatively a new concept. Thus, there is a strong need to work for its germplasm collection, evaluation, standardization of the propagation methods and oil content variation.

2. Material and methods

Multistage Random Sampling Technique was used to select the trees of soap nut. Six districts,viz., Chamba, Kangara, Mandi, Kullu, Sirmour and Solan were selected from the state of Himachal Pradesh and four seed sources were selected from each district. Five trees were selected from each seed sources. From the selected and marked trees, fresh and mature fruits were harvested during November- December months. The fresh fruits were collected manually and packed in gunny bags and brought to University campus in the departmental laboratory for detail studies and analysis. The fruits so collected and seeds extracted from such fruits of each site were kept separately with proper identify of site concern.

Different morphometric, germination parameters, percent oil content and progeny performance traits were recorded for each seed sources. Morphological parameters viz. 100 fruits weight, 100 seed weight, seed diameter and germination parameters viz. Seed viability, germination percentage, germination energy, germination capacity, number of days taken to emergence were measured by collecting five samples randomly from each selected seed source. Samples of 100 seeds from each plant were collected and weighed on electrical balance and mean was obtained. Seed viability was determined by using Tetrazolium staining test (Bonner, 1974) [4], which indicate the presence of live tissue.

Ten randomly selected seedlings were carefully uprooted without breaking the roots and observations were recorded for progeny performance traits viz., shoot length, root length, collar diameter, seedling height, leaf area and seedling dry weight at interval of 3 and 6 months after sowing.

For Extraction of oil from seed was carried out following the method of Anonymous (1965) [1], in which seeds were crushed using pestle and mortar. The oil was extracted from powdered sample (known weight) in Soxhlet extraction apparatus with petroleum ether (60-80 °C) for six hours without interruption by gently heating it on the heating mantle. Either was evaporated on a water bath until no odour of ether remained. The oil yield was expressed in terms of percentage of powdered sample.

$$\text{Oil content (\%)} = \frac{\text{Weight of oil extacted from the sample}}{\text{Weight of sample (100 g)}} \times 100$$

3. Result and Discussion

The wide spectrums of variations were observed for different characters studied during the survey (table no. 2-3). These morphometric traits, germination parameters, percent oil content and progeny performance traits showed significant variation for different seed sources in soapnut within Himachal Pradesh.

For morphometric traits, various fruit and seed morphological characters (Table no.2), viz., 100 fruit weight, 100 seed weight and seed diameter were studied during the course of investigation and analysis of variance attributed significant difference in these traits among different seed sources. Banjar (S_{16}) seed source registered significant maximum 100 fruit weight (571.00 g), 100 seed weight (226.05 g) and seed diameter (17.02 mm), while minimum 240.03 g, 138.77 and 12.40 mm for Kandaghat (S_{21}) seed sources, respectively.

For germination parameters, seed viability showed non-significant variation among different seed source areas, whereas maximum seed viability (89.83%) recorded for Banjar seed source and minimum (82.00%) recorded for Nahan and Shilli among different seed sources. Viability of seed is much affected by the stage of maturity reached at the time of its collection (Bonner, 1974) [4], its moisture content and the temperature to which it is exposed (Mathur *et al.,* 1984). The maximum germination was recorded for Banjar seed sources (83.83%), whereas minimum germination was recorded for Kandaghat (59.00%) seed sources.

Germination capacity in the present study also differs significantly due to seed sources variation. The highest germination capacity was recorded in Banjar (83.55%) seed source while minimum in Kandaghat (64.17%) and Patka (64.83%) seed source. Similarly, germination energy and germination capacity also varied significantly among seed sources. The maximum germination energy and germination capacity was recorded for Banjar (48.67%; 83.55%) seed sources, while minimum germination energy was recorded for Kandaghat (28.17%;64.17%) seed sources, respectively. The findings in the present investigation in *Sapindus mukorossi* indicate that germination behaviour is better in large and heavier seeds than the smaller and lighter ones, which are also in conformity with the results of research works for *Sapindus mukorossi* (Attri, 2015) [2], *Jatropha curcas* (Singh and Saxena, 2009) [17], *Sapindus trifoliatus* (Girish *et al*., 2001) [12] and for *Pinus wallichiana* (Ghildiyal and Sharma, 2005) [11], where they have observed significant variation among different seed sources. This may be attributed to the larger food reserves with greater nutrient pool present in the endosperm (Kandya, 1978; Tripathi and Khan, 1990) [14, 18].

