

**NET REPRODUCTIVE EFFORT, SEED PRODUCTION SPECTRUM AND QUALITY
POLYMORPHISM AS INFLUENCED BY ECOLOGICAL FACTORS IN
AZADIRACHTA INDICA Adr. JUSS, *DERRIS INDICA*. L. AND
AILANTHUS EXCELSA. ROXB., SEEDS.**

Thesis submitted in part fulfilment of the requirements for the degree of
Doctor of Philosophy in Seed Technology to the Tamil Nadu Agricultural University,
Coimbatore

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CERTIFICATE

This is to certify that the thesis entitled "**Net Reproductive Effort, Seed Production Spectrum and Quality Polymorphism as influenced by ecological factors in seeds of *Azadirachta indica* Adr. Juss, *Derris indica*. L. and *Ailanthus excelsa* Roxb**", submitted in part fulfilment of the requirements for the degree of **Doctor of philosophy in Seed Technology** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide Research work carried out by **Mr. M. SIVASAMY** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any other scientific or popular journal or magazine.

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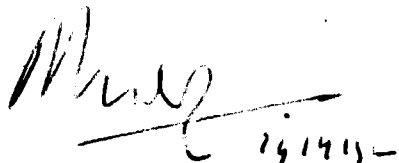
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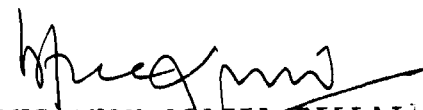
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**DEDICATED TO
MY ALMA MATER
TAMIL NADU AGRICULTURAL UNIVERSITY
AND
MY BELOVED PARENTS**

ABSTRACT

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NET REPRODUCTIVE EFFORT, SEED PRODUCTION SPECTRUM AND QUALITY
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Studies were undertaken in the Department of Seed Technology, Tamil Nadu Agricultural University, Coimbatore-3, with the seeds of *Azadirachta indica* Adr.Juss, *Derris indica* L. and *Ailanthus excelsa* Roxb, collected from various locations of Tamil Nadu, to investigate various phenology, seed development and maturation the nature of recalcitrancy (in neem only), seed polymorphism, seed source variation, storability, Azimuth influence and other seed quality characteristics.

In *Azadirachta indica* the first flowering was recorded during the first week of April, while maturity of the fruits occurred in the months of June-July. The peak flowering period was during April last week. In *Derris indica* the first flowering started during May first week; whereas the fruit maturity occurred during the month of August-September. In *Ailanthus excelsa* the first flower primordial initiation took place in the month of February (1st week) and associated with shorter flowering period in which the samara matured during the month of May-June.

The seed development and maturation study in neem revealed the maturity of the fruit and seeds of *Azadirachta indica* which took 12 weeks, when the fruit turned yellow.

Similarly, in *Ailanthus excelsa*, the samara matured after the 12th week of anthesis when the samara turned to straw yellow from greenish yellow. To attain physiological maturity *Derris indica* took 18 weeks from the date of anthesis and when the fruit turned to light brown or light straw colour, expressing the best index of physical maturity. In all the above three species, the biochemical composition of seed such as oil, protein, carbohydrates was maximum at the physiological maturity stage; while the free fatty acid and chlorophyll contents were minimum.

Results from the recalcitrancy test indicated that neem seed does not belong to the recalcitrant group. Drying the seed under direct sunlight, reduced the seed viability and vigour drastically. Interestingly drying in oven at 40°C until reduced to 16% moisture content improved the germination potential.

When seeds of neem were collected from the crow droppings germination and vigour potential were improved besides its, better storage potential. The biochemical changes were also at its minimum. The crown collected seeds performed much better under laboratory testing and also in storage evaluation than the ground collected ones.

The contact and contrast therapy using the x-ray exhibited seed source variations with respect to their seed quality revealing the anatomical and physiological potential and results indicated the superiority of the coimbatore zones (Z1).

Seed zone variation was expressive among the seeds for their germinability, vigour and biochemical compositions. Seed storage study for seeds gathered from 7 zones revealed that upon storage the temperature interacted much and the seeds of *Azadirachta indica* lost their viability sooner at low temperatures unlike other two species. The seed source variation was vivid in storage evaluations.

Azadirachta indica seeds collected during the off-season (July-Oct.) contained lesser oil and free fatty acid and it associated with more viability potential.

In *Azadirachta indica* seeds, Azimuth influence was evident and the seeds collected from South and West orientation gave best results with increased germination and vigour and associated with higher biochemical compositions.

The decoating in neem improved germination only when the seeds were forwarded for the immediate germination. The same were found not amenable for long term storage. Based on the biochemical changes and especially the free fatty acid contents the reason for the loss in viability could be correlated in all the included three species.

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude to Dr.T.V. KARIVARATHARAJU, Chairman of the Advisory Committee, Professor and Head, Department of Seed Technology, Tamil Nadu Agricultural University, for suggesting the problem and his valuable guidance, advice and encouragement throughout the study period.

I am extremely grateful and I convey my sincere thanks to the advisory committee members Dr. C.P. THIAGARAJAN, Professor, ARS, Bhavanisagar, Dr. C. SURENDRAN, Professor and Head, Forest College & Research Institute, Mettupalayam and Dr. G. RAMANATHAN, Professor, Department of Environmental Science, Coimbatore for their valuable suggestions and encouragement during the conduct of the study.

My thanks to Dr. C. Dharmalingam Professor and assistant professors, Department of Seed Technology for their valuable advice and help extended during study period.

I place on record my sincere thanks to Professor and Heads and Assistant Professors of Agricultural and Horticultural Research stations at Periyakulam, Killikulam, Srivilliputhur, Vamban and Cuddalore for their precious and timely help by providing men and material for the collection of seeds.

