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Correlation analysis of pre-sowing treatments, sowing positions and age of stones after extraction on germination of mango (*Mangifera indica* L.)

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Abstract
The present investigation was undertaken to assess the correlations between pre-sowing treatments, sowing positions and age of stone after extraction from the fruit on germination of mango cv. Kotookonam Varikka. Mango stones of different age groups *viz.*, freshly extracted stones, 10 and 20 days after extraction of pulp were soaked for 24 hours in aqueous solutions of GA_3 (100 and 200 ppm), KNO_3 (1 and 2 ppm), cow dung slurry, water and control (without treatments)and sown in flat and stalk end up positions. The correlation coefficients indicates the presence of inherent association between various characters. The study revealed that the Seedling Vigour Index –I had very high positive and very dependable relationship with germination percentage (r=0.988**) and seedling length (r=0.974**) whereas Seedling Vigour Index-II had very high positive, significant correlation and very dependable relationship with seedling length (0.931**) in case of stalk end up method over the flat method of sowing.

Keywords: Mango stones, pre sowing treatments, sowing positions, age, correlation, germination

Introduction
Mango is now commercially propagated by veneer, stone, approach and softwood grafting in different parts of the country with varying degree of success rates. Healthy, strong and actively growing rootstocks are a pre-requisite for successful graft union. Mango stones are usually available during the drier parts of the year (April-May) because of which the germination percentage and vigour are very low (Kolekar *et al.,* 2017) [5]. The availability is restricted to one season and viability of mango stones are also very low since the stones are recalcitrant in nature. Therefore the stones available during a particular season need to be utilized properly for raising the rootstocks.

There is a large variation in germination and vigour, depending upon the location and region, where rootstocks are raised. On an average mango stones begin to germinate in about 12 days after sowing, but may take more than a month to complete germination. Mango seeds have a stony endocarp which inhibits germination. Germination in mango is slow and sporadic and consequently seedlings take time to attain graftable size (Patel *et al.,* 2017) [11].

Evidence available in the public domain seems to indicate that soaking mango stones in water and chemical treatments can make a perceptible difference in the germination percentage and have a significant effect on initiation of germination, in boosting up growth and vigour stimulation. Pre sowing treatments also protect seeds from biotic and abiotic factors during critical phases of seedling growth and establishment. Synchronization and rapid seedling emergence are the commonly reported benefits of pre-sowing treatments on germination (Patel *et al.,* 2016) [10, 12].

The orientation of seeds on seed bed also have great role in boosting up of the process of germination. It has a positive influence on altering the energy levels which are needed for the radicle and plumule emergence required for completion of germination process. The stalk end up position of sowing helps to place the micropyle in the most appropriate position and resulted in minimum requirement of energy for germination and stimulate the metabolic process that release energy for radicle emergence (Bewley, 1997) [1]. Age of stone after extraction from fruit also has an impact on germination and subsequent growth. Loss of critical moisture content as the age advances can cause the alterations in a series of metabolic processes and can cause accumulation of free radicals, which result in onset of the deterioration process (Patil and Krishna, 2016) [12].

Improving stone germination and enhancing seedling growth are very important for producing healthy and good rootstocks within a short period of time. This in turn would increase the income of mango nurseries.

With these facts in view, the present investigation was undertaken to appraise the correlation among pre-sowing treatments, sowing positions and age of stones after extraction on germination behaviour of mango.

Materials and Methods

The experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala. The treatment comprises of different combinations of sowing positions (flat and stalk end up), age group of stones after extraction from fruit (freshly extracted stone, 10 days after extraction, and 20 days after extraction) and pre-sowing treatments (GA_3- 100 and 200 ppm, KNO_3 -1 and 2 ppm, cow dung slurry, water and control). Fruits of 'Kotookonam Varikka' variety of mango were selected for stone extraction and were procured from southern tracts of Thiruvananthapuram. Immediately after extraction the stones were washed thoroughly to remove extraneous material adhering to it. The stones were immersed in water and allowed to settle at the bottom of the container. Stones floating on the surface of water were discarded and those which settled at the bottom were used for experimentation. The mango stones were soaked in the above solutions for 24 hours prior to sowing during different times after extraction based on age group. Treated mango stones of different age groups were sown in both stalk end up and flat positions.