The present investigation in soapnut revealed that the oil contents were significantly affected by different seed sources. On seed basis, maximum oil content was recorded in Garsa (18.92%) and minimum oil content was recorded for Kandaghat (10.52%) seed sources.

Various progeny performance traits viz., shoot length, root length, seedling height, collar diameter, leaf area and seedling dry weight were studied during the course of investigation and analysis of variance attributed significant differences in these traits among different seed sources. In the table no.3, maximum significant mean 100 seed weight (226.05 g) and shoot length (23.35 cm; 57.30 cm), root length (18.47 cm; 41.50 cm), seedling height (41.82 cm; 98.80 cm), collar diameter (4.97 mm; 7.68 mm), leaf area (11.08 cm^2; 44.38 cm^2) and seedling dry weight (3.35 g; 7.66 g) were recorded for Banjar (S_{16}) seed source for 3 months and 6 months after seed sowing, respectively. Significantly Kandaghat (S_{21}) seed source showed minimum mean 100 seed weight (138.77 g) and shoot length (11.28 cm; 34.60 cm), root length (8.65 cm; 26.95 cm), seedling height (19.93 cm; 61.55 cm), collar diameter (3.34 mm; 5.22 mm), leaf area (4.57 cm^2; 6.74 cm^2)

and seedling dry weight (1.83 g; 4.25 g) for 3 and 6 month, respectively. Variation in *Sapindus mukorossi* with respect to the seedling traits could be due to the fact that this species grow over a wide range of rainfall, temperature, altitude, and soil type of India. Similar type of research work report also observed in *Albizia procera* (Gera *et al*., 2004) [9]. Variation in *Sapindus mukorossi* with respect to the progeny performance traits could be due to the fact that the large sized seeds excelled over seed category than all the seed traits, germinability attributes, growth characters and seedling biomass (Attri *et al*.,2015) [2].

High heritability with low genetic advance is associated with seedling dry weight and seed diameter. All traits were more over genetically controlled as revealed by high heritabilities. Phenotypic coefficient of variability is higher than genotypic coefficient of variability for all traits. Highly positive significant genotypic and phenotypic correlation was shown by all traits.

Variability and genetic estimates among morphometric traits, oil content, physico-chemical traits, and laboratory germination traits showed that 100 fruits weight had maximum genotypic coefficient of variability. Germination energy had maximum phenotypic coefficient of variability, while seed diameter and kernel weight had maximum heritability, 100 fruits weight had maximum genetic advance and genetic gain both among different morphometric traits, oil content and laboratory germination traits. All these traits showed high heritability in the present investigation.

Variability and genetic estimates among progeny performance traits at the interval of 3 months after sowing, with regard to coefficient of variance the maximum coefficient of genotypic variation 28.70 shown by leaf area. However the maximum coefficient of phenotypic variation was observed for leaf area (31.71). Maximum heritability was shown by seedling dry weight (0.961). Maximum genetic advance was shown by number of leaves (16.78) and maximum genetic gain was shown by leaf area (53.47%). At the interval of six month, among progeny performance traits showed maximum value of genotypic coefficient of variability in leaf area (25.93), while genotypic coefficient of variability in number of leaves (31.71). In respect of genetic parameters seedling dry weight showed maximum heritability (0.992). Genetic advance was found to be maximum in number of leaves (31.17). Genetic gain was maximum for leaf area (49.85%).

Conclusively Banjar and other seed sources which have larger and heavier seeds showed better performance than Kandaghat and other seed sources which have smaller and lower seeds on various progeny performance traits. Large sized seeds of soapnut exhibited superior growth characteristics than medium and small sized. Seedling and growth characteristics are independent processes and are governed by the genetic make up, environment and seed traits (Pathak *et al.,* 1984). Growth parameters have good positive relationship with seed size and weight. Growth parameters have good positive relationship with seed size and weight. Maximum height and collar diameter in *Jatropha curcas* (Singh and Saxena, 2009) [17]. Shoot length and root length in *Azadirachta indica* (Uniyal *et al*., 2007) [20]. Seedling height and collar diameter in *Castanea sativa* (Cicek and Tilki, 2007) [7]. Shoot length in *Cryptocarya alba*.

