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أفرءيتم النار التى تورون (٧١) ء أنتم أنشأتم شجرتها أم نحن المنشئون (٧٢) نحن جعلناها تذكرة و متاعا للمقوين (٧٣) .

صدق الله العظيم ،،

(الواقعه)

STUDIES ON SEED CONSERVATION AND PROPAGATION OF THE NEEM TREE (*AZDIRACHTA INDICA A JUSS*) IN SUDAN

BY

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B.Sc. (HONORS) FORESTRY
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A THESIS

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SEP. 1996

DECLARATION

I hereby declare that the work reported herein is a result of my own investigations, has not been accepted in substance for any degree and is not concurrently being submitted in candidature for any degree . The work and conclusions of other persons have been acknowledged .

Candidate

Intisar Elnour

INTISAR ELNOUR ELTERAIFY

SEP.1996

DEDICATION

This part of my soul is dedicated :

To my father, ***Elnour Elteraify*** *with deep love,*

To the memory of my beloved mother, ***Sittina osman,***

To the memory of my first teacher who taught me a

ot and gave me, my family and Sudan every thing even

his life, my brother ***Ezzeldin Elnour.***

To all ***neem believers*** *in the world.*

ACKNOWLEDGEMENT

Praise and thanks to almighty Alla, God of the world who accomplished this work and brought it in its final form.

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ABSTRACT

Neem tree (*Azadirachta indica A. Juss*) is a multipurpose tree widely planted in Sudan. Recently the tree has been singled as a high priority species for natural pesticide this gives it an economic importance. Fresh seeds germinate readily if sown directly after collection but they lose their viability very quickly (4-12 weeks).

This study was conducted at the National Tree Seed Centre, Soba-Sudan (June-December 1995) and University of Gezira farm (Dec.94 -Jan.1996). The main objectives of the research work were:

(i) To investigate the effect of storage temperature, ripening stage and fruit pulp (mesocarpe) on viability of neem seeds.

(ii) To evaluate the success of establishment by planting nursery stock and direct sowing of neem seeds.

For storage trials both whole fruits and clean seeds at different maturity stages (green, yellow and brown) were used. Storage temperatures tested were 4,12°C and room temperature (30°C) for 24 weeks. Trials on vegetative propagation of neem using hardwood stem cutting treated with NAA and IBA at different concentrations (12000, 8000 and 4000 ppm) and control were also conducted.

The results show that, fresh clean seeds have higher viability 84.0%, 73.33% and 14.67% compared to whole fruits 37.33%, 17.33% and 2.67% at different maturity stages green, yellow and brown, respectively.

Yellow neem seeds shows the highest viability 52.0% after 20 weeks storage at room temperature (30°C). At storage temperatures (4 and 12 °C) low viability was obtained from both yellow and green seeds. Brown seeds and whole fruits of all ripening stages are not recommended for storage.

Direct sowing gives no significant difference from transplanting. This method is recommended one because it is relatively less expensive. Hardwood stem cuttings of neem did not root under the conditions of the experiment.

بسم الله الرحمن الرحيم

خلاصة الاطروحه

دراسه عن طرق حفظ بذور النيم
و طرق تكاثر شجرة النيم فى السودان

شجرة النيم من الاشجار متعددة الاغراض واسعة الانتشار على نطاق السودان . وقد اختيرت حديثا كاحد اهم الانواع لاستخلاص مبيدات طبيعيه لمكافحة الافات مما جعل لها اهميه اقتصاديه عالميه .

أجريت هذه الدراسه فى المركز القومى لبذور الاشجار بسوبا (يونيو ١٩٩٥ - ديسمبر ١٩٩٥) و مزرعة جامعة الجزيره (ديسمبر ١٩٩٤-يناير ١٩٩٦) .

هدفت الدراسه اساسا الى :

- معرفة اثر درجة حرارة المخزن ، مرحلة النضج ، قشرة و غلاف الثمره على قدرة الانبات فى بذور النيم .

- مقارنة استخدام البادرات المنتجه من الزراعه المباشره فى الحقل مع البادرات المنتجه بالمشتل بعد الزراعه فى الحقل .

درجات حرارة المخزن التى استخدمت درجه حرارة الغرفه (٣٠°م) ، ١٢°م و ٤°م . اما مراحل النضج فهى خضراء ، صفراء و بنيه اللون وقد خزنت لفتره ٢٤ اسبوع.

الدراسه شملت ايضا التكاثر الخضرى بعقل الساق اذ عوملت بهرمون اندول حامض البيوتريك (IBA) و نافثلين حامض النافثليك (NAA) فى درجات تركيز مختلفه (١٢٠٠٠ ، ٨٠٠٠ ، ٤٠٠٠ ppm) واخرى غير معامله .

أوضحت النتائج ان بذور النيم حديثة الجمع لها مقدره انبات عاليه ٨٤٪ ، ٣٣ر٧٣٪ و ٦٧ر١٤٪ بالمقارنه مع استخدام الثمار كامله ٣٣ر٣٧٪ ، ٣٣ر١٧٪ و ٦٧ر٢٪ من فترات النضج خضراء ، صفراء ، بنيه حسب الترتيب .

بذور النيم الناتجه من الثمار الصفراء لها اعلى قدره على الانبات (٥٢٪) من الخضراء بعد تخزين دام ٢٠ اسبوعا فى درجات حراره الغرفه (٣٠°م) .

التخزين فى درجات ٤°م و ١٢°م اعطى قدرة انبات ضعيفه من البذور الخضراء و الصفراء بعد ٢٠ اسبوع . البذور المجموعه من الثمار البنيه والثمار من كل فترات النضج غير موصى بها للتخزين .

لا يوجد فرق معنوى بين الزراعه مباشرة فى الحقل واستخدام الشتول المنتجه فى المشتل ، غير ان الزراعه المباشره فى الحقل هى الموصى بها لقلة التكلفة بالمقارنه مع الشتول المنقوله من المشتل . عقل الساق لم يعط جذور تحت ظروف التجربه .

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INTRODUCTION

Neem (Azadirachta indica A. juss) is a favourite forestry species in Sudan. It is originally introduced from India and is now extensively grown throughout the Sudan, as an avenue and shade tree in public parks and residential areas. It is also used in shelter belts in dry areas.

The species has received a considerable international interest and has been singled as high priority species from the 4th session of FAO panel of experts on forest gene resources Australia, 1977; ESCAP/FAO/UNEP expert group meeting on fuel wood and charcoal Thailand, 1981; IUFRO workshops Serilanka, 1984; Kenya, 1986 and Peru, 1987. This is beside the three International Neem Conferences of 1981, 1983 and 1987 organized by Schumtterer et al.; World Neem Conference India (1993) and finally the world neem conference 1996 in Australia. All these scientific meetings and conferences resulted in an international neem network under the supervision of UN/FAO with collaboration of CIRAD-Foret (France); DANIDA Forest Seed Centre (Denmark); IPGRI and Indian Council of Forestry Research and Education. Sudan is a member in this network.

This promising tree with this international interest was well known in the area of its natural habitat in India and neighboring countries for more than 2000 years. It is common in open scrub forest of dry zone of Burma. It is cultivated all over India and Burma and has evidently become wild in many localities as an escape from cultivation (Troup, 1921).
Azadirachta indica is a member of the family Meliaceae (Mohogany family). It has three synonyms ; Melia azadirachta (L.), Melia indica (A. juss) BRANDIS, Antelaea azadirachta (L.) Adelb.

There is frequent confusion of A. indica with China berry (Melia azadirach) as they are closely related taxonomically and phytochemically (Schmutterer, 1995).

Neem is a fast growing tree that usually attains a height of 15-20 m. It is an ever green tree, but it may shed most or all of its leaves under extreme dry periods. Fruit is a globose drupe 1 cm across surrounded by fleshy yellow orange pulp turning brown, wrinkled when ripe. Flowers Mar. - Sep. ; fruits April - Oct. (Hamza, 1990). The exact origin of the tree in India is unknown but it was believed to be a native of Upper Burma and India (Troup,1921),(Jacobs, 1961; Braidis, 1921 cited by Bogra 1993).

Neem tree is a light demander and it has a great capacity for pushing through thorny scrub. It is weed and frost sensitive, especially in the seedling stage. It coppices well and produces root suckers especially in dry localities (Dogar, 1993). The tree is drought resistant, it thrives in dry areas with sub-arid to sub-humid conditions. The annual rainfall between 400-1200 mm. It grows in different types of soils, but it seems to develop best on well drained, deep sandy soils. It does well in black cotton soils as in Sudan and India (Troup, 1921). Its best performance was reported on well drained soils with fairly high water level in subsoil (Schmutterer, 1995). A soil pH values between 6.2 and 7.0 seem to be the best for the neem tree. But it can tolerate pH from 5 to 9 and even 10 under certain circumstances.

Neem can exist at annual mean temperatures between 21°C and 32°C. It can tolerate high to very high temperatures; but it can't tolerate low temperatures which may result in shedding of leaves or even death of young trees (Rundhawa and Parmar, 1993). The tree is usually found in plains but it thrives altitudes up to 700-800 m and occasionally 1000 m above

sea level.

Nowadays, neem is widely distributed by introductions mainly in the drier arid, Maramorosch (1996) tropical and subtropical zones of Asia, Randhawa and Parmar (1993) Africa, Schumtterer (1995) Americas, Jacobson (1981) and Pliski (1983), Australia Rice (1993), Philippines and south pacific Islands except the mountainous areas of altitudes more than 1000 m above sea level.

About 50,000 neem tress were planted in Saudi Arabia to provide shade for pilgrims. In Quatar and Yemen the tree was planted under irrigation as avenue tree. The tree is common in north eastern Africa, the limit of distribution is generally latitude 17° North. It is spreading rapidly in Americas, where there are intensive planting programmes. It is predicted that, this fascinating tree will continue to spread, by the end of this century to all tropical and subtropical countries (National Research Council, 1992). This is because of the commercial use of neem based insecticides, Azadirachtin, the main active ingredient in the seed extracts (Ermel,1986,1996). It is the abundant source of environmentally safe 'soft' insecticides for pest management in staple food crops (Saxena, 1996). Other valuable products of the tree is neem oil which can be used for lamps as well as for mosquito net impregnation. Fire wood and excellent charcoal are additional benefits derived from neem tree (Maramoroch, 1996).

The tree was introduced to the Sudan by the officials working for the colonial administration in 1916 at Shambat Station (latitude 15° 40' N and longitude 32° 32' E) and then it is widely spread all over the country. The main problem facing forest tree seeds programs in Sudan is the lack of proper storage facilities. The neem seed which is classified

as difficult or intermediate between orthodox and recalcitrant (Wang et al. 1993) has difficulties in seed handling, processing and storage. Viability is very short, lasting between 3 to 12 weeks depending on the climatic conditions (Troup,1921) and storage conditions (Ezumah,1986) and (Msanga, 1996).

The usual practice in Sudan is that; huge quantities of over mature fruits are collected and sown, from which very small number of seedlings are obtained. Enormous losses of seedlings are due to the low germination capacity. Neem trees provide abundant fruits; thus little or no work has been done in Sudan on germination and storage of neem seeds. Which is a main problem facing afforestation programs with this species. No or very few data is available on viability of neem seeds. However, reports showed a low viability when seeds with a high germination percentage were stored for several weeks (Badi,et al, 1989).