The germination percentage was calculated using the formula given below;

$$\text{Germination percentage} = \frac{\text{Number of germinated stones}}{\text{Total stones}} \times 100$$

The rate of germination was determined by dividing the germination percentage with number of days taken for attaining the germination. The seedling vigour index-I was calculated by multiplying germination % and seedling length, while the seedling vigour index II was determined by multiplying germination % and dry weight of seedling.

Five mango seedlings were selected at random from each replication for recording observations related to germination. The germination of stones started 15 days after sowing and continued upto 55 days. Observations were recorded daily for germination parameters; and vegetative parameters like seedling length, dry weight and seedling vigour index I & II were recorded 4 months after sowing.

The experiment was laid out in Factorial Completely Randomized Block Design with 42 treatments. The treatments were replicated thrice. The experimental data recorded was subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1967) [9]. The treatment means were separated using F test values at 5% level of significance. The correlation studies were done by Karl Pearson's method.

Results and Discussion

a. Effect of sowing positions

The stones which were sown with stalk end up position resulted in the highest germination (60.85%), minimum number of days for initiation of germination (22.95 days) and for 50% germination (31.75 days), high rate of germination (0.47), highest seedling length (21.84 cm), dry weight (8.4 g), Seedling Vigour Index –I (1324.23 cm) and Seedling Vigour Index –II (521.67 g) (Table 1).

To ensure good germination, rapid emergence and good performance, seeds must be placed in a position and in an environment that ensures the availability of nutrients and water from the soil. Seed orientation affects seedling emergence greatly. The results are in conformity with Garner and Chaudhri, (1976) [2] and Hammed *et al*. (2014) [4] in cashew. Mango stones with stalk-end up places the micropyle in the most suitable position, i.e., pointing downward, and therefore require less germination energy for the radicle to emerge from the embryo. Moreover, stalk-end facing up might enhance accessibility to required oxygen for the initial metabolic process that produces energy for radicle emergence (Bewley, 1997) [1].

Table 1: Effect of sowing positions on germination and growth of mango cv. Kotookonam Varikka

Parameters	Days taken for initiation of germination	Days taken for 50% germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index –I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
Flat	29.15	40.91	40.95	0.26	18.34	7.46	27.33* (746.93)	17.44* (304.15)
Stalk end up	22.95	31.75	60.85	0.47	21.84	8.64	36.39* (1324.23)	22.84* (521.67)
SE(m)	0.046	0.166	0.690	0.001	0.054	0.026	0.226	0.143
$CD_{0.05}$	0.130	0.466	1.940	0.004	0.152	0.073	0.637	0.402

*transformed values

b. Effect of age of stones after extraction from the fruit

The highest germination percentage (59.84%), minimum number of days for initiation of germination (18.56 days), rate of germination (0.47), seedling vigour indices on growth basis and weight basis were the best for the freshly harvested stones (Table 2.). Germination characteristics of freshly harvested stones were the best compared to other ages of stones (Chaudhari and Patel, 2012) [3]. Germination became progressively slower as the age advances.

Table 2: Effect of age of stones after extraction from the fruit on germination and growth of mango cv. Kotookonam Varikka

Parameters	Days taken for initiation of germination	Days taken for 50% germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index –I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
Freshly extracted stone	18.56	31.29	59.84	0.47	22.76	8.60	36.80* (1354.24)	22.60* (510.76)
10 days after extraction	24.56	36.50	52.38	0.36	21.07	8.07	33.05*(1092.30)	20.45*(418.20)
20 days after extraction	35.03	41.20	40.48	0.28	16.45	7.48	25.74*(662.55)	17.37*(301.72)
SE(m)	0.057	0.203	0.845	0.002	0.066	0.032	0.277	0.175
$CD_{0.05}$	0.160	0.571	2.376	0.005	0.186	0.090	0.780	0.492

*transformed values

c. Effect of pre-sowing treatments

The stones pre-treated with GA_3 100 ppm recorded the highest germination (62.59%), and seedling vigour indices on both growth and weight basis. GA_3 200 ppm required the least number of days for initiation of germination (22.62 days) and for 50% germination (31.78 days) highest germination rate (0.47), maximum seedling length (22.69 cm) and dry weight (9.58 g) (Table 3.).

