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Studies on seed storage and germination of jackfruit (*Artocarpus heterophyllus* Lam.)

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Abstract
Recalcitrant seeds are desicative and chilling sensitive and are viable for a very short period. Seeds of Jackfruit (*Artocarpus heterophyllus* Lam.) being recalcitrant in nature pose storage problem. Hence, an experiment was conducted during 2020-21 to study the different growing media and pre-germination treatments on viability, vigour and growth of jackfruit seeds. The two factorial experiment was conducted on the different growing media [Soil + FYM (3:1)-control, Soil + Cocopeat (3:1), Soil + Vermicompost (3:1) and Soil + Vermicompost + Cocopeat (2:1:1)] on seed germination and different growth regulators and chemicals *viz.*, water soaking (control), GA_3 @ 250 ppm for 12 hour, KNO_3 @ 1 per cent for 3 hour, and Thiourea @ 1 per cent for 1 hour. Results revealed that Soil + Vermicompost + Cocopeat (2:1:1) and GA_3 @ 250 ppm for 12 hours were exhibited maximum germination (69.54% and 91.26%), seedling height (32.75 cm and 43.47 cm), number of leaves (4.54 and 6.32) seedling vigour index-I (4905 and 6473), maximum fresh (14.26 g and 18.35 g) and dry weights (3.54 g and 4.45 g) of seedlings.

Keywords: Jackfruit, Recalcitrant, Vermicompost, *Artocarpus heterophyllus* Lam.

Introduction
The coastal warm and humid climate of the Konkan region is favourable for jackfruit (*Artocarpus heterophyllus* Lam.) cultivation. There is a great potential for increasing the area under jackfruit in the Konkan region. A success of a fruit nursery depends on raising healthy rootstock. Preparation of potting mixture plays an important role in the production of seedling. Propagation media also plays an important role in seed germination. Media not only acts as a growing place but also as a source of nutrient for plant growth (Ramteke *et al*., 2015) [19]. Hence, it is of prime importance to standardize the suitable media composition for commercial production of jackfruit seedling.

There are 55-67 genera and 900-1000 species comes under the family Moraceae (Bailey, 1949) [2]. There are eight edible *Artocarpus* species in the genus *Artocarpus*. Only two of them, jackfruit (*Artocarpus heterophyllus* Lam.) and bread fruit (*Artocarpus altilis*) are horticulturally important. It is thought to have originated in India's Western Ghats (Samaddar, 1990) [21] and then spread to Malaysia and East Africa (Dutton, 1976) [9].

The use of growth regulators for improving the germination of seeds has been known for a long time. However, due to poor growth and development of seedlings restricts the availability of healthy planting material on large scale. Therefore, it is highly essential to accelerate the rate of seed germination and growth rate by treating the seed with growth substances to obtain more germination percentage and good size of seedling within a short period. In the seeds of recalcitrants, it is much importance to enhance germination per cent and viable period so that, the availability of viable seeds can be extended by proper storage in congenial temperature so as to use seeds in multiplication of planting material and for raising of rootstocks (Bhavya, *et al*., 2017) [6].

Generally, soil + FYM are used as a potting mixture for production of seedling as a rootstock. However, requirement of soil is huge which seriously affect the farming in this region. On this background a search for alternatives for replacement of soil by some other easily available components as a growing media constitute an immediate requirement. Hence, the investigation was carried out at Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi to study the different growing media and pre-germination treatments on viability, vigour and growth of jackfruit seeds.

Material and Methods

Details of the experimental site

The experiment was conducted at the K.R.C. college of Horticulture, Arabhavi, of the University of Horticultural sciences, Bagalkot, in Karnataka, India. Arabhavi is situated in Northern dry Zone of Karnataka state (Zone NO.3, Region-2) at 16°15' N latitude and 74°45' E longitude, 612 m above mean sea level. The experimental sites receive, on an average, about 550 mm rain annually.