The help rendered by Mr. Kalaiselvan, Assistant Professor, R. Velumani, R. Shanmugasundaram and S. Sundareswaran and other friends who had helped much for shaping this thesis is thankfully acknowledged.

I express my heart felt and special thanks to Mr. Kuppusamy, Department of Seed Technology, for his help rendered during critical period of shaping my thesis.

My thanks are due to my beloved parents, sister, brother and well wishers of my life, who were extending the constant course of inspiration and encouragement throughout the period of study.

The financial assistance provided by Indian Council of Agricultural Research [ICAR] for my study is thankfully acknowledged.

I am always grateful to my Alma Mater Tamil Nadu Agricultural University for shaping me to acquire this new height.

I finally thank M/S. THATHA Clapce for taking up the data analysis and for making this draft as a masterpiece.

m.  11/12/21

M. SIVASAMY

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INTRODUCTION

CHAPTER I

INTRODUCTION

The "Nature" is increasingly put under pressure currently than ever before. However the man has started understanding the increasing distance between him and the nature, which is the welcoming sign of saving the globe from the emerging disastrous scenerio. The environmental scientists world wide continue to caution the people and the governments about the consequences of deforestation, environmental pollution, oil slicks and even the wars.

Deforestation has already caused very great problems leading to soil erosion, flooding and changes in local climate. The long term effects of the removal of the extensive forest area are at present incalculable. However, there are indications that the importance of forest to the general environment is now being recognised and it seems inconceivable that it will be allowed to disappear completely (Lawrence, 1985).

Today's silviculturists are faced with a monumental task of reviving the nature. They must maintain the present extent of forest cover and must attempt, wherever possible, to make its composition, at least somewhat like that of the natural forest. At the same time they have to ensure a yield of timber or forest products to meet ever-increasing demand, and last but not the least one must keep in mind that the forest is not just a wood producing factory, but plays a vital role in the water balance of the area and in preventing the soil erosion, thus following 'eco' preservation and 'eco' development.

In 1974 (according to the Food and Agriculture Organisation of the United Nations) forests covered about 30 per cent of the land surface, approximately 4,000 million hectares, and represented 350 thousand million m³ of wood in the world. Indonesia leads the hard wood production (140.8 million m³), followed by Brazil (130.7 million m³) and India (128.6 million m³). As on 31.12.1980 as per the forest

departments of the states and Union territories report, in India the total forest area was 74,743 thousand hectares constituting 22.73% to the total geographical area of 328,778 thousand hectares and the percapita area is just 0.11 ha. The remote sensing data exhibits fast depleting forest cover and the real picture makes the environmentalists and scientists to worry more. Hence afforestation must be taken as peoples movement and should be done at war-footing basis. In Tamil Nadu the total forest cover was 2,179 thousand hectares constituting 16.75% to the total geographical area of 13,007 thousand hectare. In Tamil Nadu the total forestry seeds collected during 1989 for afforestation programme runs to the tune of 17,466 tonnes including all acacias, eucalyptus, sandal and teak seeds indicating the potentiality of seed source in extinct.

Tree species of *Ailanthus excelsa*, Roxb, *Azadirachta indica*. Adr.Juss, and *Derris indica*. L. are considered to be the most important species in afforestation programme. The economic benefit out of the trees to be also considered while taking up such programmes, aiming at sustainable use of the resources of the land and water.

Hence the above listed species occupy paramount position in the economic front of the Indian subcontinent, which yields, raw material for pesticide, soap, resin, match and fertilizer industry as well.

Though lot many uses of the *Azadirachta indica* seeds are considered important, the foremost of them is the use of neem kernels as a source of biologically active substances for pest control is increasing world-wide. It has been found that about 200 species of insects belonging to different orders would be managed with neem products under "Integrated pest management" popularly known as IPM. Other uses such as neem oil as lubricant, oil in soap industry, neem cake as bio-fertilizer etc, is ever increasing (Ketkar, 1976).

Similarly the seeds of pungam also has the phenomenon of controlling the pest as that of neem, besides the cake is used as biofertilizer and leaves as a rich green manure.

Ailanthus excelsa is extensively used in the match industries in South India and the demand is in high order. Nearly 80 per cent of the requirements by these industries in Tamil Nadu is met by this species (Ramakrishnan, 1988).

For above uses one must realise the importance of the quality seed and the seed production spectrum of a tree species. The use of sound seed from stands of high inherent quality is widely recognised as the best means of ensuring fast grown and healthy plantations capable of yielding high quality wood. (Aldhous, 1972). Of all quality measurements of seed lots none is more important than the potential germination of the seeds (Bonner, 1974).

The test species though belongs to different families, they all can be grouped under oil seeds, since the seeds contain considerable oil in it. Poor viability in these species may be due to many reasons, but the scientists world wide could not come to a definite conclusion. However, they have estimated various biochemical compositions over the period of maturity and during storage and finally related one or two factors responsible for the shorter viability. Till date neem is under controversy either it belongs to recalcitrant or orthodox group. In this connection Roberts (1973) classified seeds as orthodox which can tolerate dehydration down to 5-6% (dry weight basis). The other group of seeds termed as recalcitrant which are high in moisture content and unable to withstand much desiccation. Recently in 1984, Chin *et al.*, proposed the fruitful method to estimate the recalcitrancy in tree seeds. Hence effort was made on this aspect to understand the possible mechanism responsible for the viability loss in the present study. Similar studies were made on other tropical and temperate tree crops, such as *Shorea siamensis* miq (Panochit *et al.*, 1984), *Quercus* (Clatterbuck and Bonner, 1985) and *Shorea robusta* (Nautiyal and Purohit, 1985).

