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Identification of Causes for Seed Dormancy and Its Safe Removal in Sponge Gourd (*Luffaa egyptiaca*) and Snake Gourd (*Trichosanth escucumerina*)

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Abstract

The Cucurbit species of sponge and snake gourds have hard seed coat dormancy and viable seeds cannot germinate even in favourable environments. Consequently, the present study was carried out with the objective, to identify the causes and to break the dormancy in the seeds of sponge gourd and snake gourd with two different lots. Seeds were soaked in distilled water for 24h and 48h. After pre-soaking, the observations were recorded as number, weight and percentage of imbibed and intact (non-imbibed) seeds. It was observed that about 50 per cent seeds remained hard even after 24h of imbibition, but on the other hand even after 48 hours of imbibition, only 57 to 68 per cent of seeds imbibed water properly and 32 to 43 per cent seeds remained hard. From these observations, it was found that the seeds of sponge and snake gourd showed physical dormancy due to hard seed coat. Hard seed dormancy is a common phenomenon with sponge and snake gourd seeds and therefore, scarification, chemical and dry heat treatments were used to break dormancy in the selected gourd seeds. Manual scarification followed by chemical (GA_3@100 ppm, KNO_3@ 0.5 %) treatments, mere water soaking and dry heat treatments were also adopted. After these dormancy breaking treatments, seed germination results showed that scarified seeds treated with KNO_3@ 0.5 per cent for 18h gave the higher germination in sponge gourd (78, 80 %) and snake gourd (79, 78 %) followed by scarified seeds treated with GA_3 @100ppm for 18 h (74, 74 %) and (75,72 %) in two different lots, respectively. Seeds without scarification recorded on par results with control, which exhibited very low germination (63, 61, 65 and 63%) in both the seed lots.

Keywords : Sponge gourds, Snake gourds, Cucurbits, Seed dormancy imbibition, Radicle emergence, Mean germination time, Growth regulators

Cucurbits (*Cucurbitaceae*) are among the most important plant families supplying humans with edible products and useful fibres. Plants of this family are very similar in the above ground development, but they have high genetic diversity for fruit shape and other fruit characteristics, resulting in a variety of uses. The Cultivated cucurbits have spread through trade and exploration from their respective old and new world centres of origin to the six arable continents and are important in local, regional and world trade. Cucumber, melon, pumpkin, squash, gourd and watermelon comprise the major cucurbits. Bitter gourd, bottle gourd, wax gourd, sponge, ridge gourd and snake gourd are minor cucurbits from a global perspective that are of import to small shareholder farmers, mostly in Asia. The FAO estimates that cucurbits in India are grown on about 4,290,000 ha with a productivity of 10.52 t/ha. Thus, cucurbits cultivation accounts for about 5.6 per cent of India's total vegetable production. Cucurbits can play an important role in dietary health. They are low in nutritional value, but can be significant dietary sources of vitamins and minerals. Some cucurbits, such as bitter gourd, have medicinal properties. Cucurbits are generally valued for their delicious fruits, which can be sweet, bitter or aromatic, and may be highly perishable or stored for months with little change in quality. The seeds are good sources of vegetable oil and protein. Gourd shells may be used for storage containers, or as musical instruments. The cultivated cucurbits have been greatly improved by plant breeders using conventional plant breeding techniques for more than 100 years. Rapidly advancing molecular technologies are being applied to cucurbits to ensure sustainable production, improve fruit quality

and shelf life, and develop novel fruit types. Considering the importance of these crops, sustainable supply of quality seeds at affordable cost is pivotal to cope up with their production, productivity and supply to meet the ever growing demand of these crops. However, the vegetable seed industry is facing recurrent problem on seed quality of these crop plants due to their immaturity, ill-filling, hard seed coat etc., causing poor germination and seedling vigour which leads to poor plant establishment in field.