Experimental details

The present investigation was carried out during the year 2020- 2021 at K.R.C. College of Horticulture, Arabhavi in Belgaum district of Karnataka, India. The experiment was laid in factorial completely randomized design with three replications. Observations were recorded in respect of seedling height and number of leaves at 30, 45 and 60 days interval. The germination percentage was worked out after complete germination, i.e., after stoppage of germination. It was calculated by dividing total number of seeds sown with the number of seeds germinated and was multiplied by 100. Fresh and dry weights of seedlings were also recorded. Seedling vigour index was calculated based on the following formula (Bewley and Black, 1985) [4].

Vigour index I = Per cent germination × Length of seedling

Treatment details

Factor A: Different growth regulators and chemicals

G_1: Water soaking (control)
G_2: GA_3 @ 250 ppm for 12 hour
G_3: KNO_3 @ 1% for 3 hour
G_4: Thiourea @ 1% for 1 hour

Factor B: Different growing media

M_1: Soil + FYM (3:1)- control
M_2: Soil + Cocopeat (3:1)
M_3: Soil + Vermicompost (3:1)
M_4: Soil + Vermicompost + Cocopeat (2:1:1)
Note: Seeds sown under shade net conditions.

Result and Discussion

Germination

When germination was started from the first day of germination to last day of germination (specify the final Day) was observed and the data pertaining to percentage of seeds germination are presented in Table 1.

Effect of different growing media on seed germination percentage

Significantly the highest germination percentage was observed in treatment M_4 (Soil + Vermicompost + Cocopeat 2:1:1) (91.26%) and The lowest germination (78.32%) was recorded in M_1 (Soil + FYM 3:1). It might be because of media containing organic manures possess organic acid, which improves drainage, aeration, water holding capacity, and the highest nutrients within them. Therefore, more available moisture and some acids may have helped in minimum days to germination and better germination percentage. The results are following Mirza *et al.* (2014) [13] in Karonda.

Effect of different growth regulators and chemicals on seed germination percentage

Treatment G_2 (GA_3 @ 250 ppm for 12 hours) gave significantly the highest germination (69.54%) followed by G_3 (KNO_3 @ 1 per cent for 3 hours) (63.00%). Significantly lowest germination percentage (59.62) was noticed in treatment G_1 [Water soaking (Control)]. It might be due to higher moisture content in the seed which promotes early germination and the possible reason for minimum days taken for complete germination by GA_3 treated seeds might be due to that GA_3 which activates the hydrolysis of starch and their translocation facilitate early start as well as completion of germination.

The results of the present investigation revealed that the maximum germination percentage was recorded when seeds were treated with GA_3. This might be due to GA_3 acting directly on embryos relieving them from dormancy through promoting protein synthesis and elongation of coleoptile and leaves helping in the production of ethylene. This ethylene invokes the synthesis of hydrolases, especially amylose, which favors seed germination (Stewart and Freebarin, 1969) [23]. Thus, the enhanced enzymatic reactions along with suppression of inhibitors by these growth substances might have acted in faster germination. The results conform with those found by Pandiyan *et al.* (2011) [15] in jackfruit, Gupta (1989) [10] in Rangpur Lime, and Barche *et al.* (2010) [3] in papaya.

Effect of different growing media on seedling height and number of leaves

The data in respect to seedling height and number of leaves at 30, 45 and 60 days after germination were recorded and presented in Table 2 and 3. Significantly the highest seedling height (31.62, 39.88 and 43.47 cm, respectively) and number of leaves (1.84, 4.03 and 6.32 respectively) was observed in treatment M_4 (Soil + Vermicompost + Cocopeat 2:1:1), which was at par with M_3 (Soil + Vermicompost 3:1) (1.72, 3.83 and 5.79 respectively). The lowest seedling height (27.87 34.13 and 38.19 cm respectively) and number of leaves (1.57, 3.55 and 5.16 respectively) was recorded in M_1 (Soil + FYM 3:1)-control at 30, 45 and 60 days after germination. The increase in height of seedling might be due to presence of more nutrients along with that it provides good drainage, proper aeration and more water holding capacity. The highest nutrients uptake by root system results in the highest seedling height. The results have been supported by Bhardwaj (2013) [5] who obtained maximum seedling height in papaya due to vermicompost application. In the current investigation Soil + Vermicompost + Cocopeat has favoured the maximum production of leaves. Whereas the media containing Soil + FYM had a minimum number of leaves per seedling at all stages of growth. Nutrients are the key factors for executing many metabolic activities and also the hormonal balance within the plant. The variation in number of leaves of the seedlings on different growing media thus obviously appears to be due to different physical and chemical properties of the growing media. The results have been supported by Bhardwaj (2013) [5].