The seed source variations were reported on many tree species and this variation is dictated by the soil and edaphic factors. This may be due to altitudinal variations (Barnett and Farmer, 1978 in yellow poplar (*Populus sp*), or region of collection (Bonner, 1984 in Oaks, Domeritt and Kettlewood 1976 in white pines). Variation in biochemical composition of seeds collected from various source was reported by Chalupa and Durzan (1972) in *Pinus banksiana*, Battacharya (1979) in *Picea glauca*. By studying the above aspects, useful information is expected on the species taken up for the study.

Tracing the seed maturation supported by the biochemical changes will help the tree scientists to fix the optimum time of harvest and to have an insight into physiological and biochemical aspects as causative factor for taking up the effective storage. Documentation, on the above aspect was made in plenty on the temperate species, leaving the tropical tree species far behind including the test species.

Among the test species *Azadirachta indica* is spread over all the zones of Tamil Nadu and the other two, are restricted to mostly the border districts of Western ghats and Eastern ghats and to some extent along the river course.

To find out the variation in seed quality, the different seed sources spread over seven Agro-ecological zones was considered and hence the study was made on the seed of *Azadirachta indica*, *Derris indica* and *Ailanthus excelca* to understand the net reproductive effort and seed production spectrum. The study comprised of the following aspects:

1. Phenological study.
2. Seed development and Maturation in neem, pungam and Ailanthus.
3. Identification in neem as to its recalcitrant nature
4. Effect of seed drying, crow feeding on neem seed quality.

5. Seed quality in relation to variation in seed source in *Azadirachta indica*, *Derris indica* and *Ailanthus excelsa*
6. Seed storage studies. Studies in the category 3 and 4 was performed only on neem seeds, since 1) neem seeds are high moisture seeds require suitable drying method, 2) tree scientists world-wide have varied opinion on the recalcitrant nature of neem seeds, 3) normally crow feeds only on neem among the test species.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Economically important tree species of neem, pungam and *Ailanthus zadirachta indica*. Adr.Juss, *Derris indica*. Linn. and *Ailanthus excelsa*. Roxb) were lected for understanding the seed source variations, phenological implications, rmination, seed size variations, storability etc. To fix the optimal stage of harvest, seed aturation study was carried out. Besides, the seed quality variations were also studied ing X-ray method and variations due to Azimuth influence, crow fed seeds, crown and ound collected seeds. Hence, the review has been made on the above aspects briefly ice the available literature is scanty for the selected species. The review has been made . the following aspects: seed source variations, seed development and maturation, orability etc., on the other tree crops involving both temperate and tropical species.

1. SEED SOURCE VARIATIONS

1.1. Physical and physiological variations

To obtain knowledge on seed source variation and characteristic criteria r identification of individual seed sources, physical and physiological characteristics of eds and their subsequent growth have been intensively studied.

Wakeley (1954) while reporting artificial regeneration had indicated the onomic importance of geographic source of seeds have been recognised over 100 ars.

Teaotia and Singh (1972) observed considerable variations in seed rmination of 24 guava (*Psidium guajava*) varieties. Maximum seed germination of 72% is recorded in the variety 'Wasik' with minimum of 23.8 % in variety 'Lucknow'.

Chalupa and Durzan (1972) examined seed size (length, weight of embryo and endosperm, weight of seed) variations in jack pine (*Pinus banksiana*), from various provenances across the natural range as a criterion for the identification of the region.

Gupta *et al.*, (1973) observed similar variations in germination of *Acacia senegal* collected from different seed sources in India. *A. senegal* seeds from the Thumshunu hills region gave maximum germination of 82%; while the lowest of 22% was recorded from seeds collected from the sitar plantations.

McGee (1974) found that *Quercus rubra* propagated from seed collected at four elevations in western North Carolina and planted at sites covering the altitudinal range of the species, showed a correlation between elevation of seed source, date of bud break and rate of seedling development.

Pathak *et al.*, (1974) examined seeds of *Leucaena leucocephala* from various sources in India and Australia and found that there was a trend of increasing heavy seeds towards the Southern latitudes with almost very heavy seeds occurring in Australia only. The seed length, breadth and thickness followed a similar pattern in respect to weight. It was observed that heavier seeds gave higher emergence in the field.

Gupta and Pattanath (1975) obtained the results from teak seeds of 18 Indian sources which evidently showed great variations in germination capacity and after ripening requirements as well as in responses to soaking in water, nutrients solution and mesocarp treatments among the seed sources.

Domeritt and Kettlewood (1976) measured total height and diameter of 29 seed sources of eastern white pine in 12 field plantings at 10 locations over 16 years in the North eastern United States and observed significant differences for unit seed source for total height and diameter.

Barnett and Farmer (1978) recorded the main source of germination variance of yellow poplar (*Liriodendron tulipifera*) seeds in the southern Appalanchians.

The variation was due to the elevation of the parent trees, with high elevation families exhibiting substantially lower germination than that of lower elevation families.

Manoharan (1978) noted the variation in germination among different samples of the same species of Malaysian ratoons. For example, germination of different seed lots of *Colanus manan* varied from 0.2 to 83 per cent.

Thapliyal and Gupta (1980) studied the germination of deodar (*Cedrus deodara*) seeds collected from six different sources which indicated variation with intensity of dormancy. The percentage of germination without stratification varied from 16.0% to 68.0% in different lots.

Cecich and Rudolph (1982) collected cones of *Pinus banksiana* from ten provenances and evaluated them for cone and seed attributes viz., seed colour, volume, fresh and dry weight, density and embryo length. Maximum embryo length was obtained two weeks before the peak germination was reached.