Burton (1952) suggested the study of genotypic coefficient of variability together with heritability estimate would give the best picture of progress to be achieved though selection if phenotypic coefficient of variability are higher than genotypic coefficient of variability it means that the characters have interacted with the environment to some degree. Johnson *et al*., (1955) [13] pointed out that heritability estimates along with genetic gain is more useful than heritability alone. In present case high heritability with low genetic advance is associated with seedling dry weight and seed diameter. This further confirms that the expressions is possibly controlled by intra and inter allelic interactions. All traits were more over genetically controlled as revealed by high heritabilities. Phenotypic coefficient of variability is higher than genotypic coefficient of variability for all traits it means that the characters have interacted with the environment to some degree. These results support the findings Gera *et al.* (2002) [8] in *Dalbergia sissoo.*

Table 1: Description of seed sources of *Sapindus mukorossi* Gaertn.) in Himachal Pradesh under study

Sr. no.	District	Seed source	Latitude	Longitude	Altitude (ma sl)
1	Chamba	Trimuth (S_1)	32°25.590’	075°59.383’	1003
		Tornu Kamni(S_2)	32°26.314’	075°59.208’	1108
		Patka(S_3)	32°20.407’	076°02.039’	1308
		Simble Ghatta(S_4)	32°20.208’	076°01.544’	1280
2	Kangara	Jachh(S_5)	32°16.475’	075°51.471’	532
		Nagrota Bagwan(S_6)	32°06.324’	076°22.537’	550
		Jwalamukhi(S_7)	31°51.453’	076°19.076’	609
		Palampur(S_8)	32°05.575’	076°33.174’	1300
3	Mandi	Jogindar Nagar(S_9)	31°59.340’	076°47.228’	1185
		Baggi(S_{10})	31°34.332’	076°58.226’	1234
		Chail Chowk(S_{11})	31°33.545’	077°00.030’	1268
		Pandoh(S_{12})	31°39.537’	077°03.076’	1358
4	Kullu	Bhuntar(S_{13})	31°53.279’	077°08.433’	1085
		Garsa(S_{14})	31°50.533’	077°10.304’	1224
		Panarsa(S_{15})	31°46.582’	077°11.293’	1200
		Banjar(S_{16})	31°38.238’	077°20.347’	1530
5	Sirmour	Deothal(S_{17})	30°50.191’	077°09.301’	1189
		Sarahan(S_{18})	30°43.203’	077°11.183’	1380
		Naina Tikkar(S_{19})	30°48.108’	077°07.098’	1365
		Nahan(S_{20})	30°33.204’	077°17.526’	821
6	Solan	Kanda Ghat(S_{21})	30°57.557’	077°06.256’	1428
		ThadiSubathu(S_{22})	30°58.264’	076°59.283’	1260
		Shilly(S_{23})	30°54.301’	077°09.069’	1480
		Jatoli(S_{24})	30°52.439’	077°07.359’	1195

Table 2: Variation in morphometric traits, germination parameters and percent oil content in soapnut from different seed sources of Himachal Pradesh

