Kamaladevi, P. 1964. Response of acreage to change in price – A study of Madras State. Econ. *weekly* (Bombay), **16**: 1536-36.

Koranne, K.D. 1996. Research and development gains urgency. The Hindu Survey of Indian Agriculture 1996, M/s Kasturi & Sons Ltd., Chennai.

Lande, M.G. 1996. Constraints in increasing cotton productivity in India, 1996. AER Vol.8, No.6, Directorate of Extn., Ministry of Agriculture, New Delhi.

Ramachandran, K., Joshi, L.S. and Menon, C.B. 1980. Erosion in profitability from cotton farming. *Cotton Development* (Bombay), **9**: 27

Sankaran, M.R. 1971. Study on market structure and supply response to prices of chewing tobacco in selected taluks of Coimbatore District. Unpub. M.Sc.(Ag.) Thesis, Divn. of Agrl. Economics, TNAU, Coimbatore

Senthil, D. 1983. A critical analysis of hybrid cotton seed growers. Unpub. M.Sc.(Ag.) Thesis, TNAU, Coimbatore

Singh, Sikka Arjan, Avtar Singh, S.M., Gadkani, P.D., Balasubramanyan, R., Iyengar, N.K., Paranjpe, V.N. and Panigrahi, N.S. 1961. Cotton in India, A Monograph. Vol.IV, Indian Central Cotton Committee Examiners Press, Bombay, pp.185

Sriram,N. 1997, Eco-friendly agricultural practices in cotton cultivation – Farmers awareness, attitude and adoption, Unpub. M.Sc. (Ag.) Thesis, TNAU, Coimbatore.

(Received : October 2001; Revised: November 2001)

Madras Agric. J. 88 (10-12) : 607-611 October-December 2001
https://doi.org/10.29321/MAJ.10.A00383

Influence of moisture levels and storage temperature on storability of neem stones

P. SELVAKUMAR, K. SUNDARALINGAM, K. MALARKODI AND P. SRIMATHI
Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003.

Abstract: Studies were carried out with neem stones to trace the influence of stone moisture and storage temperature on its storability each at three different levels. The six months study expressed that neem stones with 15-20% moisture content could be stored at ambient temperature for 3 months, at 5°C for 4 months and at 10°C for 6 months. *(Key words: Moisture level, Storage temperature, Neem Stones).*

Roberts (1973) introduced the term recalcitrant in seed storage. Later on Ellis *et al.* (1990) introduced the terminology intermediate in storage of seeds that falls inbetween orthodax and recalcitrant storage behaviour of seeds. Bellefontaine and Audinet (1992) noted a characteristic difference between neem seeds from India, Pakistan and Tailand on one side and those from Africa and latin America on the other side. Seeds of African and Central American varieties could be lowered to 5.7% moisture content and can be stored well for many years, while the seeds of provenances like India and Pakistan could not be so. Hong and Ellis (1998) reported that *Azadiracta indica* expresses intermediate storage behaviour, while Sacande *et al.* (1998) reported that neem seeds with initial moisture content of around 10 per cent can be stored at 10-15°C for upto 2 years. Hence studies were conducted to elucidate the influence of moisture level and temperature on storage life of neem stones collected from Coimbatore location of Tamil Nadu, India.

Materials and Methods

Fruits collected from fifty years old neem trees located at Tamil Nadu Agricultural University, Coimbatore (11°N 77°E 426.72 MSL) formed the base material for the study. Physiologically matured yellow fruits were collected and depulped with water. Stones were extracted carefully by hand without damaging the kernel and were shade dried to bring the moisture content to different levels *viz.* 20% (M_1), 15% (M_2) and 10% (M_3). The stones were treated with thiram @ 4g kg^{-1} of stone and packed in 300 gauge polythene bag and kept at different temperature conditions *viz.*, T0 (room temperature), T_1 (10°C)

Table 1. Effect of initial moisture content and temperature on moisture content (%) of neem stone under storage