Ezumah (1986) conducted the germination test on the neem (*Azadirachta indica*) seeds collected from different locations of Ethiopia and could not find significant differences among the lots tested.

2.1.2. Biochemical Variations

Chalupa and Durzan (1972) estimated the biochemical composition (soluble sugars, amino acids, soluble proteins) of jack pine (*Pinus banksiana*) from various provenances across the natural range as a criterion for the identification of the region of jack pine seeds.

Bergmann (1975) reported that the gene coding for the acid phosphatase enzyme system of Norway spruce (*Picea abies*) and Douglasfir (*Pseudotsuga menziesii*) endosperms was particularly dependent on environmental factors. The acid phosphatase allele coding for single band enzymes or for double band enzymes can be identified as representing colder and moderate climatic zones respectively of the species range.

Battacharya (1979) analysed white spruce (*Picea glauca*) seeds from Ontario and the Yukon for isoenzymes and the results showed that the banding patterns of total protein and isoenzymes changed with seed origin.

2.2. Phenology

According to Madhava Rao *et al.*, (1965) the cashew trees normally start bearing in three to five years. The inflorescence being an indeterminate panicle of polygamonoecious type, in each branch of the cluster, a terminal flower is subtended immediately by two or more bracts and from the axis of these bracts grow further bracted flower stalk.

Damodaran *et al.*, (1966) reported occurrence of about 200 to 1600 flowers in a panicle of *Anacardium occidentale*.

Khan, (1986) observed the duration of flowering in *Anacardium* which took about four months from last week of November to last week of March. Further, the fruit set was around 4 to 6 per cent under West coast conditions.

According to Gunjate *et al* (1983) fruit set in Alphonso mango ranged from 0.61 to 0.67 %, whereas the fruit drop was about 94 per cent.

2.3. Seed development and Maturation

2.3.1. Maturation indices

Bonner (1970) pointed out the pitfalls in hardwood seed collection and handling and emphasised the importance of timing by applying the various known seed maturity indices.

Tekrony *et al* (1980) working on the harvestable maturity defined it as the time taken for the drying of seed to a moisture content of 14 % or less.

Tekrony *et al* (1981) used the term "physiological maturity" most frequently to describe the point when the seed reached its maximum dry weight.

2.3.2. Seed colour variation

Colour change of the seed coat from light brown to dark brown or black was offered as a reliable index of maturity in *Picea glauca* (Crossley, 1953).

Harris (1971) described cone maturation in yellow cedar (*Chamaecyparis nootkatensis*) (D. Don. Spatch), which is signalled by a colour change from green (often with purple markings) to yellow or golden brown with dark brown markings.

Gratkowski (1976b) found that seeds of a browsing shrub, *Ceanothus sanguineus* matured when the exterior pulp dried, blackened and partially flaked off exposing the capsules.

According to Bonner (1976) the best index of maturity for yellow poplar seeds is the colour change of fruits from light green to yellow green.

Shafiq (1978) noted that for *Pinus brutia* seeds in Iraq there were significant differences in germination percentage due to the time of cone collection and between individual trees. During maturation the colour of the cones changed from green to yellow and then to brown-chestnut at the time of maturity, which is the best time to collect the cones.

In *Gmelina arborea*, germination capacity of green or yellow fruits collected from the ground in Perak, Malaysia did not differ from that of ripe green fruits collected from the tree (Aminuddin and Zakaria, 1980). Brown fruits registered a much lower germination potential and hence recommended not to be collected for planting.

Sasaki (1980) also suggested to use the drying and browning of the seed wings as a good indicator of seed maturity for dipterocarp seeds under Malaysian conditions.

When the kapok seeds matured, their colour changed from dark black to brown as was observed by Gawande (1985).

Seenu (1987) observed developing seeds in acid lime to attain pale green in colour upto 135th day which then changed to creamy yellow on the 150th day. Developing seeds became germinable from 120th day onwards and recorded the maximum germination of 88.3 % on the 150th day. Fruit and seed at that stage changed their colour as visible expression of seed maturity.

Ramakrishnan (1988) traced the maturity status in *Ailanthus excelsa* in which fruits attained physiological maturity for extraction in 90 days after anthesis. At this stage the colour changed from yellow to brown.

2.3.2. Moisture content

Maki (1940) studied the seed maturity indices for *Ponderosa* pines and spruce cones. Moisture content of these cones decreased with maturity and moisture index was highly correlated with specific gravity and moisture content.

Moisture content of seed progressively decreased from an initial level of 90% to approximately 50-60 % at maturity in Lee soybeans (Andrews, 1966).

Carl and Snow (1971) reported that moisture content and colour to be the best criteria for evaluating maturity in sugar maple seeds. Germination was around 95% when seed moisture dropped below 145% of dry weight.

Matyas (1972) observed that cone and seed moisture content could be used as indices of cone ripening; pre-mature cones harvested were found to reach full maturity after a month of careful air-drying and to produce seeds with normal germination energy.

Husin *et al.*, (1981) observed the morphological and structural changes to continue in rubber (*Hevea brasiliensis*) from fruit set till its dehiscence and seed viability was the highest just before fruit dehiscence which took place 23 to 24 weeks after flowering. The dry weight of fruit and seed were also the highest at this stage; but, moisture content of seed was the lowest.

According to Gawande (1985) the rate of decline in moisture content was rapid towards the end of the ripening period in kapok.

Seenu (1987) observed fruit moisture content to increase at a faster rate upto 75th day and further increase to be gradual with advancing maturity upto 150th day in acid lime.