Luffa cylindrica (L.) M., commonly called smooth loofah or sponge gourd is a member of the *Cucurbitaceae* family. The plants are economically important in many parts of the world for instance, in China, Korea, Japan, India, Central America, as well as in Thailand for their young fruits, while ripening fruits are used to produce consumer goods such as cleaning materials and engine oil filters (Oboh and Aluyor, 2009). The seeds are composed of 46 per cent oil and 40 per cent protein (Siemonsma and Piluek, 1993). *Trichosanthes cucumerina* (Snake gourd) is a monoecious annual vine which grows in subtropical or tropical conditions. In Asia, people usually eat immature fruit of snake gourd as vegetable. Mature fruit pulp is too bitter, and it is used as an economical substitute of tomato. Snake gourd seeds are well adapted to the adverse environmental conditions. These cucurbit species have severe problems with seed dormancy and viable seeds that cannot germinate even in favourable environments because of seed coat impermeability which is considered as one of the major mechanisms causing hard seed coat dormancy (Bradbeer, 1988 and Anoop Badoni, 2018). To identify the problem of dormancy in these seeds, imbibitions process may play a major role, although the published information on the identification of causes for seed dormancy through imbibitions is not available much on sponge and snake gourd. It would also be useful to increase the germination rate of these seeds, especially for those interested in commercial production of the crop. Therefore, the study was undertaken with main emphasis on to identify the causes of dormancy in both sponge and snake gourd seeds by using imbibition process.

These gourd seeds are considered hard-seeded with its thick seed structure and a hard seed coat moreover, phenolic compounds including pectin or suberin on the surface of the seed coat restrict water uptake into the seed during germination process (Doijode, 2001). Physical dormancy is caused by one or more water-impermeable layers of palisades (Baskin *et al.,* 2004 and Gowthami *et al.,* 2016). In addition, Singh and Dathan (1998) found that the seed coat of gourds is characterized by upright epidermal cells with rod-like thickenings and narrow, palisade-like osteosclereids which cause physical dormancy of gourd seeds. Seed dormancy is the most important factor limiting germination and there are various ways to break hard seed coat such as clipping, scarifying, and dry heat (Bradbeer, 1988). One such technique that has been widely and successfully used for breaking hard seed dormancy is scarification, which involves removing the seed coat or rubbing it with sandpaper or subjecting it to different chemical treatments (Bradbeer, 1988). Loyma *et al*. (2009) reported that removing the seed coat of wax gourd seeds increased radicle emergence with scarification of' Feang' and 'Fakkheaw' seeds. Removing the outer and inner testa, significantly improved radicle emergence to 96.0 and 99.5 per cent, respectively, of 'Feang' seeds and to 93.0 and 95.5 per cent, respectively, of 'Fakkheaw' seeds, compared to the un-scarified seeds (83.0 per cent for 'Feang' and 80 per cent for 'Fakkheaw'). Another technique for breaking hard seed coat dormancy is dry heat, which causes seed coat and perisperm dehydration and allows water and gases to enter the seed more quickly (Khan, 1980 and Thananthika, 2015). Hence, the secondary goal of this study was to determine the suitability of various techniques for breaking the dormancy of sponge and snake gourd seeds.

Material and Methods

Seed Materials

Sponge and Snake gourd seeds of two different lots were obtained from a Private Company in Bengaluru. Seeds were harvested and processed during October and November 2020. The study was conducted in ISTA member laboratory at Seed Technology

Research Centre, National Seed Project (Crops), University of Agricultural Sciences, GKVK, Bengaluru. The initial seed quality parameters were recorded as per the Seed Testing Rules of ISTA (2013).

Imbibition Studies

To conduct the experiment on seed imbibitions, four replications of 50 seeds each were taken and weighted separately. Seeds were then soaked in distilled water for two selected durations of 24h and 48h. After pre-soaking, the observations were recorded as number, weight and percentage of imbibed and hard (non-imbibed) seeds.