Sr no.	Seed sources	100 fruits weight (g)	100 seed weight (g)	Seed diameter (mm)	Seed viability (%)	Germination percentage	Germination energy	Germination capacity	Oil content (%)
1	Trimuth (S_1)	411.10	144.28	12.85	86.00	61.33	31.33	67.00	11.12
2	Tornu Kamni(S_2)	369.72	144.57	12.89	87.50	61.83	34.00	68.67	11.26
3	Patka(S_3)	318.97	140.63	12.50	86.17	59.83	29.50	64.83	10.95
4	Simble Ghatta(S_4)	351.05	160.72	13.68	88.00	71.83	35.33	73.17	13.05
5	Jachh(S_5)	360.03	162.27	13.80	88.83	72.67	29.17	74.67	17.24
6	Nagrota Bagwan(S_6)	364.37	161.07	13.80	85.33	72.00	29.17	76.00	17.12
7	Jwalamukhi(S_7)	438.62	169.08	13.86	85.33	70.50	30.17	77.50	16.42
8	Palampur(S_8)	434.70	166.90	13.89	85.33	69.00	43.83	75.33	16.32
9	Jogindar Nagar(S_9)	347.53	181.17	14.04	86.67	77.83	45.67	82.67	18.18
10	Baggi(S_{10})	309.38	177.12	14.02	87.50	75.83	38.67	81.00	15.93
11	Chail Chowk(S_{11})	328.58	176.80	13.99	86.50	75.17	38.50	79.67	18.12
12	Pandoh(S_{12})	313.30	175.12	13.96	86.33	73.50	31.00	77.50	15.70
13	Bhuntar(S_{13})	424.60	180.45	14.10	86.33	77.67	45.33	82.50	17.90
14	Garsa(S_{14})	542.95	218.50	16.78	87.00	78.67	47.83	84.83	18.91
15	Panarsa(S_{15})	424.25	185.28	14.25	87.67	79.33	46.83	85.83	17.85
16	Banjar(S_{16})	571.00	226.05	17.02	89.83	83.83	48.67	88.00	18.71
17	Deothal(S_{17})	442.97	158.98	13.66	84.33	69.33	34.83	76.50	14.39
18	Sarahan(S_{18})	411.15	158.53	13.61	83.83	68.83	32.17	74.83	14.34
19	Naina Tikkar(S_{19})	460.05	165.47	13.79	86.83	69.83	31.17	75.67	13.19
20	Nahan(S_{20})	419.88	163.92	13.79	82.00	68.67	30.33	75.17	14.17
21	Kanda Ghat(S_{21})	240.03	138.77	12.40	85.00	59.00	28.17	64.17	10.52
22	ThadiSubathu(S_{22})	335.38	145.63	12.97	87.167	62.67	32.17	73.00	14.76
23	Shilly(S_{23})	321.18	141.95	12.81	82.000	60.333	28.50	66.33	12.90
24	Jatoli(S_{24})	342.70	151.95	13.51	83.500	64.167	33.50	70.83	14.59
$CD^{0.5}$		16.139	7.381	0..86	NS	1.977	1.512	5.274	0.113

Table 3: Variation in morphometric traits, germination parameters and percent oil content in soapnut from different seed sources of Himachal Pradesh

Sr. No.	Seed sources	Shoot length (cm)		Root length (cm)		Collar diameter (mm)		Seedling height (cm)		Leaf area (cm^2)		Seedling dry weight (gm)	
		After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months	After 3 months	After 6 months
1	Trimuth (S_1)	12.97	38.15	10.10	29.46	3.51	5.44	23.08	67.61	5.00	7.07	2.07	4.79
2	Tornu Kamni(S_2)	12.93	37.95	9.95	29.41	3.49	5.33	22.88	67.36	4.82	6.78	2.04	4.75
3	Patka(S_3)	12.12	37.15	9.23	28.72	3.47	4.24	21.35	65.87	4.56	6.48	1.97	4.60
4	Simble Ghatta(S_4)	14.93	43.00	11.00	33.32	3.56	5.95	25.93	76.32	6.43	8.96	2.25	5.66
5	Jachh(S_5)	15.38	43.85	11.30	33.96	3.62	6.24	26.68	77.81	7.59	10.16	2.35	5.79
6	Nagrota Bagwan(S_6)	14.98	43.15	11.10	33.50	3.56	5.99	26.08	76.65	6.64	9.40	2.30	5.68
7	Jwalamukhi(S_7)	17.72	46.60	13.28	36.15	3.76	6.60	31.00	82.75	8.70	11.64	2.66	6.28
8	Palampur(S_8)	17.40	46.15	12.93	35.80	3.73	6.56	30.33	81.95	8.82	11.71	2.60	6.19
9	Jogindar Nagar(S_9)	19.43	50.15	14.75	38.80	3.96	7.09	34.18	88.95	10.28	13.47	2.96	6.91
10	Baggi(S_{10})	18.58	48.75	13.60	37.90	3.88	6.73	32.18	86.65	9.87	12.69	2.77	6.69
11	Chail Chowk(S_{11})	18.55	48.55	13.83	37.70	3.85	6.77	32.38	86.25	9.75	12.72	2.76	6.60
12	Pandoh(S_{12})	18.28	47.25	13.13	36.65	3.79	6.68	31.42	83.90	9.02	12.31	2.70	6.41
13	Bhuntar(S_{13})	19.45	50.10	14.60	38.85	4.25	7.11	34.05	88.95	10.79	14.05	2.92	6.89
14	Garsa(S_{14})	22.15	55.45	17.43	42.20	4.76	7.56	39.58	97.65	10.89	14.17	3.35	7.44
15	Panarsa(S_{15})	19.97	51.00	14.40	39.40	3.97	7.15	34.37	90.40	10.31	13.42	3.00	7.04
16	Banjar(S_{16})	23.35	57.30	18.47	41.50	4.97	7.68	41.82	98.80	11.08	14.38	3.53	7.66
17	Deothal(S_{17})	14.42	41.85	11.32	32.50	3.56	5.84	25.73	74.35	6.45	9.10	2.24	5.43
18	Sarahan(S_{18})	14.32	41.60	10.78	32.25	3.56	5.75	25.10	73.85	6.45	8.82	2.19	5.41
19	Naina Tikkar(S_{19})	16.83	45.50	12.63	35.15	3.68	6.44	29.47	80.65	8.32	10.89	2.52	6.05
20	Nahan(S_{20})	16.13	44.60	11.87	34.45	3.62	6.31	28.00	79.05	7.68	10.33	2.41	5.91
21	Kanda Ghat(S_{21})	11.28	34.60	8.65	26.95	3.43	5.22	19.93	61.55	4.57	6.74	1.83	4.25
22	ThadiSubathu(S_{22})	13.22	38.70	10.45	30.00	3.51	5.50	23.67	68.70	5.04	6.99	2.09	4.87
23	Shilly(S_{23})	12.30	37.57	10.57	29.20	3.50	5.40	22.87	66.77	4.91	6.85	2.04	4.69
24	Jatoli(S_{24})	13.60	40.40	10.67	31.30	3.57	5.64	24.27	71.70	5.27	7.39	2.14	5.16
$CD^{0.5}$		3.063	3.065	1.42	1.45	0.274	0.570	3.227	3.540	1.18	1.15	0.101	0.095