2.3.3. Season of collection

Someuk Pongumphai and Pranuk Likitrammenit (1975) collected cones of *Pinus kesiya* and *Pinus merkusii* at 10 days interval in January and March-April respectively. Germination percentage of seed was greater at the beginning than at the end of collection period for both species and they recommended that *Pinus kesiya* should be collected in mid-January while *Pinus merkusii* in early March.

Hashizume and Fukutomi (1978) studied development and maturation of fruit and seed in *Fagus crenata*. Germination capacity was maximum in mid to the late September but seeds collected 20 days before natural seed dispersal had good germinative capacity as mature seeds if they were stratified at 5°C immediately after collection.

Cecich and Rudolph (1982) observed the stage at which squirrels began to nibble the cones to coincide incidentally with seed maturity in jack pine.

Physiological maturity of seed was attained in Rangpur lime at the juvenile stage of fruit i.e., 150 days after anthesis (Desai and Patil, 1983).

2.3.4. Biochemical changes during maturation

Rediske (1961) traced the seeds of Douglas fir maturation and reported the following biochemical changes.

- a. The reducing sugar content of Douglas fir seed decreased as the seed matured.
- b. The non-reducing sugar content decreased from a high of 15 mg per g with immature seed to a low of 3.5 mg per g with mature seed, when ripened on the tree. However, when ripened artificially the non-reducing sugar concentration increased from the picking.
- c. The differences of starch, soluble nitrogen and protein nitrogen concentration between immature and mature seeds were relatively minor with high concentration of 13 per cent, 1 mg per g and 22 mg per g respectively.
- d. The crude fat concentration as well increased from 16% when immature to 23 % when matured.

Bonner (1972) studied the maturation of sweet-gum and sycamore seeds for over three consecutive years in central mississippi and reported that sweet gum (*Liquidambar styraciflua*. L) and sycamore (*Platanus occidentalis*. L) fruits had nearly reached full size by late June. Sweet gum seeds were physiologically mature by mid August, but dry weight increased until late September. As sweet gum seeds matured, the crude fat level rose to 27 % of seed dry weight. During maturation, concentrations of soluble nitrogen, soluble carbohydrates, and magnesium decreased; while those of protein, nitrogen and phosphorous increased. Sycamore seeds became physiologically mature by early September. Chemical changes in sycamore were similar to those in sweet gum, except that the major food reserve were carbohydrates and not fats.

Bonner (1974a) estimated the fats and carbohydrates, the major stored energy reserves in acorns of the Water oak which began to accumulate rapidly in August. Crude fat levels in Water oak acorns reached 20 % of acorn by weight at maturity in late October.

According to Bonner (1974b) the soluble carbohydrates gradually increased from July to early September, which dropped sharply due to its conversion to insoluble forms.

At maturity the total carbohydrates content of Water oak acorns was 26% with all but 5% in insoluble forms.

Blanche *et al.*, (1980) related the loss of green colour in the acorns to the decreasing total chlorophyll content.

Nautiyal and Purohit (1985) studied the growth of sal (*Shorea robusta*) seeds from the day of anthesis till full maturity to find out if the changes during this period are associated with the early loss of seed viability. The spurt in the activity of acid phosphatase coincided with that of active period of differentiation and maturation and the on set of desiccation was accompanied by the fall in the level of soluble carbohydrates. Further, they have estimated the change in the chlorophyll ratio over the period of maturation.

According to Seenu (1981) the protein content increased progressively upto maturity; while the oil content declined after 135 days in acid lime.

Renganayaki (1989) traced the maturation in cashew in which the apple took 56 days to obtain harvestable maturity while the reducing sugar content was high at 56 days after fruit set.

2.4. SEED QUALITY VARIATION STUDIES

Bonner (1984) tested the Southern oak seed quality through expressions of germination rate such as Peak Value (PV) or Mean Germination Time (MGT) which provided good estimates of acorn quality, but completion required minimum of 3 weeks. For more rapid estimates, tetrazolium staining was recommended.

FAO (1985) reported that seeds of some of the trees passed through the digestive systems of animals and birds improved the germination.

2.5. AZIMUTH INFLUENCE

Subbiah (1983) reported that the productivity of an entire inflorescence or a whole fruiting branch was related to its orientation with respect to the sun. The number of nodes, fruit set and the percentage of fruit set were the highest in panicles on the western and southern sides of the canopy. Damage by *Helopeltis antonii* was also less on those sides. However, the physiological disorders of apple cracking was higher than those on the eastern and northern sides.

Investigation by Renganayaki (1989) indicated that *Anacardium occidentale* trees had more primary and secondary branches in southern and western directions of the plantation. The number of hermaphrodite flowers and percentage of fruit set were also high in these two directions than northern and eastern directions. The oil content and protein content of fruit and sugar content of apple were high in these directions than northern and eastern directions.

2.6. X- ray ANALYSIS OF SEEDS : CONTACT AND CONTRAST THERAPY

Simak (1957) successfully used X-ray contrast method which involve various contrast or radiopaque agents.

Kamra (1964) cited that the X-ray technique which was first used by Lundstrom as early as 1903. He reported that the principle of X-ray contrast method was based on the principle of semi-permeability. When seeds are treated with a contrast agent, for example aqueous BaCl_2 or vaporous CHCl_3 , their living tissues are able to prevent its entry due to their semi-permeability, but the dead tissues become impregnated. The impregnated tissues absorb X-radiation more intensively, they appear lighter on the film than the un-impregnated ones.

Kamra (1973) successfully applied the X-ray radiography in determining the number of seeds in fruits of Teak (*Tectona grandis*) and for studying their degree of development.

Kamra (1974, 1976 and 1980) used this technique on the fruits or seeds of sixty tropical forestry species and the results showed that it can be reliably applied in processing such seeds.