Methods of Breaking Seed Dormancy

Seeds were subjected to scarification followed by different chemical treatments to study methods of breaking dormancy. The experiment was arranged in a completely randomized design with eight treatment combinations. It consisted of two methods for breaking dormancy. The first method involved manual scarification by rubbing with sand paper for few seconds and second method was chemical treatment with GA_3 and KNO_3. Seeds after subjecting to dormancy treatments were tested for germination as per ISTA (2013). First and final counts were recorded at 4, 14 in sponge gourd and 4, 8 in snake gourd days respectively after putting for germination in between paper method and sand method.

Treatment Combinations

T_0 : Control

T_1 : Scarification (Mechanical)

T_2 : Scarification + GA_3 @100ppm for 18 h

T_3 : Scarification + KNO_3@ 0.5 % for 18 h

T_4 : Scarification + Water soaking for 18 h

T_5 : Scarification + Dry heat @ 70 ^{0}C for 3 h

T_6 : GA_3 @ 100 ppm for 18 h without scarification

T_7 : KNO_3@ 0.5 % for 18 h without scarification

T_8 : Water soaking for 18 h without scarification

Mean Germination Time

The number of normal seedlings was counted from the day of first count up to the day of final count. The mean germination time (MGT) was calculated using Equation below (Ellis and Roberts, 1981).

$$MGT = \Sigma nD/\Sigma n$$

Where, n= number of seeds newly germinated (2 mm, radicle emergence) at time D at 25 °C, D=days from the beginning of the germination test, Σn=final germination.

Radicle emergence was tested by removing the seed coat of the gourd seeds by soaking the seeds in water for 24h under room condition and incubation of them in the petri plates at 30 °C.

Results and Discussion

Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity and management options. In arid and semi-arid environments, the water needed for germination is available for only a short period, and consequently, successful crop establishment depends not only on the rapid and uniform germination of seed, but also on ability of seed to germinate under low water potential. However, if the stress effect can be alleviated at the germination stage, chances for attaining a good crop with higher production would be possible. The initial seed quality parameters recorded is depicted in Table 1.

The results on seed imbibition studies depicted in Table 2, suggested that even after 48h of imbibition, only 57 to 60 and 64 to 68 per cent seeds were imbibed water adequately and remaining 40 to 43 and 32 to 36 per cent seeds were hard in sponge and snake gourd of two seed lots, respectively.

Similarly, According to reviews the main reason for germination failure was the inhibition of seed water uptake due to a high salt concentration, whereas others have suggested that germination was affected by salt toxicity in the soil water (Thananthika *et al*., 2015). However, the results of present study indicated that more than 40 per cent of sponge gourd and 35 to 40 per cent of snake gourd seeds did not imbibe water and due to non-imbibition, embryos of the seeds

TABLE 1

The initial seed qualities parameters of Sponge and Snake Gourds

Seed quality parameters	Sponge gourd			Snake gourd		
	L_1	L_2	Mean	L_1	L_2	Mean
Seed moisture content (%)	9.30	10.0	9.65	7.5	7.5	7.50
1000 seed weight (g)	80.0	83.0	81.5	215	212	213.5
Seed viability (%)	95.0	97.0	96.0	100	100	100.00
Germination (%)	63.0	61.0	62.0	65.0	63.0	64.00
Hard seeds (%)	26.0	25.0	25.50	28.0	27.0	27.50

TABLE 2

Effect of different durations of soaking in sponge and snake gourds

Crop	Lot	Average initial weight of four replications		Seed Imbibition (hours)							
				24				48			
				Imbibed		Hard seed (Non-imbibed)		Imbibed		Hard seed (Non-imbibed)	
		No.	Wt. (g)	No.	Wt. (g)	No.	Wt. (g)	No.	Wt. (g)	No.	Wt. (g)
Sponge gourd	Lot-1	50	4.02	27.5	3.33	22.5	1.76	30.0	4.27	20.0	2.84
	Percentage (%) of Imbibed and Hard Seeds			55	45	60	40				
	Lot-2	50	4.35	25.0	3.28	25.0	2.17	28.5	4.68	21.5	3.53
	Percentage (%) of Imbibed and Hard Seeds			50	50	57	43				
Snake gourd	Lot-1	50	12.57	29.5	11.35	20.5	7.92	32.05	12.34	18	6.93
	Percentage (%) of Imbibed and Hard seeds			59	41	64	36				
	Lot-2	50	14.17	28.5	11.0	21.5	8.30	34.00	13.12	16.00	6.17
	Percentage (%) of Imbibed and Hard Seeds			57		43		68		32	