According to the available literature there were two theories regarding storage of neem seeds to conserve relatively high viability :

Theory 1. Dry storage using neem seeds with very low moisture content (5%) in airtight containers at cold store (4-5 °C) Bellefontaine and Audinet (1993).

Theory 2. Humidification of the store to conserve high relative humidity using neem seeds with high moisture content at cool store (12-15 °C) Masanga (1996), Wolf (1993) and Maithani et al. (1989).

Sudan is a hot dry country where tree seed storage facilities are poor, theory 1 Bellefontaine and Audinet (1993) seems to be more suitable for neem storage in sudan, and accordingly this study was conducted to test storage conditions of neem seeds.

The main objectives of this study are:

1- To determine the suitable stage of maturity of fruits and storage conditions to retain viability of neem seeds.

2- To test possible alternatives as direct sowing of seeds, when viable, vegetative propagation, to over come the rapid loss of viability of neem seeds.

CHAPTER II

LITERATURE REVIEW

2.1.1 LEAFING, FLOWERING AND FRUITING :

Neem (A. indica) is a multipurpose tree with diversified utilities such as medicinal, shade and forage (Carlowitz, 1986). The tree is found in full foliage in summer when most of the trees are leafless (Tewari, 1994). The peak of flowering is in April-May. The panicles of small white, fragrant flowers appear from March to May. Fruiting is in May-june, and the peak for ripened fruits in July (Troup, 1921). In some restricted areas fruiting is during December-January. Thus, the ideal time for seed collection could be June-July for arid and semi-arid regions. In sub-humid areas the peak of ripening occurs in August (Schmutterer, 1995). Fruits are smooth ellipsoidal drupes of 1-2 cm greenish yellow when ripe, one celled and one seeded or sometimes with two seeds. The seeds do not retain their viability for long time (Troup, 1921).

2.1.2 SEED GERMINATION :

Seed germination is enhanced by soaking seeds in water overnight before being directly sown in the soil. The highest percentage of germination (88%) was obtained for seeds soaked in water for 6 days at room temperature or dipped in Gebrillic acid (GA_3) for 30 minutes at 32°C (Fagoonee, 1983). Chaney and Knudson (1983) reported that soaking of seeds in water had no effect on germination, while removal of endocarp improved germination significantly even when seeds were air dried for up to 6 days. Germination after 21 and 24

days reached values of 62.5 - 65.0%. Removal of seed coat also increased germination but to a lessor extent (52.5%). Ezumah (1986) reported that, germination started after one week and attained a maximum of 83-85% in 32 days.

2.1.3 STORAGE OF SEEDS IN RELATION TO VIABILITY:

Troup (1921) mentioned that, neem seeds have an extremely short span of viability. Storage of neem seeds is essential for gene conservation and plantation programmes. Fresh neem seeds readily germinate up to 91%, and 15 days stored seeds can be recommended for sowing, increase in storage period reduced seed viability (Venkatesh, et al. 1990). There are conflicting views regarding storability of seeds. Ezumah (1986) who suggested that, seeds can be dried at 26-28°C or even at higher temperatures and maintained for longer periods with higher level of viability at 15°C or at room temperatures than at low temperatures. However, Roederer and Bellefontaine, (1989) suggested that, the dried seeds can be stored at as low temperature as 5°C. On the other hand Bogra, (1993) indicates that the neem seeds can neither be described as recalcitrant, since they can not be dried at higher temperatures, nor stored at lower temperatures. The germination percentage of neem seeds reaches 8% at the end of three months storage at room temperature compared with 90% when freshly collected. This is accompanied with drop in moisture content from an initial moisture content 30.8% to 15.4% while seeds stored in earthen pots buried in a moist sand bed manifested little loss in seed moisture content and reached a germination of 62% at the end of 3 months (Ponnuswamy, et al. 1991). The germination of sun dried neem seeds stored in cloth bags reached 91% for fresh seeds, but this value decreased to 50% after 15 days and to only 10%

after 4 months of storage (Venkatesh, et al., 1990).

Neem seeds have a germination at or near zero percent after 2-6 months storage. However, seeds without endocarp stored at 5°C gave 42% germinative capacity after more than 5 years of storage (Roederer and Bellefontaine, 1989).

Amata (1986) reported that, separation of nuts from pulp before storage is an efficient mean of extraction as 15% germination was obtained after six months for seeds stored in aerated container at room temperature. Sealed containers at 5°C caused rapid deterioration and complete loss of germinative capacity in one to four months.

Chaisurisri, et al. (1986) reported that, seeds retained their viability for more than 16 weeks with germinative capacity of 62% under the conditions of sun drying for three days (M.C : 46.18%) in a cotton bag at 15°C.

Wolf (1993) reported a 40-56% drop in viability of neem seeds stored in plastic drums under room temperature for 11 weeks. While seeds stored in a bucket with water at the bottom and in a basket with free air circulation could keep the germination on a low level.

The storage of dried seeds in air tight container at 3°C in laboratory as well as under green house conditions gave similar results, beginning with a low germination. germination capacity dropped from 85% to 60% and 45% for seeds stored at room temperature and cold store of 6-7°C respectively . The viability was almost completely lost after 12 weeks in cold storage and after 16 weeks for storage at room temperature (Ezumah, 1986). The rapid dehydration of seeds was a major cause for loss of viability in neem seeds. However, seeds dried under shade and stored in moist sand in earthen pots had 62% viability after 12 weeks

of storage (Surendran, et al., 1992).

Hedge (1991) reported that, as the neem seeds contain certain chemicals which inhibit germination, it has been recommended to soak the seeds in warm water at 65-70°C for 30 minutes to improve the germination.

The initial quality of seeds, before storage, is one of the most important factors maintaining the maximum longevity of seeds of different trees (Wang, 1993). This requires careful control of their original genetic and physiological quality throughout the phases of collection, handling, processing, testing and storage (Wang, 1993). Moisture content, together with storage temperature and oxygen are the three critical factors affecting seed longevity in storage (Bewely and Black, 1983).

Seeds stored in cotton bags at 15°C maintained viability better than those in air tight containers (Chaisurisri, et al. 1986). Recalcitrant seeds do not tolerate desiccation. However, they have to be stored at high moisture content. Kraak (1993) reported that desiccation sensitivity in the recalcitrant seeds is due to the initiation of germination-associated processes before and after shedding. It is assumed that the desiccation sensitivity of recalcitrant seeds is intimately associated with their persistent state of metabolic activity (Berjak and Pammenter, 1996).

2.1.4 FRUIT RIPENING IN RELATION TO VIABILITY :

Germination of 80% could be obtained from the greenish-yellow fruits with moisture content of 5% depulped and dried under shade (Nagaveni, et al. 1987). Pukittayacamee (1994) reported that seeds from fully mature yellow fruits gave higher germination when

compared with less mature greenish yellow seed. Wolf (1993) reported that greenish yellow is the recommended stage for high germinative capacity. However Msanga (1996) found that seeds extracted from green fruits have a lower desiccation tolerance capacity and can not keep their viability as long as those extracted from greenish yellow and yellow fruits.

2.2 PROPAGATION OF NEEM :

Neem can be propagated by seed or vegetatively (cuttings, tissue culture ...etc) Gautam, et al (1993). Propagation by seeds is commonly used but it is limited by the very short viability of seeds. This restricts the distribution and exchange of seeds over different countries, and tree improvement programmes (Schmutterer, 1995).

2.2.1 PROPAGATION OF NEEM BY SEEDS:

Seeds fall on the ground in (or just before) rainy season and must be used within 1-2 weeks. Seeds are collected in July from the trees when ripe and sown soon after collection. Direct sowing gives very good results (Troup, 1921). However, experiments carried out at Dehra Dun, India have shown that development of neem seedlings is much retarded by weed growth and that regular weeding greatly stimulates the growth and vigor of seedlings. It reached a height of 150-210 cm by the end of the third season. Where weeding was not carried out, seedlings were suppressed, poorly developed and were eventually killed (Troup, 1921).

In Sudan the fruits are collected from the ground thus, the viability falls off rapidly after 2 weeks. This loss of viability appears to be due to the fermentation of the cotyledons (Chaturvidi, 1993). He also reported that, seedlings raised in the nursery can be planted out

when shoot height is 7-10 cm and tap root of about 15 cm long. Compolucci (1990) reported that in Niger neem was used with Acacia spp. as wind breaks which were established as shoot cuttings, direct sowing or by seedlings. Bosshard, (1966) reported that; Azadirachta indica is one of the recommended species of plantations in Khartoum Greenbelt. Direct sowing is also recommended as a practical method of establishment under irrigation conditions.

In Burkina Faso neem tree is a favourite species, and usually seedlings are transplanted from under mother tree (Gijsbers, et al. 1994). In Chad neem and mahogany (Khaya senegalensis) were selected beside Eucalyptus spp. and Prosopis spp. for shelterbelts and live fencing (Thomassey, 1991). CTFT (1963) reported that in Nigeria direct sowing of A. indica by aerial broadcasting at an average of 10 seeds/sq. yd. gave profuse germination, but all seedlings died as a result of scorching sun. However, those in direct shade of natural scrub were healthy and were able to survive the dry season. direct sowing of neem seed by aerial broadcasting would have been successful if sufficient ground cover would have been assured. Mackay (1952) reported that direct sowing of neem seeds between lines of millet make the method successful. Bhargava (1956) recommended direct sowing of neem seeds on raised lines with cross drainage and frequent soil working over planting for afforestation on alkaline soil in India.

2.2.2 VEGETATIVE PROPAGATION OF NEEM:

Neem seeds collection and storage, in Sudan, is not a rational practice as no seed source is identified and the genetic quality of seed available is unknown. Added to this the very poor storage facilities .

Vegetative propagation may be employed as an alternative to seed propagation in case of which plants produce seeds of very short viability (Harttmann and Kester, 1968). The main advantage of cuttings, can be used to raise plants in nursery when there were no viable seeds available or seeds are difficult to germinate, (Bosshard 1966). He also reported 5.8% of neem cuttings succeeded to be established when planted directly into irrigated field at the western end of Khartoum Greenbelt.

Rooting of neem stem hard wood cuttings using sandy soil gave 37% and 38% with and without using growth regulators (El Khalifa, 1989). However Mohinder, et al. (1992) reported that; the semi hard wood cutting of neem tree failed to root by using growth regulators IBA and phenols, while about 30% of leafy soft wood cuttings rooted even without hormonal treatment. A combination of IBA with the phenols inhibited rooting of neem.

Wright (1976) reported that, raising of planting stock by cuttings, if successful, can solve the problem of seed availability. Gill (1983) reported that, vegetative propagation always develop a plant identified to its parent. Accordingly desirable characteristics such as Azadirachtin content, fast growth, good form and high yield, which could be lost in seed propagation are easy to preserve by vegetative propagation.