Simak (1980) revealed the use of the X-ray technique when radiographing a seed, the X-rays penetrate through a sandwich of seed tissues which possess different densities. Each X-ray registered on the film the total density of the seed parts through which it had penetrated, i.e., the vertically supposed layers of seed tissues cannot be registered separately in the film. He used this technique to determine the empty seeds, insect infested seeds, mechanical damage to the seeds, seed quality according to the degree of seed development and quality of the ungerminated seeds at the end of germination test.

In horticulture, assessment of seed quality is an important factor of progress (Chauaghat 1987) which must be given with the highest precision. Among the different techniques used, soft X-ray radiography is a fast and commonly used method of seed quality observation. Further, it has the greatest advantage of not being destructive. It prints the inside structure of one or several seeds on a radiographic paper or a film without damaging germinative capacity.

2.7. SEED DRYING

Hume (1959) found that seeds under storage, particularly in citrus if allowed to dry, lost viability quickly.

Mantenegro and Salibe (1960) registered decline in seed germination in respect of caipira, trifoliate orange, rough lemon and cleopatra mandarin when allowed to dry in storage.

Berjak *et al.*, (1984) studied the drying effect of propagules which are recalcitrant in *Avicennia marina*, being shed at a moisture content of approximately 63.% (wet mass basis). They lost viability in 14 days on dehydration to 52%, although

this value depended on the rate of dehydration. He studied the change in root primordia polysome levels, mitochondrial activity and vacuolation by cytoplasm formation. With continued dehydration, the degree of vacuolation increased considerably and various subcellular systems lost their integrity, became markedly deteriorated by the stage of loss of viability. It was suggested that the differing desiccation tolerancy of orthodox and recalcitrant seeds may be related to the differences of subcellular water in the two types.

Edwards and Mumford (1985) dried the seeds of sour orange in streams of air and some of its constituent (oxygen, nitrogen and CO₂) at two temperatures. Seed lost moisture at different rates in the atmosphere of gases at the same temperature and showed marked variation in germination. Intact seeds dried at the rate of 30% moisture loss per 100 h in a rapid air current showed the best viability.

2.8. ESTIMATION OF RECALCITRANCY IN SEEDS

Chin *et al* (1984) recommended a method to identify the presence of recalcitrancy in seeds. Seeds could be classified into two groups, viz., orthodox and recalcitrant. However, recently it was found that some of the recalcitrant species are not truly recalcitrant. This classification was a result of faulty drying which damaged and killed the seeds.

2.9. SEED STORAGE

2.9.1. Container

The sole virtue of sealed storage is to preserve proper moisture content and prevent contamination by fungi and possibly other enemies in storage. Obviously if the seeds are not dried to the optimal moisture content before sealed, sealing may serve only to prolong an unfavourable condition (Baldwin, 1942).

Lewis (1952) found that seeds of *Primula sinensis* in sealed containers remained reasonably viable for atleast 7 years.

Citrus seeds recorded maximum germination when stored at ambient temperature and 50 per cent Rh followed by storing in polythene bag of 700 gauge (Bajpai *et al.*, 1962).

Heit (1967) reported that seeds of *Ailanthus altissima* (Mill) Swingle, could be stored well for longer period in sealed containers. Bonner (1981) reviewed the work done on seed storage of hard wood species and recommended the required moisture content, temperature and storage conditions of various tree seeds including both recalcitrant and orthodox seeds.

In Australia, seeds of *Acacia harpophylla* deteriorated rapidly (Turnbull, 1983) unless stored in sealed containers at 2-4°C.

In *coffea arabica*, seed stored with moss in polyethylene bags showed good viability upto 200 days which declined there after to a germination of 27 per cent (Reddy and Vishveshwara, 1985).

Ezumah (1986) reported that germination of fresh neem seeds was good after a short term storage, provided seeds were stored in air-tight containers.

Among the storage containers for *Ailanthus excelsa*, paper aluminium-foil-polyethylene laminated pouch proved effective in maintaining seed quality (Ramakrishnan, 1988). In general, seeds packed with sand medium registered the maximum germination and vigour irrespective of the containers.

2.9.2. Seed moisture and temperature

Various tree species require varying conditions of seed moisture content and temperature to maintain their viability and vigour during storage (Holmes and Buszewicz, 1958).

Heit (1967) reported that seeds of *Ailanthus altissima* (Mill.) Swingle could be stored well for long period at low moisture content.

Roberts (1973) classified seeds into two categories i.e., orthodox and recalcitrant. Seeds which can be dried down to a low moisture content of around 5% (wet basis) and successfully stored at low or sub-freezing temperature for long period are classified as orthodox seeds, and seeds which cannot survive while drying below relatively high moisture content (20-25% wet basis) and which cannot be successfully stored for long periods are classified as recalcitrant.

Boland *et al.*, (1980) recommended a moisture content of 4.8% for an adequate storage life. They also indicated that over 80 % of the forestry commissions seed stocks were below 8% moisture content and 95 % were below 10 % moisture content.

King *et al.*, (1981) observed maximum viability in lemon and lime seed when stored at a low moisture content at 5 % and temperature of -20°C.

Lockett (1981) reported high moisture content to depress storage life in *Eucalyptus* seed. Findings of Edwards (1982) indicated seed moisture content to be the critical factor governing storage period in *Abies* seeds.

According to Hor *et al.*, (1984) Cocoa seed maintained a germination of above 67 % for 70 days when stored at a moisture content of 33-35 % and a temperature of 17°C to 30°C.

Germination of fresh neem seed was good at 26°C-30°C but was adversely affected at temperatures above 30°C and totally suppressed at 6-7°C (Ezumah, 1986).