Early stone germination in GA_3 200 ppm treatment might be due to increased endogenous auxin content due to application of GA_3. The pre-soaking treatment of GA_3 might have affected and altered the enzymatic reaction, protein synthesis and conversion of starch to sugars involved in the germination process (Paleg, 1960) [8]. Similar results in case of GA_3 were reported by Shaban (2010) [13] in mango and Lay *et al*. (2013) [6] in papaya. The difference in rate of germination may be attributed to the differential ability of the pre sowing treatment of these chemicals for reducing the time taken for germination and to remove the obstruction in embryo growth (Muralidhara *et al*., 2015) [7].

The highest seedling length might be due to the fact that the GA_3 stimulates vegetative growth by increased osmotic uptake of nutrients, cell multiplication and cell elongation. This might have reflected in the increased height of seedlings in this treatment. These results are in accordance with results obtained by Shalini *et al.* (1999) [14]. The increased weight of seedling was mainly attributed to enhanced germination, early seedling emergence and better seedling growth. The higher vigour indices may be due to the higher germination percentage induced by these chemicals.

Table 3: Effect of pre-sowing treatments on germination and growth of mango cv. Kotookonam Varikka

Parameters	Days taken for initiation of germination	Days taken for 50% germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index -I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
GA_3 - 100 ppm	23.89	33.94	62.59	0.43	21.16	8.47	36.37* (1322.78)	22.99* (528.54)
GA_3 - 200 ppm	22.62	31.78	55.19	0.47	22.69	9.58	35.30* (1246.09)	22.95* (526.70)
KNO_3 - 1 ppm	24.49	34.17	52.96	0.42	22.14	9.15	34.09* (1162.13)	21.92* (480.49)
KNO_3 - 2 ppm	25.69	35.56	50.00	0.36	20.14	8.00	31.60* (998.56)	19.85* (394.02)
Cow dung slurry	25.78	35.78	55.19	0.35	19.94	7.64	33.10* (1095.61)	20.46* (418.61)
Water	28.84	40.11	42.96	0.31	18.11	7.01	27.81* (773.40)	17.28* (298.60)
Control (no treatment)	31.01	42.94	37.40	0.25	16.45	6.49	24.76* (613.06)	15.51* (240.56)
SE(m)	0.087	0.310	1.291	0.003	0.101	0.049	0.424	0.267
$CD_{0.05}$	0.244	0.872	3.630	0.008	0.285	0.137	1.192	0.751

*transformed values

d. Interaction effect

The freshly extracted mango stones which were soaked in 200 ppm GA_3 solution and sown in plumule up position recorded the least number of days for initiation of germination and 50% germination, highest rate of germination, seedling length and dry weight whereas freshly extracted mango stones which are soaked in 100 ppm GA_3 solution recorded the highest germination, seedling vigour index- I and seedling vigour index- II (Table 4).

Table 4: Interaction effect of sowing positions, age of stones after extraction from the fruit and pre-sowing treatments on germination and growth of mango cv. Kotookonam Varikka