remains dry; which directly affect the metabolic activities of the seeds during germination process. Therefore, it is concluded that the seeds of sponge and snake gourd shows physical dormancy mainly due to hard seed coat permeability.This physical dormancy is caused by one or more water-impermeable layers of palisades according to Baskin and Baskin (2004).

The effectiveness of dormancy breaking methods in sponge and snake gourd seeds is shown in Table 3 & 4. There was a significant difference in seed germination among the treatments. The seeds scarified and treated with KNO_3 @ 0.5 per cent gave the highest germination (78, 80 %) and vigour index-I (2828, 2839) in sponge gourd and snake gourd (79, 78 per cent & 3697, 3572) in two different lots, respectively followed by seeds scarified and treated with GA_3 @100ppm [(74, 74 %), (2445, 2455) and (75, 72 %), (3195, 3060), respectively). Seed scarified and treated with KNO_3@

TABLE 3

Effect of different dormancy breaking methods on germination (%) and number of hard seeds in sponge gourd and snake gourds

Treatments	Sponge gourd						Snake gourd					
	Germination (%)			Hard seed (%)			Germination (%)			Hard seed (%)		
	L_1	L_2	Mean	L_1	L_2	Mean	L_1	L_2	Mean	L_1	L_2	Mean
T_0	63	61	62.0	26 * (31)	25 * (30)	25.5 * (30.5)	65	63	64.0	28 * (32)	27 * (31)	27.5 * (31.5)
T_1	68	66	67.0	24 (29)	24 (29)	24.0 (29)	68	65	66.5	24 (29)	26 (31)	25.0 (30)
T_2	74	74	74.0	18 (25)	17 (24)	17.5 (24.5)	75	72	73.5	18 (25)	18 (25)	18.0 (25)
T_3	78	80	79.0	14 (22)	13 (21)	13.5 (21.5)	79	78	78.5	15 (23)	16 (24)	15.5 (23.5)
T_4	68	69	68.5	20 (27)	20 (27)	20.0 (27)	64	63	63.5	18 (25)	19 (26)	18.5 (25.5)
T_5	67	66	66.5	19 (26)	18 (25)	18.5 (25.5)	69	68	68.5	19 (26)	20 (27)	19.5 (26.5)
T_6	63	66	64.5	25 (30)	22 (28)	23.5 (29)	67	64	65.5	24 (29)	24 (29)	24.0 (29)
T_7	65	66	65.5	23 (29)	24 (29)	23.5 (29)	65	67	66.0	23 (29)	26 (31)	24.5 (30)
T_8	65	65	65.0	25 (30)	23 (29)	24.0 (29.5)	66	65	65.5	24 (29)	24 (29)	24.0 (29)
Mean	67.89	68.00	67.9	21.56 (27.6)	21.00 (26.8)	21.3 (27.2)	68.67	67.22	67.9	21.44 (27.4)	22.22 (28.1)	21.8 (27.7)
	SEm±	CD (0.05P)		SEm±	CD (0.05P)		SEm±	CD (0.05P)		SEm±	CD (0.05P)	
Lots (L)	0.191	0.543		0.163	0.465		0.192	0.545		0.192	0.545	
Treatments (T)	0.382	1.086		0.327	0.929		0.384	1.091		0.384	1.091	
L x T	0.540	1.536		0.462	1.314		0.542	1.542		0.542	1.542	
CV (%)		2.17			4.41			1.59			4.03	