CHAPTER III

MATERIALS AND METHODS

3.1 STORAGE EXPERIMENT :

3.1.1 COLLECTION AND PROCESSING OF NEEM SEEDS:

The experiment was conducted at the seed laboratory of the National Tree Seed Centre - Soba during (Jun.-Dec. 1995). Fruits were collected from a plantation of A. indica at Hantoub, Gezira state (latitude 14° 05' N and longitude 33° 38' E). Twenty fruit bearing trees about 10 m tall were selected for collection. Collection of fruits was made using long handled pruning shears to trim branches bearing fruits. Collected fruits were transported immediately to the National Tree Seed Centre. Collections of fruits at different maturity stages were made at three different intervals green fruits were collected on June 01, 1995, yellow fruits collected on June 24, 1995 and over mature brown fruits were collected from the ground on August 02, 1995.

Each lot of collected fruits was mixed by hand and a sample of 5 kilos was drawn from each lot using the seed divider. Each sample from each lot is divided into two equal subsamples . One sample was stored as whole fruit the rest was depulped, cleaned and dried

. **Cleaning methods of neem seeds:**

Green and yellow fruits were immersed into clean tap water and gently pressed by fingers to remove the pericarp and pulpy mesocarp, floatation method was used to separate the pericarp and seeds then seeds were washed with clean water to remove the remaining

parts of the mesocarp . The seeds obtained (seeds with endocarp) from green and yellow fruits were surface dried on cemented floor in a shaded and well ventilated processing room. Brown fruits were soaked for 6 hours to ease the removal of the pericarp and mesocarp by hands . cleaning and drying was same as above .

3.1.2 STORAGE OF NEEM SEEDS:

Before and after processing a sample from each type of fruits was taken to determine initial moisture content of the seeds and fruits. The seed and fruit samples were then divided into three subsamples for storage under three different conditions. Storage period was six months.

Storage container used was cotton sacks. The storage conditions were : ambient temperature in the laboratory (about 30°C), 12°C and cold store of 4°C. Two kg of seeds were packed up in one cotton sack. From which samples were drawn for testing every month for six months.

3.1.3 GERMINATION TEST OF NEEM SEEDS:

The germination percentage was used to evaluate the viability of seeds. Samples of 25 seeds replicated 3 times were used in this test. Seeds were germinated in sand medium in transparent plastic boxes. In the germination room under controlled temperature (30°C) and light for 8 hours. A complete randomized block design was used. Germination counts were made every 7 days for 35 days , only a single germenant for seed was considered according to ISTA (1993).

3.1.4 MOISTURE CONTENT OF NEEM SEEDS:

Samples of 15 seeds replicated 4 times were drawn for moisture content determination every month for 6 months from each seed and fruit samples . The low constant oven temperature method described in the ISTA rules 1993 for tree species was used in which the seeds were dried for 17+1 hours at a constant temp. of 103 °C . The moisture content was calculated on a wet weight basis with a tolerance range of 2.5% for the initial moisture test before storage and a tolerance of 0.8% onwards .

3.1.5 CUTTING TEST OF NEEM SEEDS:

Samples of 25 seeds replicated 4 times were used for cutting test every month for six months. Seeds were cut transversely; embryo and cotyledons were visually investigated as described by ISTA Rules (1993).

3.1.6 DATA ANALYSIS :

For statistical analysis data on germination percentage, germination rate, moisture content and cutting test was analyzed on the computer using SAS (1990) program for analysis of variance and Fisher's protected least significant difference test.

3.2 FIELD EXPERIMENT :

3.2.1 LAND PREPARATION AND LAYOUT :

The experiment was conducted at the Gezira University farm, Medani, Sudan (latitude 14° 05' north and longitude 33° 38' E) and altitude 407 m above sea level during 21-December 1994 and 01- January 1996.

The soil is deep cracking, heavy alkaline clay (pH 8.0), low in organic matter (0.02%)

and nitrogen (0.25%) (Osman, 1984). Land was disc ploughed, levelled and then ditched to make furrows of about 30 cm deep. Furrows are 3 m apart.

The area was divided into four blocks running east-west. Each block was further sub-divided into two subplots. Each contained 3 furrows. Seeds were directly sown in pits at spacing of 3x3 m. Pit sowing was carried out at the slope of the ridges of the ploughed field slightly above the maximum level of the irrigation water. A small hole was dug with bamboo stick. the seeds were then put and covered with soil by hand in such away that there was no variation in the depth of sowing in each pit. Each subplot contained 60 pits.

The design used was a randomized block design with 4 replications.

3.2.2 NURSERY STOCK PRODUCTION OF NEEM:

Clean neem seeds were directly sown in soil medium

(2 clay : 1 sand) in polythene pots placed under partial shade (traditional nursery) and irrigated every day. The sowing date for direct seeding in the field and for seedling production in the nursery was the same (21th December, 1994). Seedlings were left in the nursery for 90 days and then hardened for 10 days under direct sun before transplanting. Transplants were irrigated to field capacity every 15 days.

3.2.3 SAMPLING, DATA COLLECTION AND ANALYSIS :

Random destructive samples were collected for measurements of plant height(cm), root length(cm), diameter at collar(mm) and number of leaves. Other measurements of shoot fresh weight(g), shoot dry weight(g), root fresh weight(g) and root dry weight(g) were reported . The plant height, diameter at collar and canopy diameter were recorded every

month for six months.

Data was analyzed in the computer using SAS (1990) programmes for analysis of variance and Fisher's protected least significant difference test.

3.3 VEGETATIVE PROPAGATION OF NEEM:

The experiment was carried out in the National Tree Seed Centre, Soba during Sep.-Nov. 1995. It was intended to examine the effect of hormonal treatment (IBA and NAA) at different concentrations (4000, 8000 and 12000 PPM) on rooting of neem cuttings .

3.3.1. cuttings.

The branches were taken from the lower crown position in the morning. Segments of leafless stem cutting 15-20 cm with lateral buds were prepared. Two growth regulators were used IBA (Indonl butyric acid) and NAA (Naphthalene acetic acid) with three concentrations (12000, 8000, 4000 PPM) in addition to the control . The fresh cuttings were dipped into the hormone solutions for 5 seconds prior to insertion into the rooting medium (sand). Trays were placed in the germination room with controlled temperature 30°C , 8 hours light from cool florescent lamps and relative humidity 30 - 40 % . The sand was kept moist and the cuttings were left in the rooting medium for 70 days after which they were removed from the sand, washed carefully and investigated for root production. Complete randomized block design was used with three replications of 20 cuttings each.

CHAPTER IV

RESULTS

4.1 STORAGE OF NEEM SEEDS :

4.1.1 THE EFFECT OF RIPENESS STAGE ON GERMINATION PERCENTAGE OF NEEM CLEAN SEEDS AND WHOLE FRUITS :

Germination tests conducted at harvesting and before storage for clean seed and whole fruits revealed that germination percentages were 84.0%, 73.3% and 14.67% for clean seeds from green ,yellow and brown respectively. For whole fruit germination percentage decreased significantly to 37.33% for green fruits, 17.33% for yellow fruits and 2.67% for brown fruits. Differences between germination percentages, of whole fruits and the clean seeds at different maturity stages was found to be highly significant ($P < 0.0001$) Fig. 9, 11. Yellow seeds maintained the highest viability of 65.33% , 26.67% and 56.0% after 4 weeks storage at 30, 12 and 4°C when compared with green and brown seeds (Fig 9). This viability decreased to 52.0% , 17.33% and 0% after 20 weeks storage at the same storage temperatures. Brown seeds started with very low viability and reached about 0% after the end of the second month. Whole fruits of all stages did not maintaine the viability because of the fungus infection in green and yellow fruits which were discarded from the store at the end of the second month (Table 1). In general yellow seeds were significantly different from green and brown seeds (Table 2). Initial germination percentage was found significantly different from the other storage periods. There was no significant difference between brown seeds and

whole fruits of all maturity stages (table 5 and Fig: 13, 18 and 19).

A simple cutting test to investigate the soundness of seeds showed that, the color of cotyledons for green and yellow seeds and whole fruits changed from dark green at collection to pale yellow after the 3rd month and dark brown at the end of storage period (six months). The color of the cotyledons for brown seeds and whole fruits changed from pale yellow at collection to dark brown after the 3rd month. The percentage of sound seeds at collection ranged between 97-85% for green stage, 80-75% for yellow stage. No insect-infected seeds were noticed.

4.1.2 EFFECT OF STORAGE CONDITIONS ON VIABILITY OF NEEM SEEDS:

Ambient storage (30°C) gave highest germination percentage for both whole fruits and clean seeds compared to storage of seeds and fruits at 12°C and 4°C during six months of storage (Table 1 and Fig: 15, 16 and 17). It gave the highest viability from all maturity stages, green, yellow and brown (table 3 and Fig: 6, 7 and 8) . Germination of clean seeds and whole fruits declined sharply with time during the six months following collection (Fig: 4, 14 and 10).

Table 1. (a). Effect of storage conditions on viability of neem seeds.

	Green			Yellow			Brown		
*	4 °C	12 °C	30 °C	4 °C	12 °C	30 °C	4 °C	12 °C	30 °C
0	84.00	84.00	84.00	73.33	73.33	73.33	14.67	14.67	14.67
1	00.00	6.67	18.67	56.00	60.65	65.33	4.00	6.67	1.33
2	00.00	22.67	2.67	00.00	26.67	57.33	6.67	18.67	9.33
3	00.00	5.03	2.67	00.00	14.67	41.33	2.67	5.33	4.00
4	00.00	17.33	12.00	00.00	28.00	49.33	0.00	0.00	0.00
5	00.00	26.67	24.00	00.00	17.33	50.67	0.00	0.00	0.00
6	00.00	18.67	17.33	00.00	00.00	52.00	0.00	0.00	0.00

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* Storage period (months) [0-6 for months from June to December]

Fig.1 Relationship Bet. M.C & germination % of Green Seeds

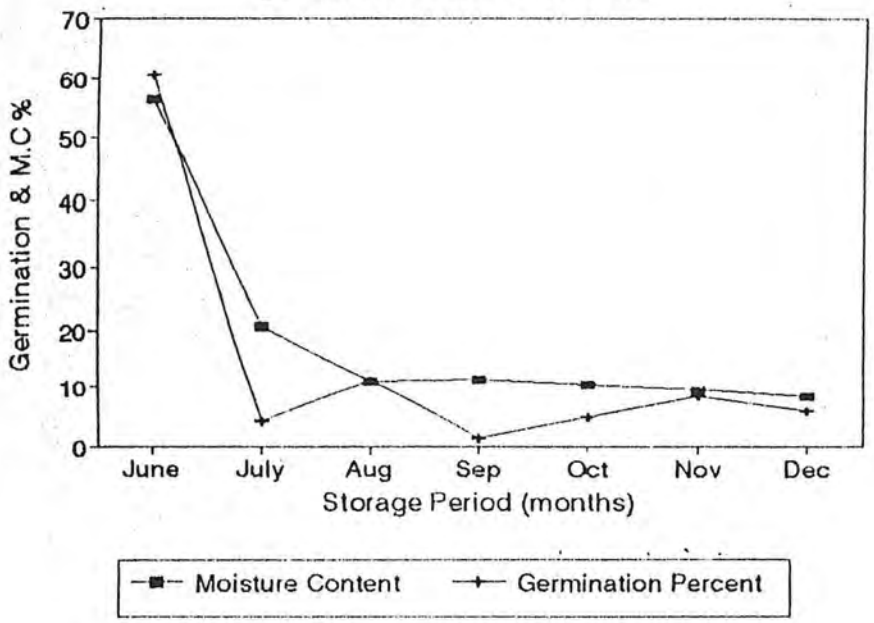

Fig. 2 Relationship Bet. M.C & Germination % of Yellow Seeds.