Sl. no.	Treatments	Days taken for initiation of germination	Days taken for 50% germination	Germination (%)	Rate of germination	Seedling length (cm)	Dry weight of seedling (g)	Seedling vigour index -I Growth basis (cm)	Seedling vigour index- II Weight basis (g)
1	$S_1A_1T_1$	19.13	31.33	62.22	0.51	21.83	8.65	36.86*(1358.60)	23.22* (538.50)
2	$S_1A_1T_2$	17.73	30.33	53.33	0.58	23.92	9.60	35.69* (1276.57)	22.62* (511.44)
3	$S_1A_1T_3$	18.33	31.67	51.11	0.51	23.38	9.17	34.49* (1191.39)	21.634* (469.13)
4	$S_1A_1T_4$	21.00	33.67	46.67	0.40	21.41	7.88	31.58* (999.91)	19.17* (367.49)
5	$S_1A_1T_5$	22.20	33.33	53.33	0.41	20.10	7.70	32.73* (1073.47)	20.26* (410.25)
6	$S_1A_1T_6$	23.73	38.34	40.00	0.26	19.04	7.36	27.55* (761.82)	17.13* (293.35)
7	$S_1A_1T_7$	25.73	42.33	35.55	0.21	16.07	6.89	23.89* (570.54)	15.66* (244.59)
8	$S_1A_2T_1$	26.00	37.34	51.11	0.24	20.47	8.00	32.35* (1046.73)	20.24* (408.90)
9	$S_1A_2T_2$	24.00	36.33	42.22	0.25	22.17	8.55	30.60* (937.13)	19.01* (360.99)
10	$S_1A_2T_3$	26.53	41.33	40.00	0.24	22.11	8.37	29.69* (885.15)	18.28* (334.71)
11	$S_1A_2T_4$	27.67	41.67	35.55	0.26	19.23	7.68	26.16* (685.56)	16.54* (273.32)
12	$S_1A_2T_5$	26.87	39.33	44.45	0.26	19.65	7.24	29.55* (873.29)	17.96* (322.17)
13	$S_1A_2T_6$	31.60	45.34	33.33	0.21	16.67	6.70	23.53* (556.84)	14.93* (223.27)
14	$S_1A_2T_7$	33.27	47.66	31.11	0.15	14.99	6.22	21.58* (466.33)	13.93* (193.53)
15	$S_1A_3T_1$	36.80	44.67	44.45	0.14	14.98	7.17	25.81* (666.65)	17.87* (319.08)
16	$S_1A_3T_2$	35.47	41.00	37.78	0.21	16.90	7.99	25.28* (640.29)	17.39* (302.30)
17	$S_1A_3T_3$	37.40	44.33	35.55	0.16	16.27	7.62	24.04* (577.96)	16.46* (270.34)
18	$S_1A_3T_4$	37.94	45.34	31.11	0.14	14.60	6.91	21.30* (454.25)	14.68* (215.35)
19	$S_1A_3T_5$	37.20	47.00	37.78	0.14	15.30	6.33	24.05* (579.32)	15.47* (238.70)
20	$S_1A_3T_6$	40.27	51.00	28.90	0.11	13.86	5.58	20.00* (400.01)	12.72* (161.52)
21	$S_1A_3T_7$	43.20	55.67	24.45	0.11	12.17	4.95	17.24* (297.41)	11.03* (121.15)
22	$S_2A_1T_1$	13.53	26.34	82.22	0.66	26.05	9.62	46.29* (2142.03)	28.14* (791.48)
23	$S_2A_1T_2$	13.00	23.00	73.33	0.74	27.35	10.70	44.75* (2003.42)	28.00* (784.27)

24	$S_2A_1T_3$	14.67	24.33	73.33	0.60	27.26	10.31	44.69* (1998.67)	27.49* (755.38)
25	$S_2A_1T_4$	16.40	27.34	68.90	0.42	24.85	8.80	41.37* (1710.92)	24.64* (606.16)
26	$S_2A_1T_5$	16.07	28.66	75.56	0.42	23.89	8.55	42.44* (1806.03)	25.40* (646.50)
27	$S_2A_1T_6$	18.33	32.00	64.45	0.45	22.20	7.89	37.83* (1430.94)	22.57* (508.97)
28	$S_2A_1T_7$	19.93	35.33	57.78	0.33	21.20	7.21	34.98* (1224.40)	20.42* (416.37)
29	$S_2A_2T_1$	19.53	30.00	75.55	0.56	23.77	8.83	42.38* (1795.72)	25.85* (667.58)
30	$S_2A_2T_2$	18.53	28.33	66.67	0.60	24.67	10.53	40.54* (1644.89)	26.48* (700.47)
31	$S_2A_2T_3$	20.87	30.00	68.90	0.58	24.08	9.84	40.67* (1658.92)	26.01* (678.26)
32	$S_2A_2T_4$	21.27	30.33	73.33	0.50	23.15	8.46	41.18* (1696.92)	24.92* (621.33)
33	$S_2A_2T_5$	20.40	31.34	71.11	0.45	23.05	8.12	40.50* (1639.88)	24.04* (577.17)
34	$S_2A_2T_6$	22.47	35.00	55.55	0.41	21.12	7.53	34.25* (1172.97)	20.47* (418.65)
35	$S_2A_2T_7$	24.73	37.00	44.45	0.33	19.80	6.96	29.67* (880.53)	17.60* (309.75)
36	$S_2A_3T_1$	28.33	34.00	60.00	0.42	19.85	8.51	34.51* (1193.87)	22.59* (510.35)
37	$S_2A_3T_2$	27.00	31.67	57.78	0.44	21.15	10.13	34.97* (1222.87)	24.21* (585.77)
38	$S_2A_3T_3$	29.13	33.33	48.89	0.42	19.72	9.61	30.98* (962.18)	21.66* (470.11)
39	$S_2A_3T_4$	29.87	35.00	44.45	0.41	17.59	8.25	27.95* (781.25)	19.17* (367.07)
40	$S_2A_3T_5$	32.00	35.00	48.89	0.41	17.64	7.90	29.31* (862.45)	19.63* (386.25)
41	$S_2A_3T_6$	36.67	39.00	35.56	0.40	15.79	7.06	23.70* (562.14)	15.85* (250.81)
42	$S_2A_3T_7$	39.20	39.67	31.11	0.34	14.47	6.69	21.20* (449.67)	14.44* (208.39)
SE(m)		0.212	N/A	N/A	0.007	0.248	0.119	N/A	N/A
CD at 5%		0.597	N/A	N/A	0.019	0.698	0.335	N/A	N/A