* Figures in the parentheses are arcsine transformed values

T_0 : Control
T_1 : Scarification (Mechanical)
T_2 : Scarification + GA_3 @100ppm for 18 h
T_3 : Scarification + KNO_3@ 0.5 % for 18 h
T_4 : Scarification + Water soaking for 18 h
T_5 : Scarification + Dry heat @ 70 ^{0}C for 3 h
T_6 : GA_3 @ 100 ppm for 18 h without scarification
T_7 : KNO_3@ 0.5 % for 18 hrs without scarification
T_8 : Water soaking for 18 hrs without scarification

0.5 per cent and GA_3@100ppm recorded 15 to 20 per cent higher germination over control (Fig. 1 & 2). However, hard seeds were found minimum when scarified seeds were subjected to chemical treatments (13 %) over non-scarified seeds with or without chemical treatments (26 %). Besides, scarified seeds soaked in water and dry heat treatments showed slightly improved germination and less number of hard

TABLE 4

Effect of different dormancy breaking methods on seedling vigour index-I in sponge gourd and snake gourds

Treatments	Seedling vigour index-I					
	Sponge gourd			Snake gourd		
	L_1	L_2	Mean	L_1	L_2	Mean
T0	1339	1355	1347	2002	1802	1902
T1	1646	1645	1645	2326	2113	2219
T2	2445	2455	2450	3195	3060	3128
T3	2828	2839	2834	3697	3572	3635
T4	1690	1733	1711	2208	2218	2213
T5	1829	1924	1876	2498	2441	2470
T6	1501	1510	1506	2184	2016	2100
T7	1612	1755	1684	2191	2318	2254
T8	1676	1742	1709	2303	2321	2312
Mean	1841	1884	1862	2512	2429	2470
	SEm±	CD (0.05P)		SEm±	CD (0.05P)	
Lots (L)	9.45	10.51		9.56	10.24	
Treatments (T)	14.63	13.86		15.34	14.65	
L x T	32.15	34.56		33.24	34.76	
CV (%)		3.67			4.58	

Fig 1 : Germination of sponge gourd scarified seeds with KNO_3 treatment and control

Fig. 2 : Germination of snake gourd scarified seeds with KNO_3 treatment and control

seeds compared to non-scarified seeds with KNO_3 and GA_3 treatment. Therefore, these results obviously indicated manual scarification has helped to break the physical dormancy of the seeds and increase 15 to 20 per cent of germination in gourd seeds. Loyma *et al*. (2009) have also stated that scarifying the seed coat by manual method scratched only the outer seed coat, but had no effect on the inner seed coat however, the seed coat of scarified seeds was the thinnest. Application of growth regulators in addition to scarification would further assist in enhancing germination by way of removing dormancy.

Mean Germination Time (MGT)

The MGT of sponge and snake gourd seeds by different methods of breaking dormancy is shown in Table 5. The seeds scarified and treated with KNO_3 @ 0.5 per cent registered shortest MGT of 4.78, 4.63 days in Sponge gourd and 3.16, 3.09 days in Snake gourd of different lots, respectively. This was the fastest and had the highest seed germination of up to 80 per cent (Table 1) and it was followed by seeds scarified and treated with GA_3 @ 100 ppm. However, the non-scarified seeds showed longer MGT of 8.52, 8.27 days

TABLE 5

Effect of different dormancy breaking methods on mean germination time without removing the seed coat in sponge gourd and snake gourds

Treatments	Seedling vigour index-I					
	Sponge gourd			Snake gourd		
	L_1	L_2	Mean	L_1	L_2	Mean
T0	7.49	7.39	7.44	4.93	4.81	4.87
T1	5.28	5.42	5.35	4.17	4.26	4.21
T2	5.16	5.29	5.22	3.49	3.24	3.36
T3	4.78	4.63	4.70	3.16	3.09	3.12
T4	5.63	5.72	5.67	4.86	4.75	4.80
T5	6.09	6.41	6.25	5.78	5.46	5.62
T6	7.48	7.56	7.52	5.13	5.03	5.08
T7	7.96	7.64	7.80	4.42	4.56	4.49
T8	8.52	8.27	8.39	4.98	5.21	5.09
Mean	6.49	6.48	6.48	4.55	4.49	4.52
	SEm±	CD (0.05P)		SEm±	CD (0.05P)	
Lots (L)	0.014	0.041		0.015	0.042	
Treatments (T)	0.029	0.081		0.029	0.083	
L x T	0.040	0.115		0.041	0.117	
CV (%)		1.29				1.86