Treatments	Period of storage							M-Mean	Temperature		
	P_0	P_1	P_2	P_3	P_4	P_5	P_6		Room	10°C	5°C
20% moisture content (M_1)	20.0	16.7	15.5	14.3	13.2	12.3	11.5	14.7	10.7	16.4	17.1
15% moisture content (M_2)	15.0	13.0	12.4	11.7	11.0	10.5	10.0	11.9	9.6	12.9	13.1
10% moisture content (M_3)	10.0	9.7	9.5	9.2	9.0	8.7	8.4	9.2	8.8	9.3	9.4
Room temperature (T_0)	15.0	10.4	9.4	9.0	8.7	8.4	8.3	T-Mean	9.7	12.9	13.2
10°C temperature (T_1)	15.0	14.5	13.8	12.8	12.0	11.4	10.6				
5°C temperature (T_2)	15.0	14.6	14.1	13.4	12.6	11.7	11.0				
P - Mean	15.0	13.1	12.4	11.7	11.1	10.5	10.0				
				P	M	T	P x M	P x T	M x T		
CD (P=0.05)				0.1	0.1	0.1	0.2	0.2	0.1		

Table 2. Effect of initial moisture content and temperature on germination (%) of neem stone under storage

Treatments	Period of storage (months)							M-Mean	Temperature		
	P_0	P_1	P_2	P_3	P_4	P_5	P_6		Room	10°C	5°C
20% moisture	88	76	64	52	46	37	28	59	54	64	59
content (M_1)	(69.73)	(60.66)	(53.13)	(46.14)	(42.70)	(37.46)	(31.94)	(50.01)	(47.88)	(52.91)	(50.50)
15% moisture	84	73	64	51	44	34	26	54	43	62	57
content (M_2)	(66.42)	(58.69)	(53.13)	(45.57)	(41.55)	(35.66)	(30.65)	(47.29)	(41.00)	(52.98)	(49.05)
10% moisture	80	72	61	50	42	32	20	48	38	55	52
content (M_3)	(63.43)	(58.05)	(51.35)	(45.0)	(40.39)	(34.44)	(26.56)	(43.85)	(37.28)	(47.97)	(46.12)
Room	84	74	54	39	33	22	2	T-Mean	45	60	56
temperature (T_0)	(66.42)	(59.24)	(47.37)	(38.62)	(34.60)	(27.93)	(20.20)		(42.05)	(51.29)	(48.56)
10°C temperature (T_1)	84	77	68	60	52	44	36				
	(66.42)	(61.42)	(56.05)	(50.82)	(45.98)	(41.50)	(36.78)				
5°C temperature (T_2)	84	74	66	56	46	37	26				
	(66.42)	(59.24)	(54.21)	(48.26)	(42.71)	(37.61)	(30.56)				
P - Mean	84	75	63	52	44	35	25				
	(66.42)	(60.03)	(52.54)	(45.90)	(41.09)	(35.68)	(29.18)				
				P	M	T	PxM	PxT	MxT		
CD (P=0.05)				1.5	0.7	0.7	2.5	2.5	1.2		

(Figures in parentheses indicate arc sine transformation)

and T_2 (5°C). The low temperatures (10° and 5°C) maintained in the refrigerator were utilised for the study. The kernel samples were drawn at monthly (P_1-P_6) intervals upto 6 months and evaluated for seed quality characters *viz.* moisture content and germination percentage (ISTA, 1999). The vigour index values were computed as per Abdul-Baki and Anderson (1973) and expressed as whole number. The data gathered were statistically scrutinized as per Panse and Sukhatme (1967) for understanding the level of significance.