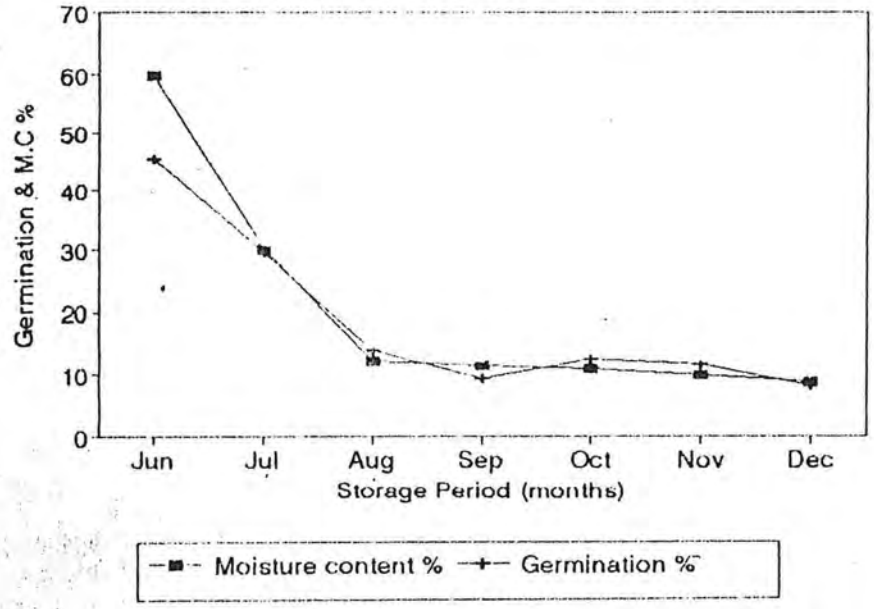

Fig. 3 Relationship Between M. C and Germination % of Neem Brown Stage.

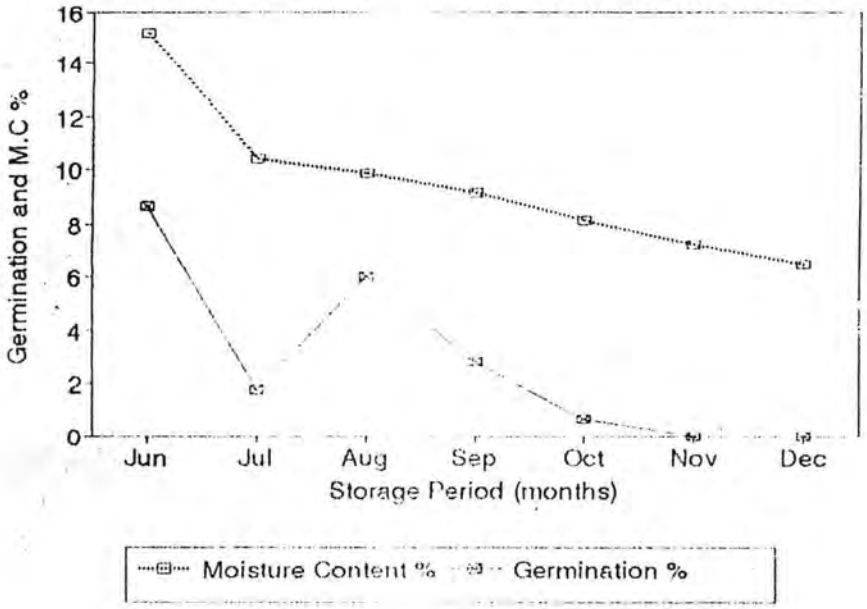

Fig 4. Effect of Ripening Stage On Ger. Rate Of Neem Seeds

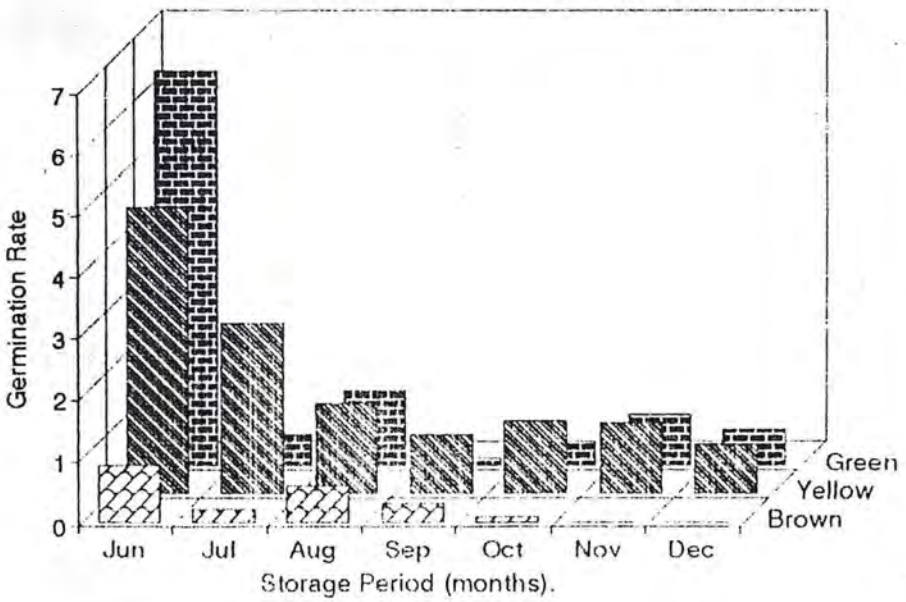

Fig.5 Moisture content curve of neem green, yellow and brown stages.

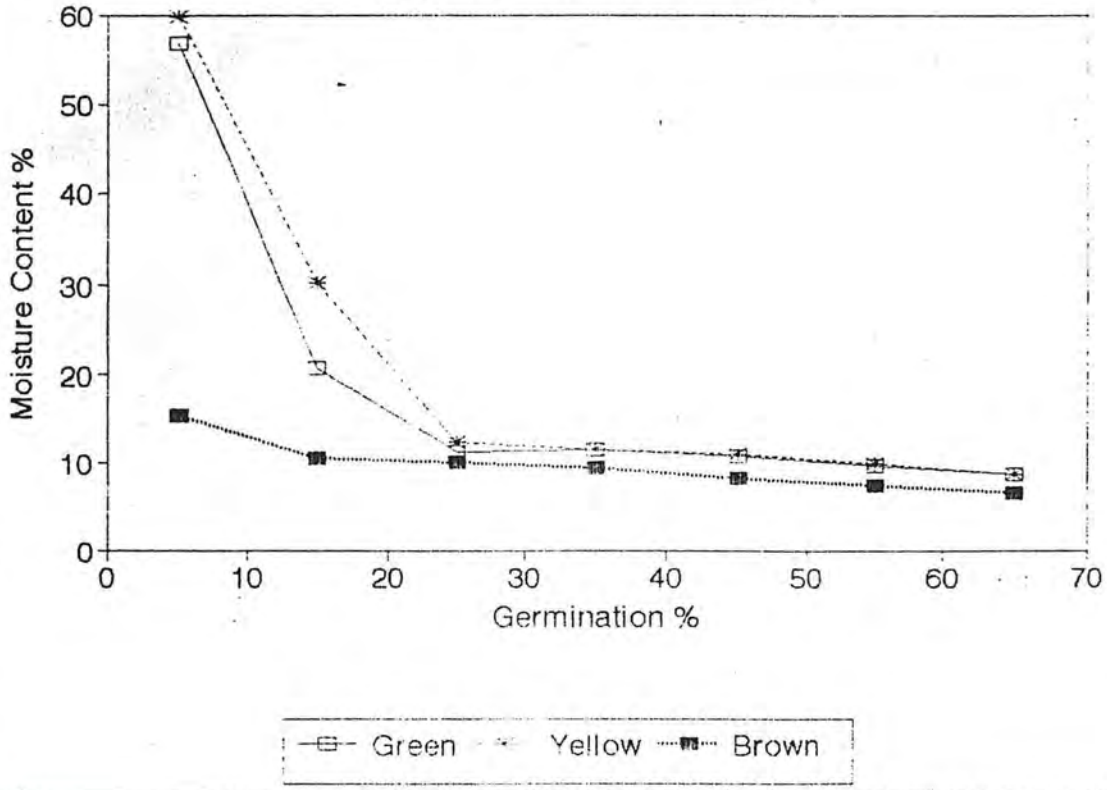

Table 1.(b). Effect of storage conditions on viability of neem fruits.

	Green			Yellow			Brown		
*	4 °C	12 °C	30 °C	4 °C	12 °C	30 °C	4 °C	12 °C	30 °C
0	37.33	37.33	37.33	17.33	17.33	17.33	2.67	2.67	2.67
1	00.00	0.00	4.00	0.00	1.33	9.33	0.00	1.33	4.00
2	00.00	0.00	0.00	00.00	0.00	0.00	0.00	1.00	1.33
3	00.00	0.00	0.00	00.00	0.00	0.00	0.00	0.00	0.00
4	00.00	0.00	0.00	00.00	0.00	0.00	0.00	0.00	0.00
5	00.00	0.00	0.00	00.00	00.00	0.00	0.00	0.00	0.00
6	00.00	0.00	0.00	00.00	00.00	0.00	0.00	0.00	0.00

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* Storage period (months) [0-6 for months from June to December]