Table 4: Variability and genetic parameters for morphometric traits, germination parameters and oil content (%) of *Sapindus mukorossi*

Traits	Coefficient of variability		Heritability (broad sense)	Genetic Advance	Genetic gains (%)
	Genotypic	Phenotypic			
100 fruits weight (g)	19.22	19.56	0.966	150.5	38.91
100 seed weight (g)	13.11	13.20	0.985	44.61	26.80
Seed diameter (mm)	7.75	7.75	0.999	2.21	15.98
Germination percentage	9.72	10.03	0.940	13.62	19.41
Germination energy	18.14	21.21	0.731	11.39	31.94
Oil content (%)	16.98	17.31	0.963	5.18	34.30

Table 5: Variability and genetic parameters for progeny performance traits of *Sapindus mukorossi*

Traits	3 months after sowing					6 month after sowing				
	Coefficient of variability		Heritability (broad sense)	Genetic Advance	Genetic gains (%)	Coefficient of variance		Heritability (broad sense)	Genetic Advance	Genetic gains (%)
	Genotypic	Phenotypic				Genotypic	Phenotypic			
Shoot length	17.78	23.97	0.532	4.27	26.26	12.96	13.94	0.815	10.44	23.43
Root length	18.68	21.22	0.775	4.18	33.87	12.03	12.56	0.917	8.16	23.73
Seedling height	18.81	21.22	0.786	9.82	34.34	12.46	13.06	0.911	19.34	24.50
Collar diameter	9.62	11.51	0.699	0.63	16.71	12.39	14.74	0.707	1.33	21.38
Leaf area	28.70	31.71	0.819	4.08	53.47	25.93	27.78	0.871	5.12	49.85
Seedling dry weight	17.63	17.98	0.961	0.89	35.74	16.08	16.14	0.992	1.97	33.50

4. Conclusion

Genetic variability was evaluated for different traits viz., morphometric traits, germination parameters, percent seed oil and progeny performance traits were carried out among different twenty four seed sources from Himachal Pradesh. The study revealed significant variation among different seed sources. These morphometric traits, germination parameters, percent oil content and progeny performance traits showed significant variation for different seed sources in soapnut within Himachal Pradesh. Banjar and other seed sources which have larger and heavier seeds showed better performance than Kandaghat and other seed sources which have smaller and lower seeds on various progeny performance traits. Large sized seeds of soapnut exhibited superior growth characteristics than medium and small sized. Growth parameters have good positive relationship with seed size and weight. Growth parameters have good positive relationship with seed size and weight.