* Transformed values

S_1: Flat S_2: Stalk end up A_1: Freshly extracted stone A_2: 10 days after extraction A_3: 20 days after extraction

T_1: GA_3- 100 ppm T_2: GA_3 - 200 ppm T_3: GA_3- 300 ppm T_4: KNO_3- 1 ppm T_5: KNO_3 - 2 ppm

T_6: Cow dung slurry T_7: Water T_8: Control (No treatment)

e. Correlation analysis of pre-sowing treatments and age of the stones after extraction on germination and growth characteristics of seedling (flat method of sowing).

The results obtained from the present investigation are summarized below:

Close perusal of correlation analyses (Table 5) revealed that, there was a significant, very high positive correlation and very dependable relationship between days taken for 50% germination and days taken for initiation of germination (r=0.932**).The germination percentage had strong negative linear relationship and non-significant correlation with number of days taken for initiation of germination (r= -0.803) and number of days taken for 50% germination (r= -0.901).

The germination rate had strong negative and non-significant correlation with number of days taken for initiation of germination (r= -0.884) and number of days taken for 50% germination (r= -0.901) but had a high positive correlation (r=837**) and marked relationship with germination percentage.

The seedling length had non-significant and strong negative linear relationship between number of days taken for initiation of germination (r= -0.920) and number of days taken for 50% germination (r= -0.918) but found high correlation and marked relationship between germination percentage (r=0.798**) and germination rate (0.848**).

The dry weight of seedling had non-significant and strong negative correlation with number of days taken for initiation of germination (r= -0.802) and number of days taken for 50% germination (r= -0.905) but found high correlation and marked linear relationship between germination percentage (r=0.785**) and germination rate (0.796**). The dry weight of seedling correlated very strongly and very dependable relationship was found with seedling length (0.910**).

Seedling Vigour Index-I (SVI-I) had strong negative and non-significant linear relationship between number of days taken for 50% germination (r= -0.960) and number of days taken for initiation of germination (r= -0.903). SVI-I had very high positive, significant and very dependable relationship with germination percentage (r= 0.958**) and seedling length (r= 0.937**). SVI-I had highly positive (significant) and marked relationship between germination rate (0.889**) and dry weight of the seedling (0.887**).

Seedling Vigour Index-II (SVI-II) had strong negative and non-significant linear correlation with number of days taken for 50% germination (r= -0.953) and days taken for initiation of germination (r= -0.849). SVI-II had very high positive, significant correlation and very dependable relationship with germination percentage (r= 0.965**), dry weight of seedling (r=0.920**) and SVI-I (0.982**). SVI-II had highly positive and significant marked linear relationship with germination rate (0.0.867**) and seedling length (0.891**).

Table 5: Correlation analysis of pre-sowing treatments and age of the stones after extraction on germination and growth characteristics of mango cv.

	Days taken for initiation of germination	Days taken for 50% % germination	Germination percentage	Germination Rate	Seedling length	Dry weight of Seedling	Seedling Vigour Index –I	Seedling Vigour Index- II
Days taken for initiation of germination	1							
Days taken for 50% germination	0.932**	1						
Germination percentage	-0.803	-0.901	1					
Germination Rate	-0.884	-0.901	0.837**	1				
Seedling length	-0.920	-0.918	0.798**	0.848**	1			
Dry weight of Seedling	-0.802	-0.905	0.785**	0.796**	0.910**	1		
Seedling Vigour Index –I	-0.903	-0.960	0.958**	0.889**	0.937**	0.887**	1	
Seedling Vigour Index- II	-0.849	-0.953	0.965**	0.867**	0.891**	0.920**	0.982**	1

* Correlation is significant at the 0.05 level of probability; ** Correlation is significant at the 0.01 level of probability; others are non-significant.

f. Correlation analysis of pre-sowing treatments and age of the stones after extraction on germination and growth characteristics of seedling (stalk end up method of sowing).