Fig. 6 Relationship Bet. Ger.%
& M.C of Neem seeds & fruits at 4 oC

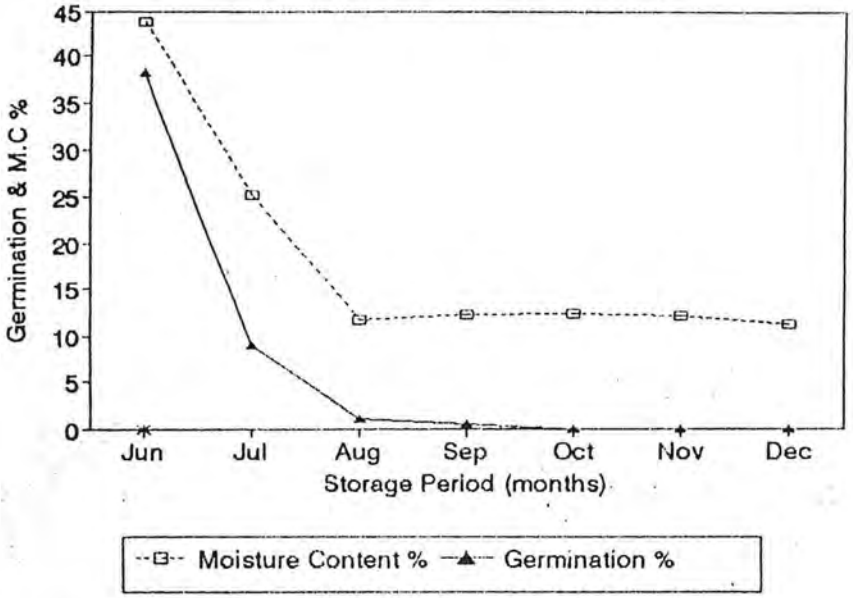

Fig.7 Relationship Bet. M.C &
Germ.% Of seeds & Fruits At 12 oC

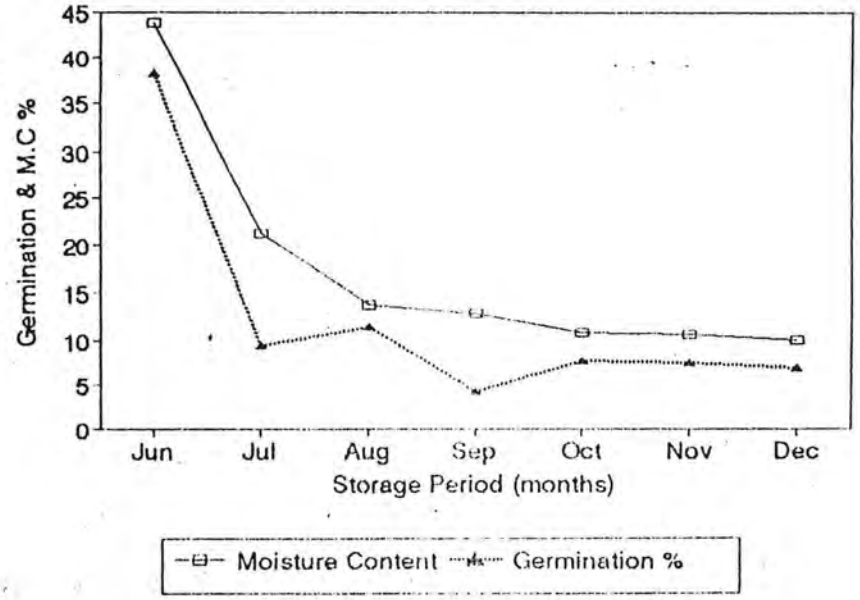

Fig.8 Relationship Between M.C and
Germ.% Of seeds and Fruits At 30 oC

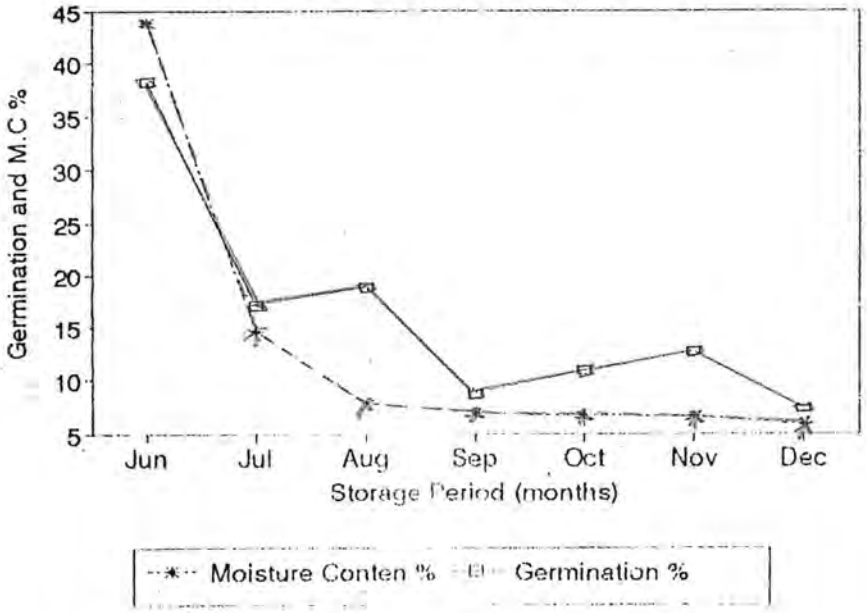

Fig.9 Effect of pericarp and mesocarp
on germination % of Neem Seeds.

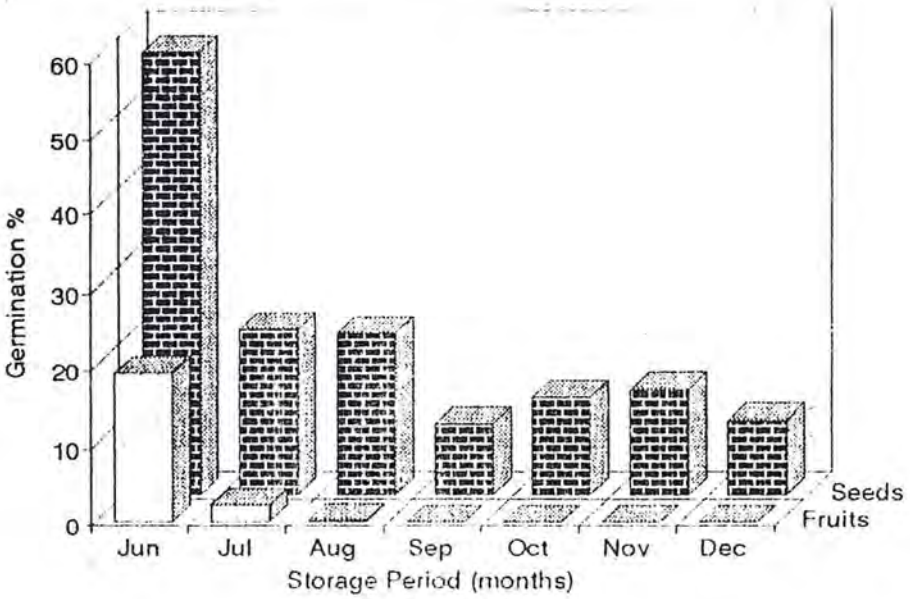

Fig. 10 Germination % Of Neem seeds & Fruits stored at 4,12 & 30 oC

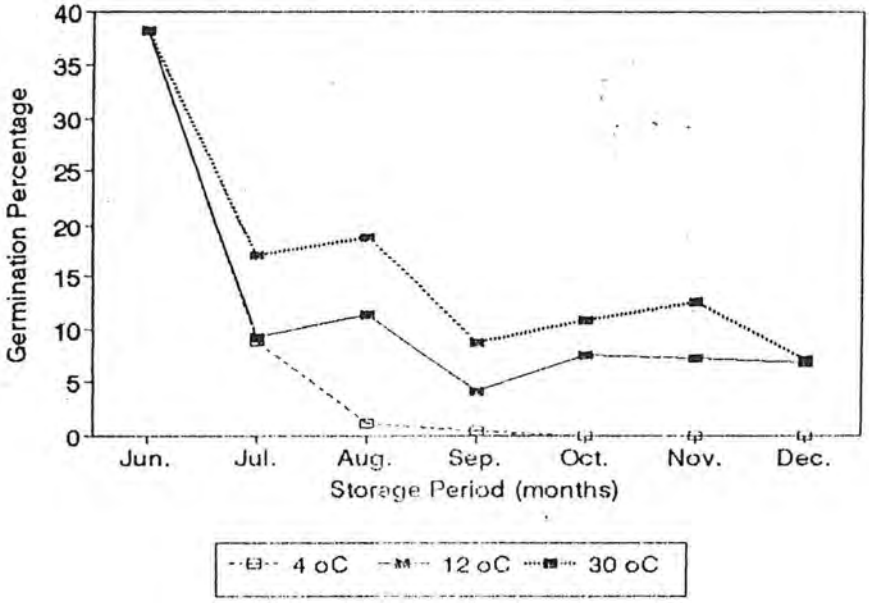

Fig 11 Germination % Of Green, Yellow & Brown Seeds Stored for 6 Months.

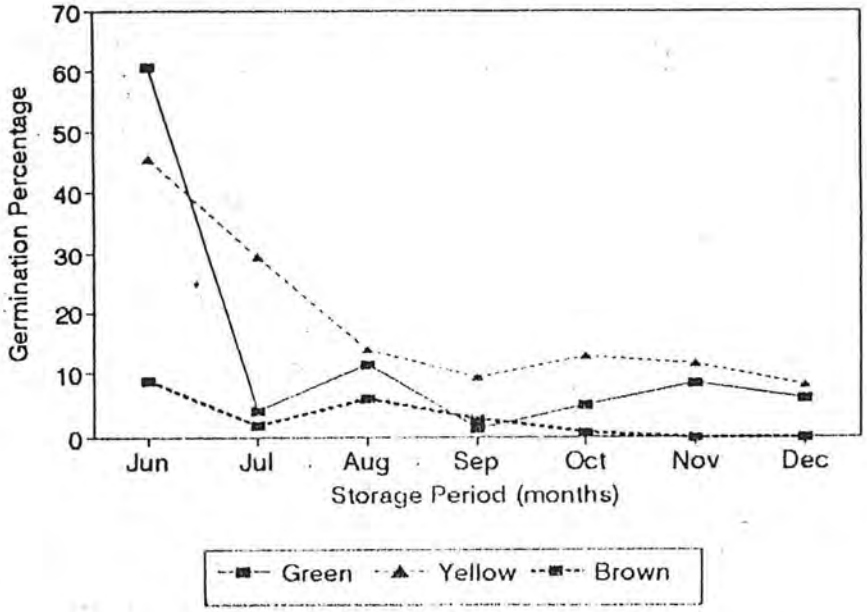

Fig. 12 Germination % of neem seeds
and fruits stored at 4 C,12 C and 30 C.

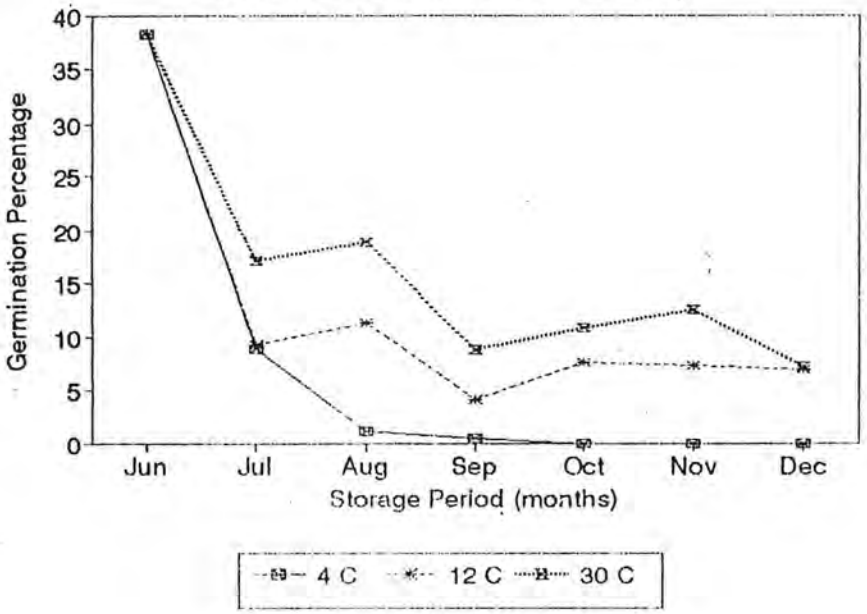

Fig.13 Effect Of Cold Store(4 C)
on viability of neem fruits.