Results and Discussion

Highly significant results were obtained due to the initial kernel moisture content, temperature and periods of storage for all the seed and seedling quality characters. The stones stored at different moisture content (20%, 15% and

10%) showed a rhythmic reduction recording a moisture content of 11.5, 10.0 and 8.4 per cent after 6 months of storage. The moisture contents maintained by the ambient, 10°C and 5°C were 8.3, 10.6 and 11.0 per cent respectively after 6 months indicating the maintenance of seed moisture between 11-10% at low temperature of 10°C and 5°C. The germinability of seed at various moisture content decreased with increase in storage period and the reduction was less at low temperatures of 10°C and 5°C, storing at 10°C preserved 6% more germination compared to 5°C. Seeds stored at 20 per cent (64%) perform poorer than 15 per cent (62%). Storing seeds at 10% moisture content reduced the germinability rapidly at ambient and slowly at 10° and 5°C storage atmospheres. The vigour index values expressed through computation of seedling length and germination and were also in the same line highlighting the possibility of storing neem stone of 20-15% moisture content at 10°C with a germinability of 62-64% over a period of 6 months.

Tompsett (1984) revealed that there are some species like coffee and citrus which were superficially appear to be recalcitrant but have the mechanism to dry down to low moisture content. In neem due to the high moisture content (37.2%) of fresh seeds, (Maithani *et al.* 1989) and the manifestation of chilling injury by these seeds (Ezumah, 1986; Maithani *et al.* 1989; Gunasena and Marambe, 1995; Msanga, 1996) it is indicated as recalcitrant. On the basis of low moisture content of seeds (12.5%) obtained from Haiti plantation, Chaney and Knudson (1988) argued that neem was not a recalcitrant. Roederer and Bellefontaine (1989) and Dickie and Smith (1992) also indicated that neem seed displays orthodox behaviour.

Roberts and King (1980) suggested that seed storage behaviour may be associated with ecology. Willan (1985) expressed that since neem occurs in dry tropical forests, while most of the recalcitrant tropical species are found in moist tropical forests it was suggested that neem may have short lived orthodox behaviour. Research reports of seed storage behaviour expressed that it varies with seed source (Poulsen, 1996). The investigation with lots of Burkima Faso (Gamena *et al.* 1996; Sacande *et al.* 1996), Tanzania (Msanga, 1995) and Italy (Hong and Ellis, 1998) exhibited intermediate storage behaviour. In the present study, stones with initial moisture content of 20% recorded significantly higher germination and vigour index values than stones stored at 15% and 10% moisture content. Similar results were obtained by Singh *et al.* (1997) in neem and Edwards (1982) in *Abies* seed.

Results of the storage temperature revealed that stones stored at 10°C registered the highest mean germination and vigour index values than at ambient temperature and 5°C. The lower storability of seeds at ambient conditions might be due to the rapid dessication during storage (Maithani *et al.*, 1989). While the lower performance at 5°C might be due to chilling sensitivity of seeds to confirmational transition in cell membranes from the liquid crystalline to gel phase (Wang, 1982). The transition temperature (Tm) of membranes for chilling sensitive tropical

Table 3. Effect of initial moisture content and temperature on vigour index of the neem stone under storage

Treatments	Period of storage							M-Mean	Temperature		
	P_0	P_1	P_2	P_3	P_4	P_5	P_6		Room	10°C	5°C
20% moisture content (M1)	2446	2241	1840	1470	1281	1003	740	1573	1469	1716	1535
15% moisture content (M2)	2404	1965	1488	1148	894	669	491	1281	1131	1419	129
10% moisture content (M3)	2200	1734	1244	957	689	488	290	1061	928	1178	1079
Room temperature (T0)	2323	2003	1418	983	772	498	262	T-Mean	1176	1438	1303
10°C temperature (T1)	2323	2027	1622	1361	1148	916	738				
5°C temperature (T2)	2323	1910	1532	1231	945	746	521				
P - Mean	2323	1980	1524	1191	955	720	507				

	P	M	T	P x M	P x T	M x T
CD (P=0.05)	25	12	12	44	44	21

plants has been estimated at approximately 10°C (Crowe *et al.*, 1989) which means that membranes are in liquid crystalline phase under ambient conditions. For neem seeds, storage temperature below 10°C was considerably less successful than above 10°C, and 15°C being found optimal. This suggested that the temperature for the phase change of cell membrane (Tm) is around 10°C for neem seeds. Sacande *et al.* (1998) reported that neem seeds with initial moisture content of around 10% could be stored at 10-15°C for upto 2 years. The present study also concluded that neem stones with 10-15% moisture content could be stored at 10°C upto six months with a germinability of 36%.