2.9.4. Seed Biochemical Changes

Clatterbuck (1985) studied the changes in food reserve of recalcitrant seeds of *Quercus* during eight months of storage at 20°C. Acorns of *Q. nigra*, *Q. shumardii*, *Q. falcata* var *pagodaefolia*, and *Q. alba* decreased steadily in crude fats and increased slowly in soluble carbohydrates. Also he studied the insoluble carbohydrates

which increased during three or four months of storage. Respiration data indicated lipid metabolism and moisture levels increased in all species during the storage.

Tonapi and Karivaratharaju (1989) obtained positive correlation of vigour with each of the soluble sugars, starch, protein and phosphorous fractions in sorghum seeds and reported the possibility to use these biochemical indices as a vigour test in other crops too.

Krishnaswamy and Seshu (1990) observed high germination rate and faster seedling growth of the seeds with high α -amylase content in paddy.

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1. MATERIALS

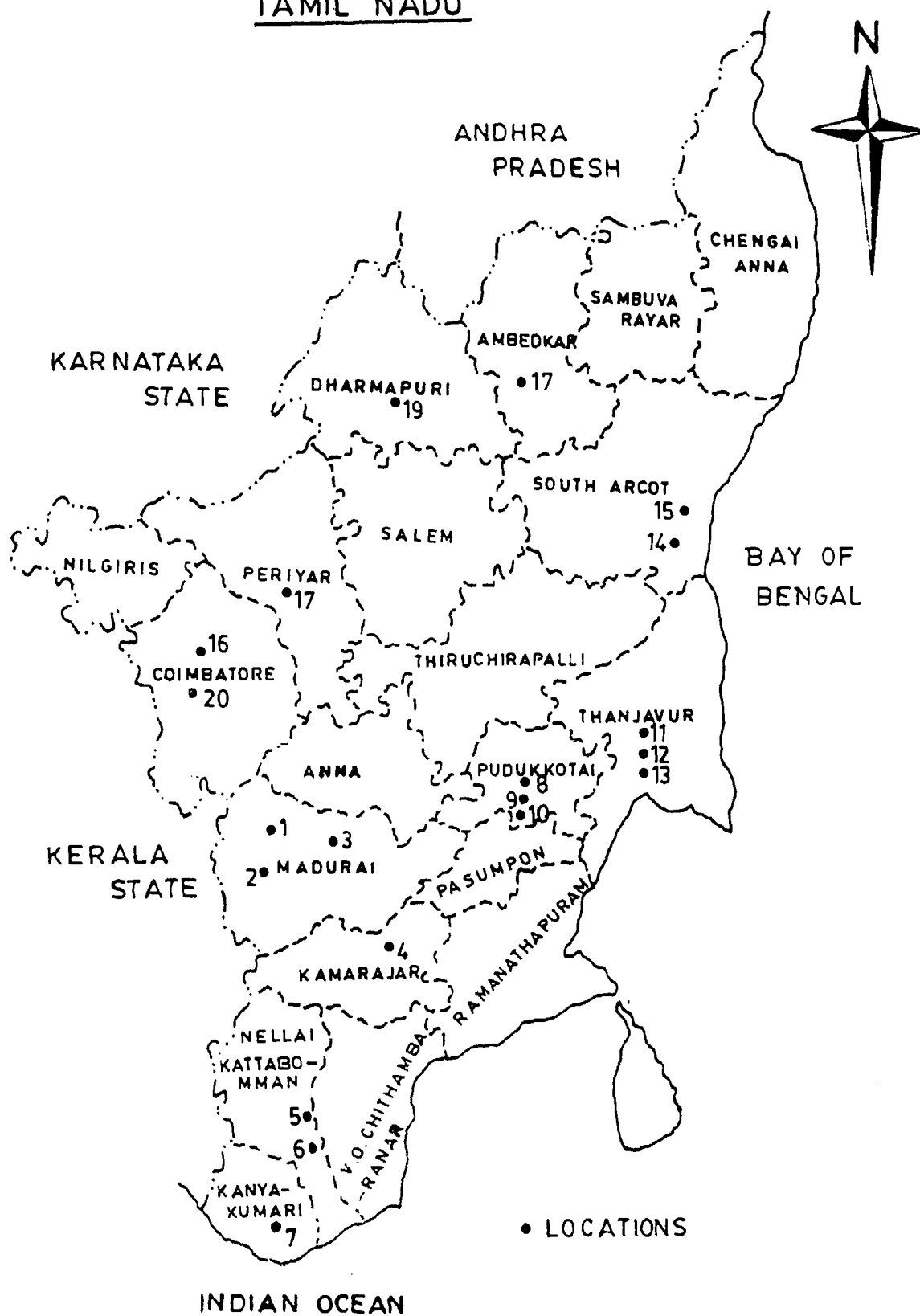
Seeds of Neem (*Azadirachta indica* Adr.Juss), Pungam (*Derris indica* L.) and *Ailanthus excelsa* Roxb. were collected from seven agro-ecological zones classified based on soil type and rainfall. Seeds gathered from 20 locations pooled to form 7 zones (*Azadirachta indica*), 14 locations pooled to form 7 zones (*Derris indica*) and 7 locations (*Ailanthus excelsa*) formed the basic seed material for the study (Fig: 1,2 & 3). The season of collection was in the month of April (*Ailanthus excelsa*), July (*Azadirachta indica*) 1989, and December 1989 for *Derris indica*. Floral description is given in Fig.,4, 5 & 6 and species description in Annexure-I