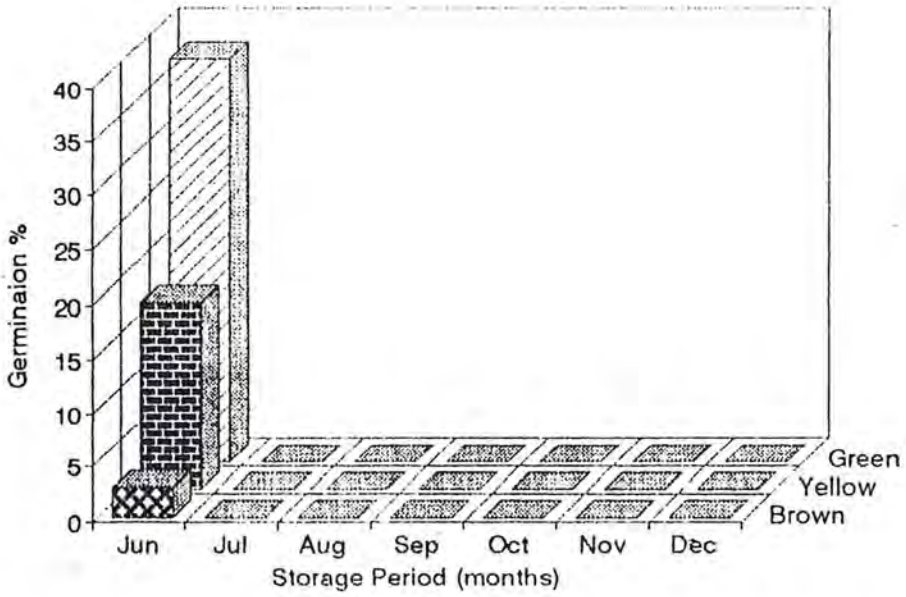

Table 2. Effect of ripening stage on germination % of neem seeds.

Ripening stage	Germination % (means)
Yellow	17.71 a
Green	13.84 b
Brown	2.83 c

($P > 0.05$), Fisher's protected LSD.

Fig. 14 Germination % Of Neem Seeds
& Fruits During 6 Months Storage.

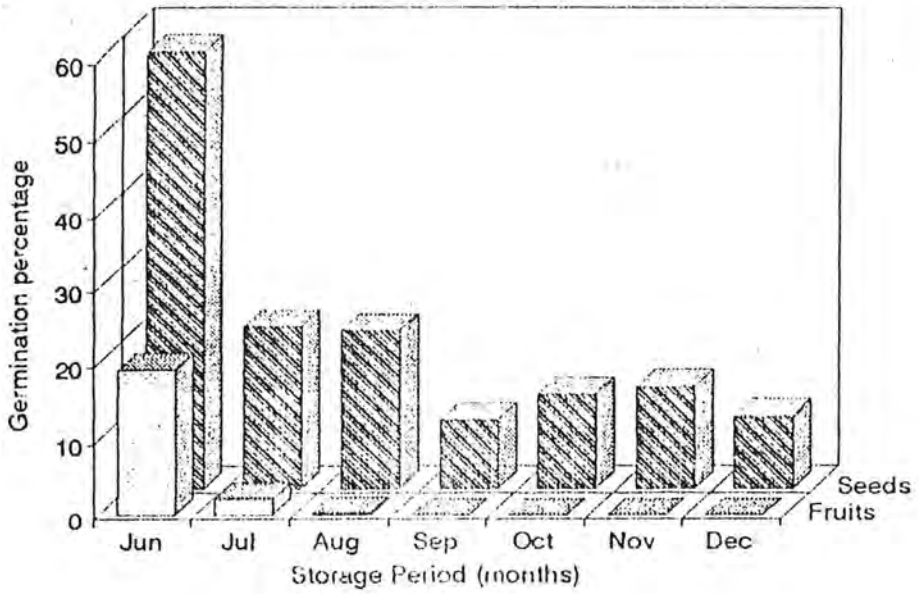

Fig 15 Effect Of Cold Store(4 oC)
On Viability Of Neem Seeds

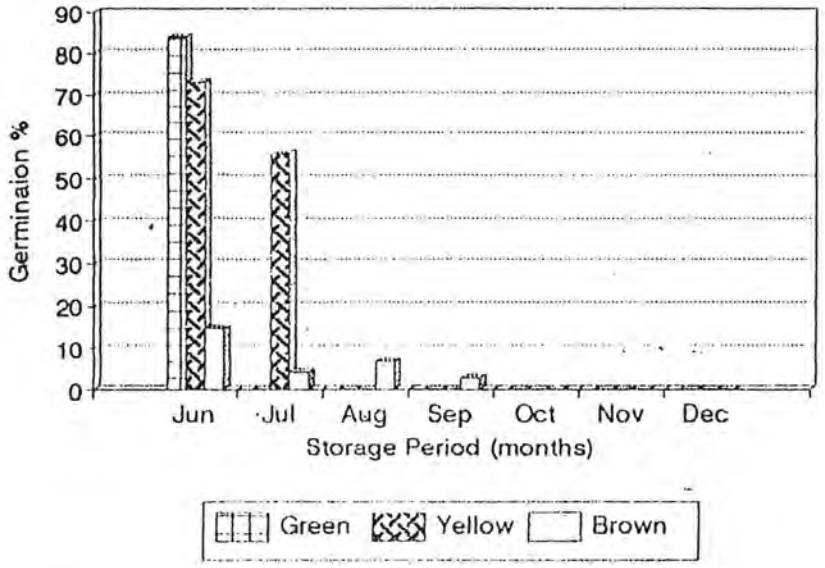

Fig.16 Effect of cold store(12 C)
on viability of neem seeds.

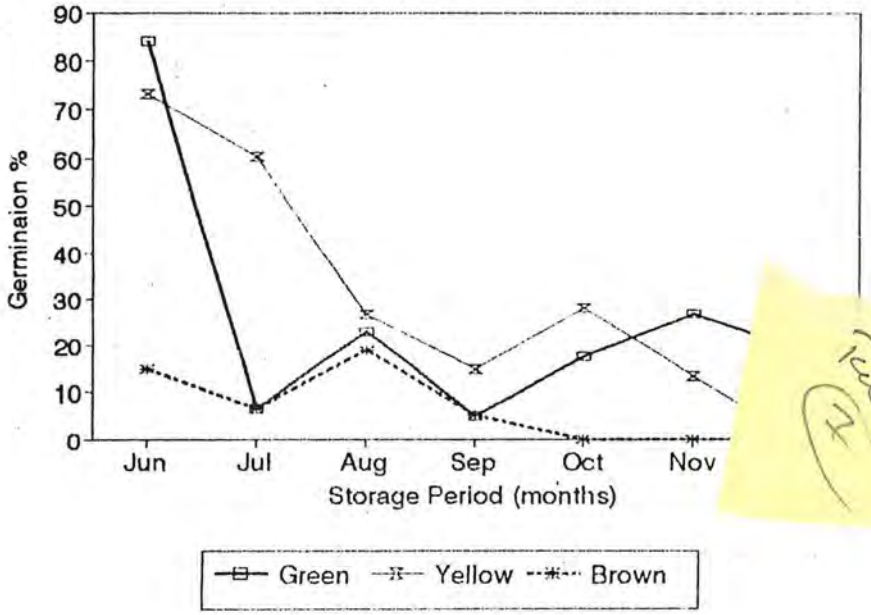

Fig.17 Effect of storage at room(30 C)
on viability of neem seeds.

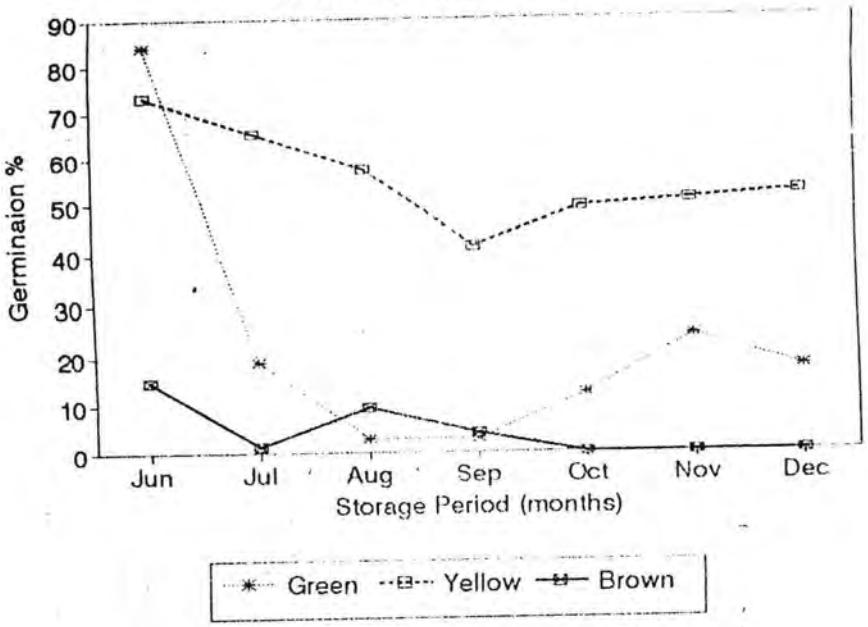

Table 3. Effect of storage temperature on germination percentage of neem seeds (1995).

Storage temperature°C	Mean Germination percentage
30	16.20 a
12	11.07 b
04	07.19 c

Means followed by same letter were not significantly different ($P > 0.05$), Fisher's protected LSD.

In general, the germination percentage of green clean seeds has sharply decreased after the first month in storage (0%, 6.67% and 18.67% at storage temp. 4°C, 12°C and 30°C respectively) and maintained about this percentages for six months (Fig. 1). For yellow seeds the decline in germination percentage was relatively less giving 56.0%, 26.67% and 65.33% after the first month. Low temperature did not elongate the seed viability (Fig. 2).

4.1.3 THE EFFECT OF NEEM SEED MOISTURE CONTENT ON VIABILITY :

The initial moisture content determined for whole fruits and clean seeds revealed that, yellow seed and fruits have the highest moisture content compared to green and brown seeds and fruits (Table 7 and Fig. 5).

Differences in moisture content of fruits and clean seeds is highly significant ($P < 0.0001$) for all maturity stages (Table 8). The moisture content of green clean seeds dropped considerably in the first and second month of storage. This drop in moisture content was accompanied by a drop in germination of seeds (Fig: 6,7 and 8).

For yellow clean seeds, the seed moisture content was high and the drop in viability was more steady compared to the green seeds (Fig. 5). For brown seeds the germination percentage did not exceed 6%, while the moisture content was in the range of 15 - 6.5 % (Fig. 3).

Fig 18. Effect of cold store(12 C)
on viability of neem fruits.