Effect of different growth regulators and chemicals on seedling height and number of leaves

At 30, 45 and 60 days G_2 (GA_3 @ 250 ppm for 12 hours) had

numerically maximum seedling height (23.64, 29.64 and 32.75 cm), number of leaves (1.43, 3.01 and 4.54) and G_1 [Water soaking (control)] showed minimum seedling height (20.77, 26.46 and 28.74 cm) and number of leaves (1.15, 2.58 and 3.86) at 30, 45 and 60 days after germination. The increased height in GA_3 treated seeds may be attributed to the reason that the endogenous levels of GA_3 synthesized by the jackfruit seedling might not be sufficient and external application of GA_3 might have boosted growth by increasing cell multiplication and cell elongation resulting in better seedling growth. The result obtained in the present investigation is in close conformity with the results obtained by Pawashe *et. al.*, 1997 [17]. The GA_3 helps for the physiological process of plants and stimulatory increased rate of photosynthetic activity and accelerated the transport and efficiency of utilizing photosynthetic products resulting in the cell elongation and rapid cell division in the growing portion (Chandra and Govind, 1990) [7].

Seedling quality parameters

Effect of different growing media on root length (cm), fresh weight (g), dry weight (g), seedling vigour index-I and girth of the seedling (mm) presented in Table 2 and 3.

Significantly the highest root length, fresh weight, dry weight, vigour index-I and girth of seedling was observed in treatment M_4 (Soil + Vermicompost + Cocopeat 2:1:1) (26.99 cm, 15.35 g, 4.45 g, 6473 and 6.14 mm, respectively) and The lowest root length, fresh weight, dry weight, seedling vigour index-I and girth of the seedling (22.83, 13.53, 2.88, 4738 and 5.12 respectively) was recorded in M_1 (Soil + FYM 3:1). It might be due to, at initial stage soil and FYM improve soil texture, porosity, water holding capacity, the activity of useful soil microfauna and flora which maintain soil temperature and improved soil health and nutrient status of media, while at later stage vermicompost which contain plant growth regulators become responsible for increasing root length and better physiological attributes. The present investigation accordance with the finding of Prajapati *et al.* (2017) [18] in acid lime and Ramteke *et al.* (2015) [19] in papaya. Height, girth and number of leaves are simple and important attributes, which can indicate the influence of growing media on overall growth. In the current investigation Soil + Vermicompost + Cocopeat favoured maximum height 60 DAS. On the contrary Soil + FYM showed minimum magnitudes of seedling height at all above mention stages of seedling growth. Similarly, the girth of the seedling was also highly enhanced by Soil + Vermicompost + Cocopeat. More the girth stronger is the vascular bundle of the plant which facilitates better translocation of solute within the plant. Thus Soil + Vermicompost + Cocopeat has favoured longitudinal as well as horizontal growth i.e., height and girth. Such phenomenon is decided by division of cell expansion and elongation which are naturally under the influence of auxins, Cytokinin's and gibberellins within the plant. The promoter effect imparted by this particular growth media i.e. Soil + Vermicompost + Cocopeat warrants that these components favor the production of natural growth promoting substances like auxins, cytokines and gibberellins Ramteke *et al.* (2015) [19].

Effect of different growth regulators and chemicals on root length (cm), fresh weight (g), dry weight (g), seedling vigour index-I and girth of the seedling (mm)