References

Abdul-Baki, A.A. and J.D.Anderson (1973). Vigour determination in soybean seed by multiple criteria. *Crop. Sci.*, **13**: 630-632.

Bellafontaine, R. and M.Audinet (1992). La Conservation de graines de neem (*Azadirachta indica* A. Juss). Symposium IUFRA sur les problems des semances foretieres onagadongou, 23-27 Nov., CIRAD-Foret, France.

Crowe, J.H., F.A.Hoelastra, L.M.Crowe, T.J.Anchorodoguy and E.Drobins (1989). Lipid phase transitions measured in infact cells with fourier transform infrared spectroscopy. *Cryobiol.*, **26**: 76-84.

Chaney, W.R. and D.M.Knudson (1988). Germination of seeds of *Azadirachta indica* enhanced by endocarp removal. *The International Tree Crop Journal*, **5**: 153-161.

Dickie, J.B. and R.D. Smith. (1992). Limits to the survival of essentially orthodox seeds of low moisture content in some woody species *Suatrieme rencontre international surles semences Angero*, 20-24, Juillet.

Ellis, R.H., T.D. Hong and E.H.Roberts (1990). An intermediate category of seeds storage behaviour. *J. Exp. Biol.*, **41**: 1167-1174.

Edwards, B.G.W. (1982). Storage of pre-chilled Abies seeds, In: Proc. IRFRO Int. Sym. For. Tree seed storage, Retawa National Forestry Institute, Chalk River, Canada, 1980, pp.162-133.

Ezumah, B.S. (1986). Germination and storage of neem (*Azadirachta indica* A.Juss) seed. *Seed Sci. & Technol.*, **14**: 593-600.

Gamena, C.S., H.L.Krack, J.G.Van Pijlen and C.H.Devos (1996). storage behaviour of neem (*Azadirachta indica*) seeds from Burkina Faso. *Seed Sci. & Technol.*, **24**: 441-448.

Gunasena, H.P.M. and B.Marambe (1995). Storage technology for neem seeds. Sri Lanka experience. Multipurpose Tree Species Network - Sri Lanka, **4**: 6-7.

Heydecker, W. (1972). Vigour. In: Viability of seed (Ed.) E.H.Roberts. Chapman and Hall, London, pp.209-252.

Hong, T.D. and R.H.Ellis (1998). Contrasting seed storage behaviour among different species of meliaceae. *Seed Sci. & Technol.*, **26**: 77-95.

ISTA. 1999. International rules for seed testing. *Seed Sci. & Technol.*, **27**: 30-36.

Maithani, G.P., V.K.Bahuguna, M.M.S.Rawat and O.P.Sood (1989). Fruit maturity and interrelated effects of temperature and container on longevity of neem (*Azadirachta indica*) seeds. *Indian Forester*, **115**: 89-97.

Msanga, H.P. (1995). Contributions from the seed research and development section. Technical report. National Tree Seed project, Tanzania.

Msanga, H.P. (1996). Effect of fruit ripeness stages and seed moisture content on storability and germination of neem (*Azadirachta indica*) seed. In Olesen, K. (ed), Proceedings of the IUFRO Symposium group, p.204-00, Seed problems. Arusha, Tanzania, Danida Forest Seed Centre (DFSC). pp.201-209.

Panse, V.G. And P.V.Sukhatme (1967). In: Statistical method for Agricultural workers. ICAR Pub., New Delhi.

Presley, J.T. (1958). Relations to protoplast permeability of cotton seed viability and predisposition of seedling disease. *Pl. Dis. Rept.*, **42**: 582.

Poulsen, K. (1996). case study: Neem (*Azadirachta indica*) seed research. In Onedraogo, A.S., Poulsen, K. Stub and Guard (Ed), Improved methods for the handling and storage of intermediate recalcitrant tropical forest tree seeds. Rome, Italy International plant genetic resources institute, pp.14-22.