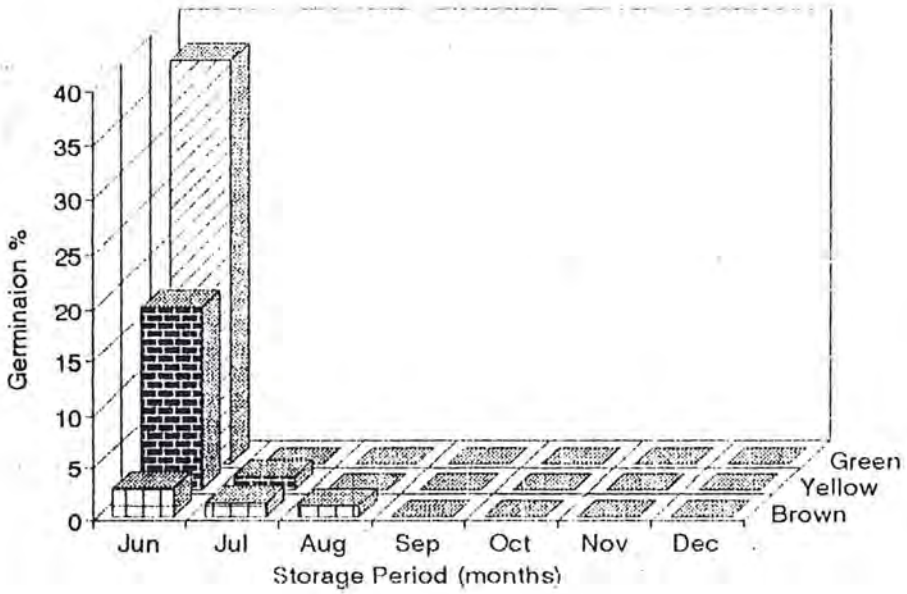

Fig 19. Effect of storage at room temp.
(30 C) on viability of neem fruits.

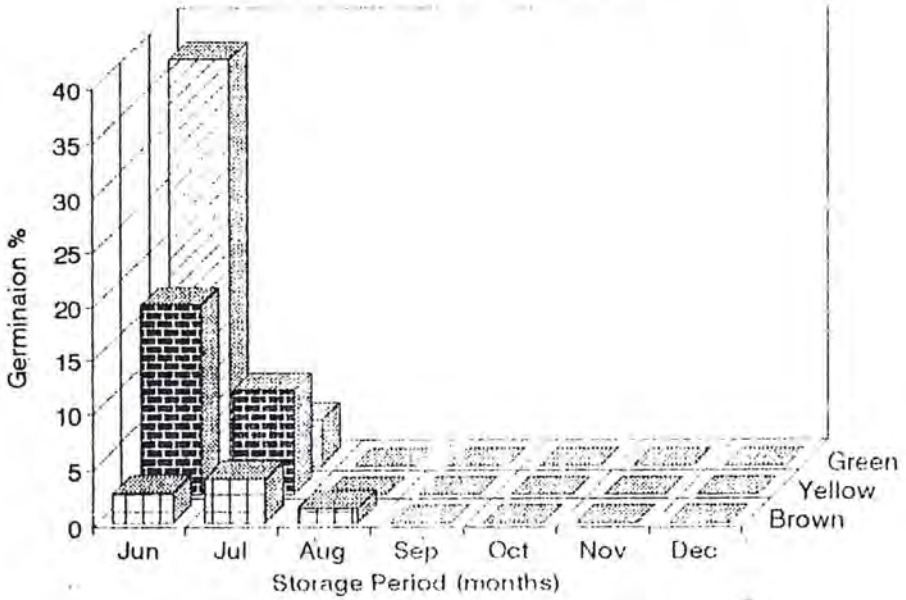

Table 5. Effect of ripening stage on germination percentage of neem seeds and whole fruit (1995).

Germination percentage			
	Ripening stage		
Status	Green	Yellow	Brown
Seed	22.159 b	34.320 a	05.008 c
Fruit	05.524 c	02.984 d	00.698 d

Means in the same raw or column followed by same letter (s) were not significantly different ($P > 0.05$), Fisher's protected LSD.

Fig 20. Moisture content % of neem seeds and fruits during storage.

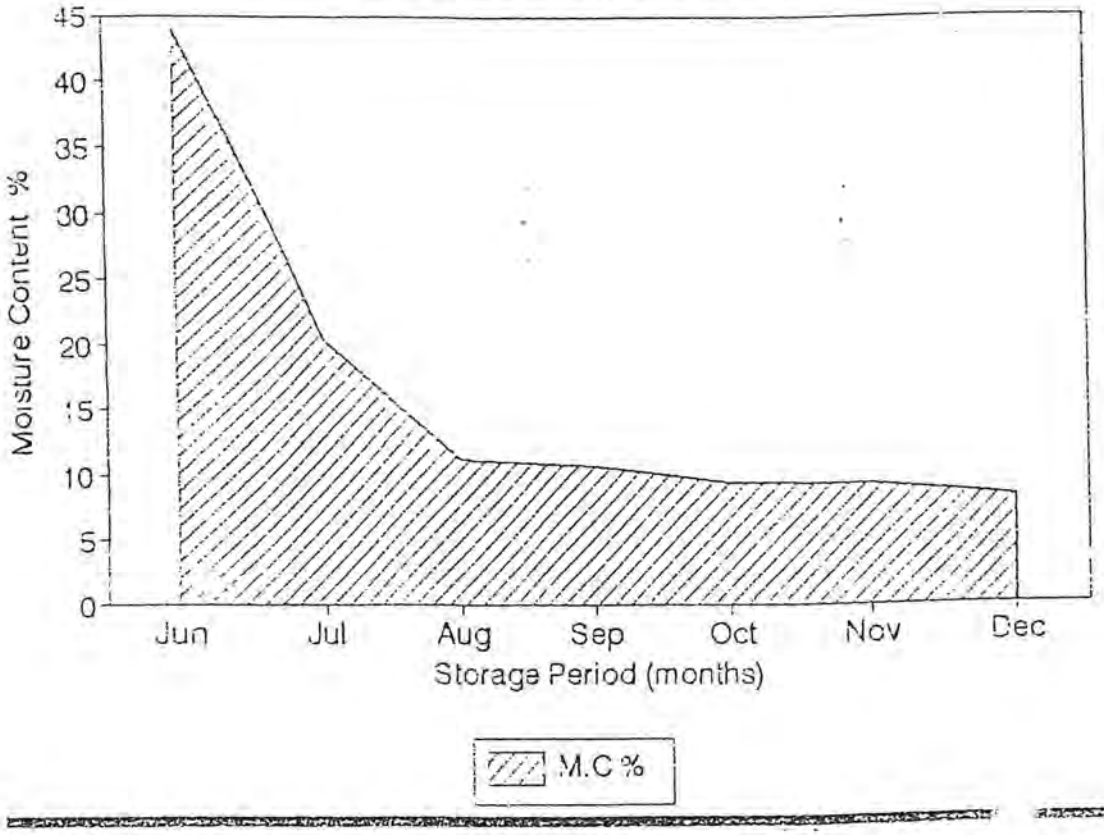

Table 7. The level of moisture content of neem seeds at different ripening stages.

Ripening stage	Moisture content (%)
Green	20.110 b
Yellow	22.210 a
Brown	10.177 c

Means followed by same letter were not significantly different (P > 0.05), Fisher's protected LSD.

Table 6. Effect of storage temperature on germination % of neem seeds and whole fruits.

	Germination %		
	Storage temp.		
Status	30	12	4
Seed	28.92 a	21.39 b	11.18 c
Fruit	3.62 d	2.85 d	2.73 d

Means in the same raw or column followed by same letter were not significantly different (P > 0.05), Fisher's protected LSD.

Table 8. Moisture content of neem seed and whole fruit.

Status	Moisture content (%)
Seed	13.78 b
Fruit	23.15 a

Means followed by same letter were not significantly different (P > 0.05), Fisher's protected LSD.

4.1.4 EFFECT OF STORAGE TEMPERATURE ON MOISTURE CONTENT OF NEEM SEEDS :

The moisture content of neem seeds has dropped from initial moisture of 43.9% to 10.1% on average during the first two months of storage irrespective of the storage temperature 30°C, 12°C, or 4°C, and maintained the same level up to six months (Fig: 6, 7 and 8).

4.2 PERFORMANCE OF NURSERY STOCK PLANTING VERSUS DIRECT SOWING OF NEEM SEEDS :

There was no significant difference in shoot height(cm) of neem seedlings raised in the nursery and of those obtained by direct sowing in the field. Sowing in the nursery and in the field was done on the same day. However, the number of leaves from nursery seedlings was double that of the seedlings obtained by direct sowing in the field.

Seedlings raised in the nursery and those produced by direct sowing showed no significant differences as far as root length(cm), diameter of seedlings at collar(mm), fresh and dry weight(g) of shoots and roots (Table 9). The assessment of the nursery stock seedlings obtained by direct sowing after out planting of nursery seedlings in the field showed no significant differences, in shoot height(cm), diameter at collar(mm) and canopy diameter(cm), during the six months following out planting of the nursery seedlings (Table 10).

The survival rate has declined from 88.8% to 37.1% for nursery stock plants after five months following out planting; and from 72.5% to 63.3% for field raised plants (Table 10).

4.3 THE EFFECT OF HORMONAL TREATMENT ON ROOTING OF NEEM HARD WOOD STEM CUTTINGS:

Vegetative propagation of neem by hard wood stem cuttings taken from mature trees, showed negative response (no rooting) to different concentrations of IBA and NAA, except small callus at the base of few number of cuttings. However, the cuttings florished shoots giving dark green leaves after the first two weeks.

Table 9. Characteristics of neem plants produced in thenursery and by direct sowing in the field (1994/95)* .

Method		
Parameter	Plants produced in the nursery	Plants produced in the field
Number of leaves/plant	14.360 a	07.333 b
Shoot height (cm)	06.570 a	07.081 a
Root length (cm)	15.639 a	11.893 a
Diameter at collar(mm)	03.044 a	02.660 a
Shoot fresh weight (g)	01.013 a	00.530 a
Root fresh weight (g)	01.652 a	00.174 a
Shoot dry weight (g)	00.565 a	00.193 a
Root dry weight (g)	00.094 a	00.086 a

Means in the same raw followed by same letter were not significantly different ($P > 0.05$), Fisher's protected LSD.

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* Sowing date in the nursery and in the field was the same (21-12-1994)

Table 10. Assessment of characteristics of nursery seedlings and direct sowing seedlings during six months following out planting (1994/95).

Months	Height (cm)		Canopy diameter (cm)		Survival rate (%)		Diamter at collar	
	Direct sowing	Transplanting	Direct sowing	Transplanting	Direct sowing	Transplanting	Direct sowing	Transplanting
June	15 a	18.am	14.83a	18.81a	72.50a	88.75a	04.39a	04.83a
July	15 a	19.79a	18.15a	15.06a	72.50a	88.75a	05.19a	04.95a
August	18 a	20.76a	23.01a	22.78a	72.50a	58.75a	05.14a	05.26a
September	22 a	21.45a	25.27a	25.29a	70.83a	45.83a	06.00a	05.42a
October	28 a	33.76a	33.63a	30.73a	61.25a	37.08a	06.80a	06.00a
November	30 a	36.60a	34.76a	31.17a	---	---	06.99a	06.40a

Mean pairs in the same raw (month) within a main column followed by same letter (s) were not significantly different ($P > 0.05$), Fisher's protected LSD.