Significantly the highest root length, fresh weight, dry weight, vigour index-I and girth of the seedling (20.69 cm, 14.26 g, 3.54g , 4905 and 4.82 mm, respectively) was observed in treatment G_2 (GA_3 @ 250 ppm for 12 hours) and the lowest root length, fresh weight, dry weight, vigour index-I and girth of the seedling (16.34 cm, 9.73 g, 1.85 g, 3570 and 3.63 mm, respectively) was recorded in G_1 [Water soaking (control)]. The increased root length in the GA_3 treatment might be due to more production of photosynthates and their translocation through the phloem to the root zone, which might be responsible for improving the root growth. More or less similar results were also reported by Anburani and Shakila, (2010) [1] in papaya, Patil *et al.* (2012) [16] in Rangpur lime and Manekar *et al.* (2011) [11] in aonla. It might be due to the overall growth of the seedling and increased rate of photosynthesis that lead to the overall assimilation and redistribution of photosynthates within the seedling and hence, resulted in higher fresh and dry weight. The results are in close conformity with findings of Meena and Jain (2005) [12] and Sasikala and Srimathi (2006) [22] in papaya. This might be due to the higher germination capacity of fresh seed with more vigour, which resulted in better growth of seedlings ultimately superior physiological attributes. The present investigation was supported by Prajapati *et al.* (2017) [18] in acid lime, Deepika *et al.* (2014) [8] in karonda and Pallavi, *et al.*, (2022) [14] in passion fruit.

Table 1: Effect of different growing media and pre-sowing seed treatments on germination percentage of jackfruit seedlings

Treatment	Germination (%)				
	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean
M_1: Soil + FYM (3:1)- Control	73.17	86.60	76.92	76.58	78.32
M_2: Soil + Cocopeat (3:1)	76.58	92.94	81.99	80.21	82.93
M_3: Soil + Vermicompost (3:1)	79.31	95.63	86.60	83.25	86.20
M_4: Soil + Vermicompost + Cocopeat (2:1:1)	88.92	95.70	90.50	89.92	91.26
Mean	59.62	69.54	63.00	61.87	
	S. Em ±		CD @ 1%		
Factor -A	0.94		2.70		
Factor-B	0.94		2.70		
Interaction (A×B)	1.87		NS		

NS: Non-Significant

Table 2: Effect of different growing media and pre-sowing seed treatments on seedling height (cm)of jackfruit.

Treatments	30 DAS					45 DAS					60 DAS				
	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 - Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 - Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean
M_1: Soil + FYM (3:1)- Control	26.44	29.37	28.20	27.36	27.84	32.53	36.40	34.93	32.67	34.13	35.50	42.40	38.20	36.67	38.19
M_2: Soil + Cocopeat (3:1)	26.73	31.47	28.33	27.53	28.52	35.94	38.13	37.33	37.14	37.14	38.07	43.20	39.27	38.47	39.75
M_3: Soil + Vermicompost (3:1)	27.74	31.87	29.93	28.73	29.57	35.37	40.03	39.17	38.35	38.23	38.93	42.33	41.87	39.30	40.61
M_4: Soil + Vermicompost + Cocopeat (2:1:1)	29.87	33.40	32.80	30.40	31.62	37.30	43.53	40.23	38.45	39.88	40.80	46.73	43.93	42.40	43.47
Mean	20.77	23.64	22.36	21.38		26.46	29.64	28.44	27.49		28.74	32.75	30.61	29.41	
	S. Em ±		CD @ 1%			S. Em ±		CD @ 1%			S. Em ±		CD @ 1%		
Factor -A	0.51		1.46			0.71		2.06			0.74		2.12		
Factor-B	0.51		1.46			0.71		2.06			0.74		2.12		
Interaction (A×B)	1.01		NS			1.43		NS			1.47		NS		

DAS: Days after sowing
NS: Non-Significant

Table 3: Effect of different growing media and pre-sowing seed treatments on number of leaves per plant of jackfruit seedlings