It is clear from table 6 that there was a significant, high positive correlation and marked relationship between days taken for 50% germination and days taken for initiation of germination (r=0.837**). The germination percentage strong negative and non-significant linear correlation with number of days taken for initiation of germination (r= -0.893) and number of days taken for 50% germination (r= -0.889).

The germination rate had moderate negative and non-significant linear relationship with number of days taken for initiation of germination (r= -0.517) and non-significant, strong negative relationship with number of days taken for 50% germination (r= -0.766) but had moderate positive, significant correlation (r=668*) and substantial relationship with germination percentage ($p \leq 0.05$).

The seedling length had non-significant and strong negative linear relationship between number of days taken for initiation of germination (r= -0.950) and number of days taken for 50% germination (r= -0.939) but found very high and very dependable linear relationship with germination percentage (r=0.928**) and moderate correlation and substantial linear relationship with germination rate (0.705*) ($p \leq 0.05$).

The dry weight of seedling had non-significant and weak negative linear relationship with number of days taken for initiation of germination (r= -0.456) and non-significant and strong negative linear correlation with number of days taken for 50% germination (r= -0.787). The dry weight of seedling had moderate positive non-significant correlation and substantial linear relationship with germination percentage (r=0.570) and seedling length (0.660*) ($p \leq 0.05$) but showed high significant positive correlation and substantial relationship with germination rate (0.793**).

Seedling Vigour Index-I (SVI-I) had very strong negative and non-significant correlation with number of days taken for 50% germination (r= -0.925) and number of days taken for initiation of germination (r= -0.933). SVI-I had very high positive and significant correlation as well as very dependable relationship with germination percentage (r= 0.988**) and seedling length (r=0.974**). SVI-I had moderate significant correlation and substantial relationship with germination rate (0.695*) but non-significant moderate correlation and substantial relationship with dry weight of the seedling (0.618) ($p \leq 0.05$).

Seedling Vigour Index-II (SVI-II) had strong negative and non-significant correlation with number of days taken for 50% germination (r= -0.952) and days taken for initiation of germination (r= -0.823). SVI-II had very high positive, significant correlation and very dependable relationship with germination percentage (r= 0.941**), seedling length (0.931**) and SVI-I (0.953**). SVI-II had high positive correlation and marked linear relationship with germination rate (0.0.799**) and dry weight of seedling (r=0.814**).

Table 6: Correlation analysis of pre-sowing treatments and age of the stones after extraction on germination and growth characteristics of mango cv. Kotookonam Varikka by stalk end up method of sowing.

	Days taken for initiation of germination	Days taken for 50% % germination	Germination percentage	Germination Rate	Seedling length	Dry weight of Seedling	Seedling Vigour Index –I	Seedling Vigour Index- II
Days taken for initiation of germination	1							
Days taken for 50% germination	0.837**	1						
Germination percentage	-0.893	-0.889	1					
Germination Rate	-0.517	-0.766	0.668*	1				
Seedling length	-0.950	-0.939	0.928**	0.705*	1			
Dry weight of Seedling	-0.456	-0.787	0.570	0.793**	0.660*	1		
Seedling Vigour Index –I	-0.933	-0.925	0.988**	0.695*	0.974**	0.618	1	
Seedling Vigour Index- II	-0.823	-0.952	0.941**	0.799**	0.931**	0.814**	0.953**	1

* Correlation is significant at 0.05 level of probability; ** Correlation is significant at 0.01 level of probability; others are non-significant

Conclusion

The results of the present investigation suggest that the pre-sowing treatments, age of stone after extraction from fruit as well as sowing positions had very significant positive correlations with regard to germination and growth characteristics of mango cv. Kotookonam Varikka. More significant results with respect to correlation studies of vigour indices and germination characters were obtained in stalk end up method of sowing over the flat method as influenced by various pre-sowing treatments and age groups of stones.

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