CHAPTER V

DISCUSSION

5.1 THE EFFECT OF FRUIT PULP AND PERICARP ON GERMINATION PERCENTAGE OF NEEM CLEAN SEEDS AND WHOLE FRUITS:

Germination of clean neem seeds and whole fruits decreased sharply during storage irrespective of the maturity stage ; green, yellow or brown. However, when clean dry seeds were used, the germination percentage was high and no fungus infection was observed as with whole fruits. This result confirms the reports of the general practice in the Sudan that the germination of whole fruits is poor compared to clean seeds if immediately sown. The results also concur with the findings of Troup (1921), CTFT (1963) and Fagoonee (1986) who recommended the use of clean dry neem seeds to enhance the germination by eliminating the physical (pericarp) and chemical (mesocarp) inhibitors and to avoid fungus infection. In Sudan the common practice is the collection of over mature brown fruits from the ground, which are sown as whole fruits. Since the germination percentage of whole fruits at this stage of maturity is very low (14.67%), large quantities of fruits are used to compensate for the low germination . Added to this the high infection rate of neem fruits by fungi leading to further losses. This uneconomic practice needed to be improved both by choosing the right time for collection before the fruit drops and the use of clean seeds instead of whole fruits. In nature ; birds , monkeys and bats eat the pericarp and the mesocarp leaving clean seeds which germinate readily whenever the conditions permit.

5.2 THE EFFECT OF STORAGE TEMPERATURE ON VIABILITY OF NEEM SEEDS:

Seeds stored at ambient temperature (30°C) gave highest germination capacity when compared with storage of seeds at 12°C and 4°C. Low temperature does not maintain the germinative capacity of neem seeds stored for 6 months. Similar observations have been made by Venkatesh, et al. (1990) who reported, a decrease in germination of fresh neem seeds stored at room temperature from 91% to 50% after 15 days and to only 10% after 4 months.

The presented results confirm the findings of Ezumah (1986) who reported a complete loss of viability of neem seeds in 16 weeks and 12 weeks when stored at room temperature of 26-28°C and at low temperature of 6-7°C respectively. Results obtained are also in agreement with the findings of Wolf (1993) who succeeded to maintain high viability of neem seeds for 11 weeks at 30°C by humidification of store atmosphere. Results do not confirm with Bellefontaine and Audient (1993) who suggested that conservation of neem kernels viability (42%) for 5-8 years is possible by storage at 4°C in air tight containers.

5.3 THE EFFECT OF RIPENING STAGE ON VIABILITY OF NEEM SEEDS:

Green seeds gave the highest germinative capacity in the initial test conducted at collection (84%) and then declined sharply after a month in storage .Green seeds are the most sensitive to storage ; the reason could be the soft endocarp of green seeds subjecting the seeds to mechanical injury during extraction leading to the rapid loss of viability of green seeds in the store. Yellow seeds maintained the highest viability (52.0%) after 20 weeks of storage at room temperature. These results coincided with Wolf (1993) and Msanga (1996) who

recommended; collection of yellow to greenish-yellow neem seeds. The results also confirmed the recommendation of the final report of International Neem Network (1995) which recommended collection of greenish-yellow seeds to obtain the maximum germination percentage for seed exchange for the provenance trials in different participating countries. It also agreed with the finding of Gruber (1996) who reported that, trees in Nicaragua are harvested when 20% of fruits are yellow ripe and the rest are physiologically ripe but green. Brown seeds which have a very low initial germination are not recommended for storage.

5.4 THE EFFECT OF NEEM SEED MOISTURE CONTENT ON VIABILITY:

Germination percentage of seeds declined with the decline in moisture content of seeds. The highest viability was obtained from seeds with highest moisture content. The rapid loss of seed moisture content is due to evaporation as the store ambient was not humidified.

Chasiurisri, et al (1986) reported that maintaining of seed moisture content up to 46% will give germinative capacity above 62% for more than 4 months. While Rodear and Bellefontaine (1989) dried the neem seeds up to 5% and conserve them up to 5 years. According to our results obtained from this syudy; the high initial moisture of seeds during the storage (43.9 %) coincided with the highest germinative capacity and when moisture content decreased to 10 % the germinative capacity was decreased significantly at the end of the second month. It seems that neem seeds are very sensitive to losses in moisture .Which is expressed in the sharp drop in germination with the decline in moisture content.

This result confirms the findings of Wolf (1993) and Ezumah (1986) who reported a dramatic decline in seed viability with a rapid decrease in neem seed moisture content.

However, Karivatharaju, et al (1996) reported that the drying of neem seeds up to 10% moisture content did not affect the seed viability.

Conflicting results on minimum moisture content which can maintain higher germinative capacity of neem seeds among the different scientists could be attributed to the different climatic conditions, pre and post harvest problems.

5.5 THE RELATIONSHIP BETWEEN THE COLOUR OF THE COTYLEDONS AND VIABILITY OF NEEM SEEDS THROUGH SIMPLE CUTTING TEST:

Cotyledons of green and yellow neem seeds have dark green color at harvesting. This colour changed to pale green and yellow during the storage period (six months). This change of the colour of the cotyledons seems to be a good indicator for the viability of neem seeds. very low germinative capacity was obtained from brown seeds with brown cotyledon colour, compared to that obtained from green and pale yellow cotyledons of green and yellow neem fruits. The results agreed with the results of Benge (1988) who reported a good relation between the colour of the cotyledons and the viability of neem seeds.

The changes observed in the colour of the cotyledons between the different seeds, from different maturity stages and throughout the storage period ; together with the drop in germination percentage and moisture content of neem seeds may be due to the concentration and/or changes within the chemicals found in the seeds as a result of loss in moisture content, which is a main cause of the drop in seed viability.

5.6 PERFORMANCE OF NURSERY STOCK PLANTING VERSUS DIRECT SOWING OF NEEM SEEDS:

No significant differences were obtained between the characteristics of seedling raised in the nursery and those obtained by direct sowing in the field except in the number of leaves. This indicates that direct sowing of neem seeds is biologically possible and economically feasible as direct sowing is less costy than nursery stock production. Seedlings obtained from direct sowing though suffered from sun burning at early stage (3 months) following emergence, expressed in yellowish leaf margins and production of fewer number of leaves to cut the transpiration rate, their well established root system overcome this difficulty thereafter. The nursery stock plant may suffer from transplantation shock, check in growth and mortality under dry air conditions and scorching sun. This explains the high mortality rate of nursery stock plants.

The results of this study coincide with Bosshard, (1966) who recommended direct sowing for establishment of neem plantation at Khartoum Greenbelt, under arid conditions of Sudan. The results also concur with Troup (1921), CTFT (1963), Chaturvedi (1993) and Gijsbers, et al. (1994), who suggested that, transplantation can be successful from under 'mother' trees which is a common practice in Sudan especially in the Blue Nile province. The presented results confirmed the findings of Macky (1952) and Mhargava (1956) who recommended the direct sowing over the transplanting method. The results do not confirm with Letouzey (1961) who reported the superiority of pot plants over stumps and direct sowing. High cost of seedling raising at the nursery, little or no funding for the nurseries, the

long time needed for raising the seedling at the nursery in addition to this high mortality rate of transplanted seedlings are the main disadvantages upon which direct sowing is recommended.

5.7 EFFECT OF HORMONS ON ROOTING OF NEEM HARD WOOD STEM CUTTINGS CUTTINGS:

Vegetative propagation of A.indica by hard wood stem cuttings from young trees , did not show any response to different hormones (IBA and NAA) and different concentrations (4000, 8000, 12000 PPM and control) used. The complete failure of treated and untreated cuttings to root (except very small callus at the base of some cuttings) could be attributed to the following factors :

1. The conditions of the germination room where the experiment was run are not suitable, the relative humidity being relatively low .

2. The time chosen for the experiment (Sep.-Nov.) did not coincide with the growth period of the neem tree(Feb.-April).

3. The period of the experiment is short (70 days) for the woody species which usually take longer time to produce roots. Pierce, (1995) reported that the recommended period for tropical trees cuttings is 6 to 8 months according to the trials conducted in South Africa. Rooting of cuttings is a complex phenomenon influenced by factors such as physiological conditions, genetic origin of the donor plant, treatments with growth regulators, and the season during which the cuttings were taken (Hartmann and Kester,1968). This result confirmed with Mohinder et al. (1992) who reported the complete failure of neem semi hard

wood cuttings to root using growth regulators. While 30% rooting of cuttings were obtained from leafy soft wood cuttings. The results do not confirme with Elkhalifa, (1989) who reported 37% and 38% of rooting neem stem hard stem cuttings were obtained from with and without growth regulators treated during winter. The results do not confirme with Bosshard, (1966) who reported 5.8% of neem cuttings succeeded to be established by planting directly into irrigated field at Khartoum Greenbelt. He recommended the cuttings as a method of neem propagation in arid zones of the Sudan.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This study was carried out to investigate the effect of storage conditions on viability of neem seeds, and to evaluate the different methods of planting neem in Sudan. The main findings of this study were:

1- The most critical factor affecting neem seed viability is the moisture content of the seeds, which are very sensitive to any drop in moisture content below 40% .

2- The viability and high germinative capacity of neem seeds was not maintained beyond 20 weeks .

3- The low temperature of 4°C and 12 °C did not help storing the neem seeds for longer period, and they even have an adverse effect on seed viability .

4- Clean neem seeds from yellow fruits stored in cotton bags at room temperature maintained the highest germinative capacity during the storage period (6 months).

5- The germination of neem whole fruits irrespective of maturity stages is very poor compared to neem clean seeds.

6- Storage of neem seeds for conservation purposes (long term storage) is questionable at this stage all over the world .

7- the characteristics of seedlings obtained by direct sowing and in the nursery are more or less alike except in the number of leaves which is doubled in the nursery stock seedlings, and the high mortality rate of nursery seedlings after six months. 8- Neem hard wood stem

cuttings failed to root under controlled conditions of the germination room (Temp. 30 °C, 8 hours light and relative humidity 30-40 %) irrespective of the use of hormones (IBA, NAA) and the different concentrations used (12000, 8000, 4000 PPM).

9- The cutting test revealed a change in colour of the cotyledons of neem seeds with maturity which may be due to certain chemicals .

10- The only option for the short term storage of neem seeds is to maintain them under high relative humidity conditions which ensure that water content remains on above lethal minimum.

From this study and above findings we recommend the following:

1-The poor seed storability of neem under ambient conditions calls for specific storage conditions to maintain a high seed viability for a relatively longer period. A high relative humidity, high seed moisture, temperature around 15 °C and a ventilated storage container are suitable storage conditions.

2- Collection of yellow and greenish yellow fruits is recommended to obtain the maximum germination capacity.

3- The use of clean seeds instead of whole fruits is recommended to obtain the maximum possible germination.

4- Direct sowing is recommended over planting nursery stock because it is easy and relatively cheap.

5- Further studies of standardize conditions for vegetative propagation of neem are recommended.

6- Further studies are needed to investigate the chemical changes in neem seeds in relation to storage conditions, through chemical analysis and DNA extraction.

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