T0 : Control
T1 : Scarification (Mechanical)
T2 : Scarification + GA3 @100ppm for 18 h
T3 : Scarification + KNO3@ 0.5% for 18 h
T4 : Scarification + Water soaking for 18 h
T5 : Scarification + Dry heat @ 700C for 3 h
T6 : GA3 @ 100 ppm for 18 h without scarification
T7 : KNO3@ 0.5% for 18 hrs without scarification
T8 : Water soaking for 18 hrs without scarification

in Sponge gourd and 4.98, 5.21 days in Snake gourd as against scarified seeds in both seed lots.

Radicle emergence was tested by placing the seeds in petri plates lined with three layers of moist filter paper after removing the seed coats. It was observed that MGT was shortened by two days when the seed coats were removed (Table 6). The scarified seeds treated with KNO_3@0.5 per cent recorded the shortest MGT of 2.17, 2.26 days in Sponge gourd and 1.26, 1.37 days in Snake gourd in both seed lots, respectively followed by seed scarified and treated with GA_3@100ppm and water soaking. Similarly, Pinmanee *et al.* (2001) reported that cutting the bottom of the bitter gourd seed, but not removing the seed coat completely, increased germination from 40.5 to 70 per cent, while germination was increased to 90 per cent by removing the entire seed coat. The germination of watermelon seed has also been increased by removing the seed coat (Nerson, 2002).

Understanding germination requirements of gourd species is one of the most important steps in the survival of these species besides improving germination and seedling vigour in terms of speed of radical emergence and subsequent growth of seedlings. These species generally encounter germination problem due to hard seed coat and accumulation of inhibitors.

TABLE 6

Effect of different dormancy breaking methods on mean germination time after removing the seed coat in sponge gourd and snake gourds

Treatments	Seedling vigour index-I					
	Sponge gourd			Snake gourd		
	L_1	L_2	Mean	L_1	L_2	Mean
T0	5.67	5.43	5.55	3.16	3.28	3.22
T1	3.85	3.76	3.80	3.24	3.49	3.36
T2	2.56	2.73	2.64	1.75	1.85	1.80
T3	2.17	2.26	2.21	1.26	1.37	1.31
T4	3.46	3.59	3.52	2.34	2.42	2.38
T5	4.18	4.09	4.13	3.46	3.54	3.50
T6	5.34	5.27	5.30	3.69	3.72	3.70
T7	5.93	5.69	5.81	2.34	2.38	2.36
T8	6.47	6.38	6.42	2.73	2.76	2.74
Mean	4.40	4.36	4.38	2.66	2.76	2.71
	SEm±	CD (0.05P)		SEm±	CD (0.05P)	
Lots (L)	0.014	0.040		0.014	0.041	
Treatments (T)	0.028	0.080		0.029	0.082	
L x T	0.040	0.113		0.041	0.116	
CV (%)		1.93				3.02

T0 : Control
T1 : Scarification (Mechanical)
T2 : Scarification + GA3 @100ppm for 18 h
T3 : Scarification + KNO3@ 0.5% for 18 h
T4 : Scarification + Water soaking for 18 h
T5 : Scarification + Dry heat @ 700C for 3 h
T6 : GA3 @ 100 ppm for 18 h without scarification
T7 : KNO3@ 0.5% for 18 hrs without scarification
T8 : Water soaking for 18 hrs without scarification