Treatments	30 DAS					45 DAS					60 DAS				
	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 - Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean
M_1: Soil + FYM (3:1)- Control	1.40	1.74	1.64	1.50	1.57	3.37	3.67	3.63	3.53	3.55	4.47	5.53	5.47	5.17	5.16
M_2: Soil + Cocopeat (3:1)	1.43	1.90	1.85	1.52	1.68	3.27	3.83	3.57	3.47	3.57	5.07	5.63	5.60	5.20	5.38
M_3: Soil + Vermicompost (3:1)	1.64	1.82	1.74	1.66	1.72	3.47	4.07	3.93	3.87	3.83	5.27	6.20	5.93	5.77	5.79
M_4: Soil + Vermicompost + Cocopeat (2:1:1)	1.67	2.15	1.80	1.74	1.84	3.67	4.47	4.13	3.83	4.03	5.77	6.87	6.80	5.83	6.32
Mean	1.15	1.43	1.32	1.21		2.58	3.01	2.86	2.76		3.86	4.54	4.46	4.12	
	S. Em ±		CD @ 1%			S. Em ±		CD @ 1%			S. Em ±		CD @ 1%		
Factor -A	0.05		0.19			0.09		0.26			0.18		0.51		
Factor-B	0.05		0.19			0.09		0.26			0.18		0.51		
Interaction (A×B)	0.10		NS			0.18		NS			0.35		NS		

DAS: Days after sowing
NS: Non-Significant

Table 4: Effect of different growing media and pre-soaking seed treatments on girth, root length and vigour index -1 of jackfruit seedlings

Treatments	Seedling girth (mm)					Root length (cm)					Vigour index -1				
	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 - Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean
M_1: Soil + FYM (3:1)- Control	4.68	5.65	5.14	4.98	5.12	19.87	25.39	23.80	22.27	22.83	3974	5884	4750	4345	4738
M_2: Soil + Cocopeat (3:1)	4.76	6.08	5.73	5.01	5.39	20.87	27.27	25.07	24.60	24.45	4524	6338	5364	5045	5318
M_3: Soil + Vermicompost (3:1)	4.81	6.15	5.85	5.43	5.56	21.73	28.67	27.00	25.93	25.83	4852	6625	5978	5435	5722
M_4: Soil + Vermicompost + Cocopeat (2:1:1)	5.12	7.82	6.02	5.61	6.14	24.68	29.00	27.73	26.53	26.99	5690	7317	6682	6202	6473
Mean	3.63	4.82	4.27	3.94		16.34	20.69	19.43	18.63		3570	4905	4270	3942	
	S. Em ±		CD @ 1%			S. Em ±		CD @ 1%			S. Em ±		CD @ 1%		
Factor -A	0.19		0.53			0.43		1.23			156.69		451.37		
Factor-B	0.19		0.53			0.43		1.23			156.69		451.37		
Interaction (A×B)	0.37		NS			0.85		NS			313.38		NS		

NS: Non-Significant

Table 5: Effect of different growing media and pre-sowing seed treatments on fresh weight and dry weight of jackfruit seedlings

Treatment	Fresh weight (g)					Dry weight (g)				
	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean	G_1 - Water soaking (Control)	G_2 -GA_3 @ 250 ppm for 12 hours	G_3 -KNO_3 @ 1 per cent for 3 hours	G_4 -Thiourea @ 1 per cent for 1hour	Mean
M_1: Soil + FYM (3:1)- Control	11.93	14.80	14.40	13.00	13.53	2.27	2.73	3.33	3.20	2.88
M_2: Soil + Cocopeat (3:1)	12.50	16.73	16.17	13.73	14.78	2.13	4.13	3.90	2.87	3.26
M_3: Soil + Vermicompost (3:1)	13.60	21.83	16.63	15.00	16.77	2.47	6.20	3.87	3.03	3.89
M_4: Soil + Vermicompost + Cocopeat (2:1:1)	13.87	22.67	21.40	15.47	18.35	3.00	5.80	5.20	3.80	4.45
Mean	9.73	14.26	12.86	10.73		1.85	3.54	3.06	2.42	
	S. Em ±		CD @ 1%			S. Em ±		CD @ 1%		
Factor -A	0.58		1.66			0.25		0.72		
Factor-B	0.58		1.66			0.25		0.72		
Interaction (A×B)	1.15		NS			0.50		NS		

NS: Non-Significant

Conclusion

Germination of jackfruit seeds can be enhanced when seeds were treated with M_4 (Soil + Vermicompost + Cocopeat 2:1:1) and G_2 (GA_3 @ 250 ppm for 12 hours) as it resulted in maximum seedling height, root length, fresh weight of the seedling and dry weight of the seedling. The lowest results were obtained in M_1 (Soil + FYM 3:1)- control and G_1 (Water soaking) -control.

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