Roberts, E.H. (1973). Predicting the storage life of seeds. *Seed Sci. & Technol.*, **1**: 499-514.

Roberts, E.H. and M.W.King. 1980. The characteristics of recalcitrant seeds. In: Recalcitrant crop seeds. (eds. H.F.Chin and E.H.Roberts). Tropical Press, Kualalumpur, Malaysia, pp.1-5.

Roederer, Y. and R.Bellefontaine (1989). Can neem seeds be expected to keep their germinative capacity for several years after collection? *For. Genetic Res. Inf.*, **17**: 30-33.

Sacande, M., J.C.Vanpijlan, C.H.R.Devos, F.A.O.Hoekstra, R.J.Bino and S.P.C.Groof (1996). Intermediate storage behaviour of neem (*Azadirachta indica* A.Juss) seeds from Burkina Faso. In: Improved methods for the handling and storage of intermediates/ recalcitrant tropical forest tree seeds. A.S.Poulsen and K.Stubggaard (Eds.). Rome-Italy. International Plant Genetic Resources Institute, pp.101-104.

Sacande, M., F.A.Hoekstra, J.G.Vanpijlen and S.P.C.Groof (1998). A multifactorial study of conditions influencing longevity of neem (*Azadirachta indica*) seeds. Seed Sci. Res., **8**: 473-482.

Singh, B.G., N.P.Mahadevan, K.Shanthi, L.Marimuthu and S.Geetha (1997). Effect of moisture content on the viability and storability of *Azadirachta indica*. A. Juss (neem) seeds. *Indian Forester*, **123**: 631-636.

Tompsett, P.B. (1984). Desiccation studies in relation to the storage of Araucaria seed. *Ann. Appl. Biol.* **105**: 581-586.

Wang, L.Y. (1982). Physiological and biochemical responses of plants to chilling stress. *Hort. Sci.*, **17**: 173-186.

Willan, R.L. (1985). *A guide to forest seed handling*. Book compiled for DANIDA forest seed centre. D.K.3050. Humieback, Denmark (FAO, Technical paper, Rome, 1985).

(Received : December 2000; Revised : October 2001)

Madras Agric. J. 88 (10-12) : 611-614 October-December 2001

Moist storage for neem stones

P. SELVAKUMAR, P. SRIMATHI, K. MALARKODI AND K. SUNDARALINGAM
Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003

Abstract: Studies were carried out with neem stones to trace the influence of moist storage on storability of stones at ambient conditions. The study expressed that sand medium moistened to 10% level with 10 per cent Jalshakthi maintained the higher germination (46%) and vigour index value (992) upto six months. The seed also recorded the lowest EC value (0.607) at the same period of evaluation. *(Key words: Moist storage, Neem stones, Seed quality).*

In recalcitrant and intermediate category (Roberts, 1973; Ellis *et al.*, 1991) of seeds maintenance of moisture at higher level is difficult at ambient conditions due to the attainment of equilibrium moisture content by the seeds with the atmosphere (Agarwal, 1995). Moist medium are being recommended by several researchers to maintain the moisture content of these seeds in storage (Anwar and Hutomo, 1982; Reddy, 1987; Tang and Fu, 1993; Bhattacharya *et al.* 1994 and Mercykutty *et al.* 1996). Neem stones exhibit the intermediate storage behaviour where the moisture content above 10-15% was found to be beneficial for long term storage. Hence studies were made to trace the influence of moist storage on the storability of neem stones collected from Coimbatore location of Tamil Nadu, India.

Materials and Methods

Fruits of fifty years old neem trees located at Tamil Nadu Agricultural University, Coimbatore (11°N 77°E 426.72 MSL) served as the base material. The procedure described by Bhattacharya and Basu (1992) was followed for evaluation of moist storage technique for storage of Neem stones. For moist sand incubation treatment, medium sized, building quality sand was used. The sand was thoroughly washed in running water, dried in the sun and again dried overnight in the oven at 100°C followed by cooling at room temperature before use.