Findings of our study revealed that seed dormancy of sponge and snake gourd, is caused by hard seed coat that is water impermeability which results in blocking of germination process. A high level of germination was observed by scarification of seed coat and making it permeable to water and oxygen through various methods adopted. It was found that breaking dormancy by manual scarification with growth regulators treatments like KNO_3(0.5 %) and GA_3 (100ppm) had increased the germination to the extent of 15 to 20 per cent when compared to control in both sponge and snake gourd seeds. Minimum Seed Certification Standards for germination of both the gourds is 60 per cent and through scarification and chemical treatments it can be enhanced up to 80 per cent germination. Further, it is always better to remove ill-filled, immature and deteriorated seeds by floating techniques. Therefore, it is suggested that cucurbit seed growers can adopt these techniques before sowing in order to obtain better plant establishment in the field and achieve adequate and uniform plant population to get higher seed yield.

REFERENCES

ANOOP BADONI, NAVEEN CHANDRA AND VINAY CHAMOLI, 2018, Identification of dormancy in the seeds of sponge gourd. *Int. J. Pure App. Biosci*., **6** (2) : 295 - 297.

BADONI ANOOP, MAYANK NAUTIYAL, KIRAN GUSAIN, MANPREET KAUR, RAKHI DHIMAN, CHETNA BISHT AND CHAUHAN, J. S., 2009, Effect of water uptake on germinability in seeds of some medicinal plants, Uttarakhand, India, *The Journal of American Science,* **5** (4) : 123 - 128.

BASKIN, J. M., BASKIN, C. C., 2004, A classification system for seed dormancy. *Seed Sci. Res*., **14** : 1 - 16.

BRADBEER, J. W., 1988, Seed dormancy and germination. Springer Verlag, Bonn, Germany.

DOIJODE, S. D., 2001, Seed storage of horticultural crops. Food Products Press, New York, USA.

ELLIS, R. H. AND ROBERTS, E. H., 1981, The quantification of ageing and survival in orthodox seeds. *Seed Sci. Technol*., **9** : 373 - 409.

GOWTHAMY, U. AND SELVARAJU, P., 2016, Physiological changes of bioprimed snake gourd seeds during germination. *Int. J. Agri*., **6** (5) : 381 - 388.

KHAN, A. A., 1980, The physiology and biochemistry of seed dormancy and germination, second ed. Elsevier, Dordrecht, Netherlands.

LOYMA, D., PHOTCHANACHAI, S., RITTHICHAI, P., RATANAKHANOKCHAI, K., 2009, Effect of scarification on germination improvement of Benincasahispida (Thunb.) cogn.seeds. *Agric. Sci. J.,* **40** : 333 - 336.

NERSON, H., 2002, Effect of seed maturity, extraction practices and storage duration on germinatibility in watermelon. *Sci. Hort*., **93** : 245 - 256.

OBOH, I. O., ALUYOR, E. Q., 2009, Luffacy lindricaean emerging cash crop. *Afr. J. Agric. Res.,* **4** : 684 - 688.

PINMANEE, S., VEARASILP, S., SURIYONG, S., THANAPORNPOONPONG, S., KRITTIGAMAS, N., PAWALZIK, E., 2001, Optimization the germination requirements for Momordicacharantia Linn. In: Conference on International Agricultural Research for Development. 9-11 October, Deutscher Tropentag, Bonn, Germany.

SIEMONSMA, J. S. AND PILUEK, K. (1993), Plant resources of south-east Asia, no. 8. Vegetables. Pudoc, Wageningen, pp. 121 - 13.

SIEMONSMA, J. S. AND PILUEK, K., 1993, Plant resources of south-east Asia, *Vegetables. Prodoc,* Wageningen, **8** : 121 - 13.

SINGH, D., DATHAN, A. S. R., 1998, Morphology and embryology. In: Nayar, N. M., More, T. A. (Eds.), Cucurbits. Science Publishers, Inc., India, pp. 67 - 95.

THANANTHIKA AND RANGANATHAN KAPILAN, 2015, Effect of temperature and salinity on the seed germination and seedling emergence of snake gourd. *Int. J. Adv. Res.Boil. Sci*., **2** (12) : 130 - 136.

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