5. References

1. Anonymous. Official method of analysis. 10th ed. Association of official Agricultural Chemists, Washington. D.C., USA, 1965.
2. Attri Varun, Pant KS, Dhiman Rajeev, Lal Chaman, Sarvade S. Effect of Seed Size and Pre-sowing Treatments on Growth Parameters and Biomass of *Sapindus mukorossi* (Gaertn) Seedlings under Nursery Condition. Environment & Ecology. 2015; 33(1):46-49.
3. Bahar Nawa, Singh VRR. Seed source selection of *Sapindus mukorossi* in H.P. Indian Forester 2007; 133(6):731-736.
4. Bonner FT. Seed testing In: Seeds of Woody Plants in The United states. Forest services, USDA, Washington. D.C. 1974, 136-152.
5. Burton GW. Qualitative inheritance in grass. Proceedings 6th international Grassland Congress. 1952; 1:227-283.
6. Cherian BM, Leao AL, Caldeira MS, Chiarelli D, Souza SFD, Narine S *et al*. Use of saponins as an effective surface modifier in cellulose nanocomposites. Molecular Crystals and Liquid Crystals 2012; 556(1):233-245.
7. Cicek E, Tilki F. Seed size effect on germination, survival and seedling growth of *Castanea sativa* Mill. Journal of Biological Sciences. 2007; 7(2):438-441.
8. Gera Mohit, Gera Neelu, Agarwal Rashmi, Gupta BN. Gegetic variation in biochemical contents in foliage of twenty seed sources of *Dalbergia sissoo.* Indian Forester. 2002; 128(7):726-737.
9. Gera Mohit, Gera Rohit, Ginwal HS. Performance of eleven seed sources/provenances of *Albizia procera* Roxb. Under semi arid region of central India. Annals of Forestry. 2004; 12(1):73-80.
10. Ghagi R, Satpute SK, Chopade BA, Arun G. Study of Functional Properties of *Sapindus mukorossi* as a Potential Bio-surfactant. Indian Journal of Science and Technology. 2011; 4(5):530-533.
11. Ghildiyal SK, Sharma CM. Effect of seed size and temperature treatment on germination parameters of *Pinus wallichiana*. Indian Forester. 2005; 131:57-65.
12. Girish B, Shahapurmath GR, Kumar AKK, Ganiger M. Effect of seed size and depth of sowing on seed germination in *Sapindus trifoliatus*. My Forest. 2001; 37:433-489.
13. Johnson HW, Ribson HF, Comstock RE. Estimates of genetic and environmental variability in soyabean. Agronomical Journal. 1955; 47:314-318.
14. Kandya AK. Relationship among seed weight and various growth patterns in *Pinus oocarpa* Schiede seedlings. Indian forester 1978; 104:561-567.
15. Pathak PS, Gupta SK, Roy RD. Autoecology of *Leucaenea leucocephala* Linn. De Wit III. Meterogylph analysis of seedling characteristics. Journal of Tree Science 1984; 3(1, 2):15-19.
16. Roy SM, Thapliyal RC, Ophartyal SS. Seed source variation in cone, seed and seedling characteristics across the natural distribution of Himalayan low level pine *Pinus roxburghii* Serg. Silvae Genetica. 2004; 53(3):116-123.
17. Singh Nidhi, Saxena AK. Seed size variation and its effect on germination and seedling growth of *Jatropha Curcas* L. Indian Forester. 2009; 135(8):1135-1142.
18. Tripathi RS, Khan ML. Effect of seed weight and microsite characteristics on germination and seedling fitness in two species of *Quercus* in a sub-tropical wet hill forest Oikos. 1990; 57:289-296.
19. Troup RS. Silviculture of Indian trees Nasik, Govt. of India press. 1921; 3:673-74.

20. Uniyal AK, Singh Bhupendra, Todaria NP. Effect of seed size, sowing orientation and depth on germination and seedling growth in neem (*Azadirachta indica)*. Seed Technology. 2007; 29(1):68-75.