Table. Detailed description of seed source

Sl.No.	Species	Zone	Location
1.	<u><i>Azadirachta indica</i></u>	1	Coimbatore (L20) Coimbatore (L10) Onnipalayam (L16)
		2	Erode (L18) North Arcot (L17) Dharmapuri (L19)
		3	Venkatachalapuram (L2) Killikulam (TNV) (L5) Killikulam (L6)
		4	AC & RI, Madurai (L3) Sathiretipatti (L4)
		5	Nagarkoil (KAN) (L7) Dombuchery(MDU) (L1)

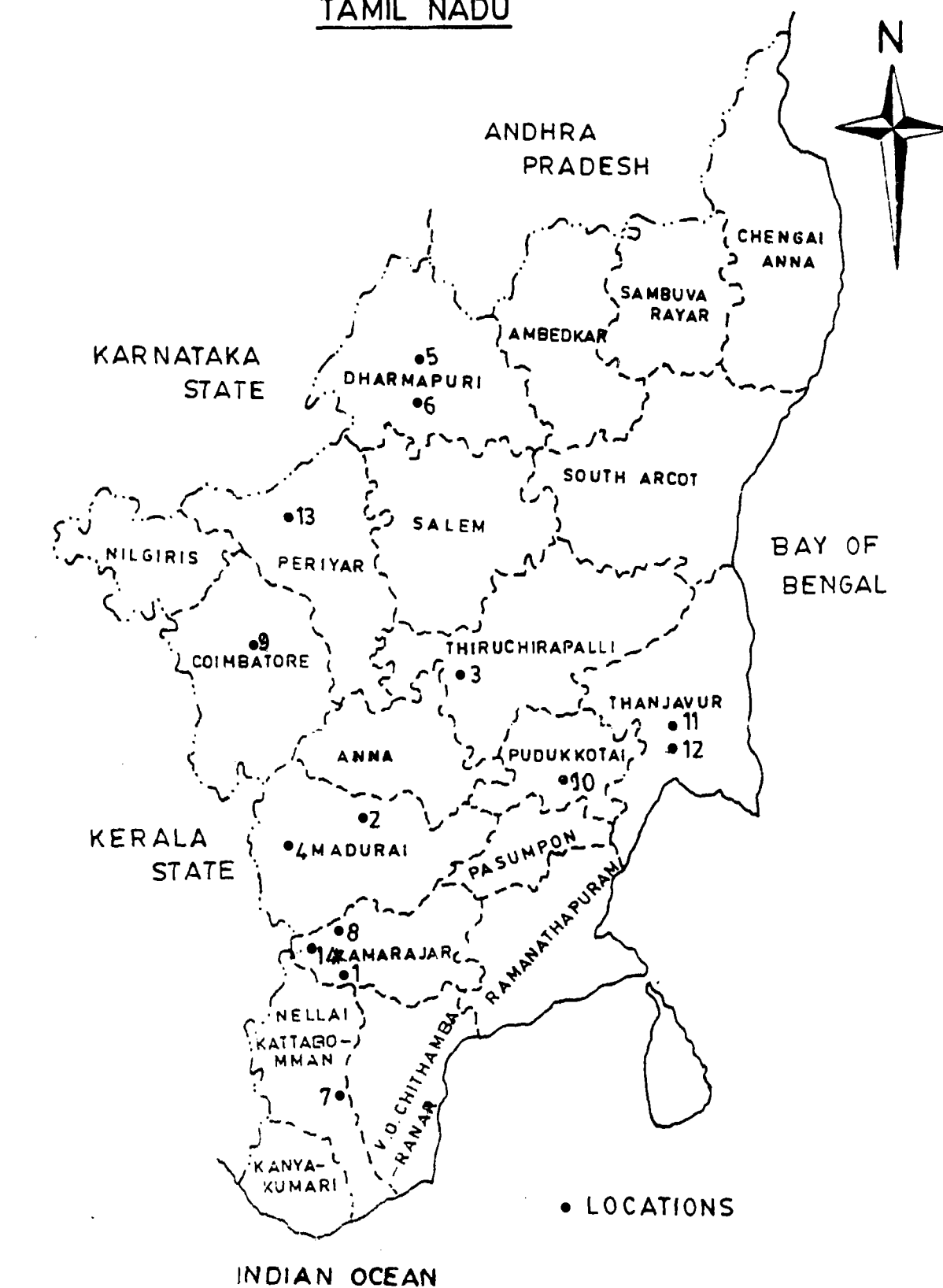
Sl.No.	Species	Zone	Location
		6	Orathanadu-1 (L11) Orathanadu-2 (L12) Orathanadu-3 (L13)
		7	Vamban (PUD)-1 (L8) Vamban (PUD)-2 (L9) Vamban (PUD)-3 (L10) Cuddalore-1 (L14) Cuddalore-2 (L15)
2.	<u>Derris indica</u>	Z1	Onnipalayam (L9)
		Z2	Dharmapuri-1 (L5), Dharmapuri-2 (L6) Erode (L13)
		Z3	Rajapalayam (L1). Srivilliputhur (L8). Senbagathoppu.(L14)
		Z4	Madurai(AC & RI) (L2).
		Z5	Dombucheri (MDU) (L4).
		Z6	Mukkombu (Trichy) (L3) Orathanadu-1 (L11). Orathanadu-2 (L12)
		Z7	Vamban-1 (L7). Vamban-2 (L10)
3.	<u>Ailanthus excelsa</u>	Location	
		L1	Vivekanandapuram.
		L2	Coimbatore.
		L3	Sathiyamangalam.
		L4	Dharmapuri.
		L5	Trichy
		L6	Madurai(AC&RI).
		L7	Namakkal, Salem.

Fig. 1 Locations of seed collection for Neem
Azadirachta indica Adr. Juss Meliaceae
TAMIL NADU



5' - 13' 10' - N. Latitude

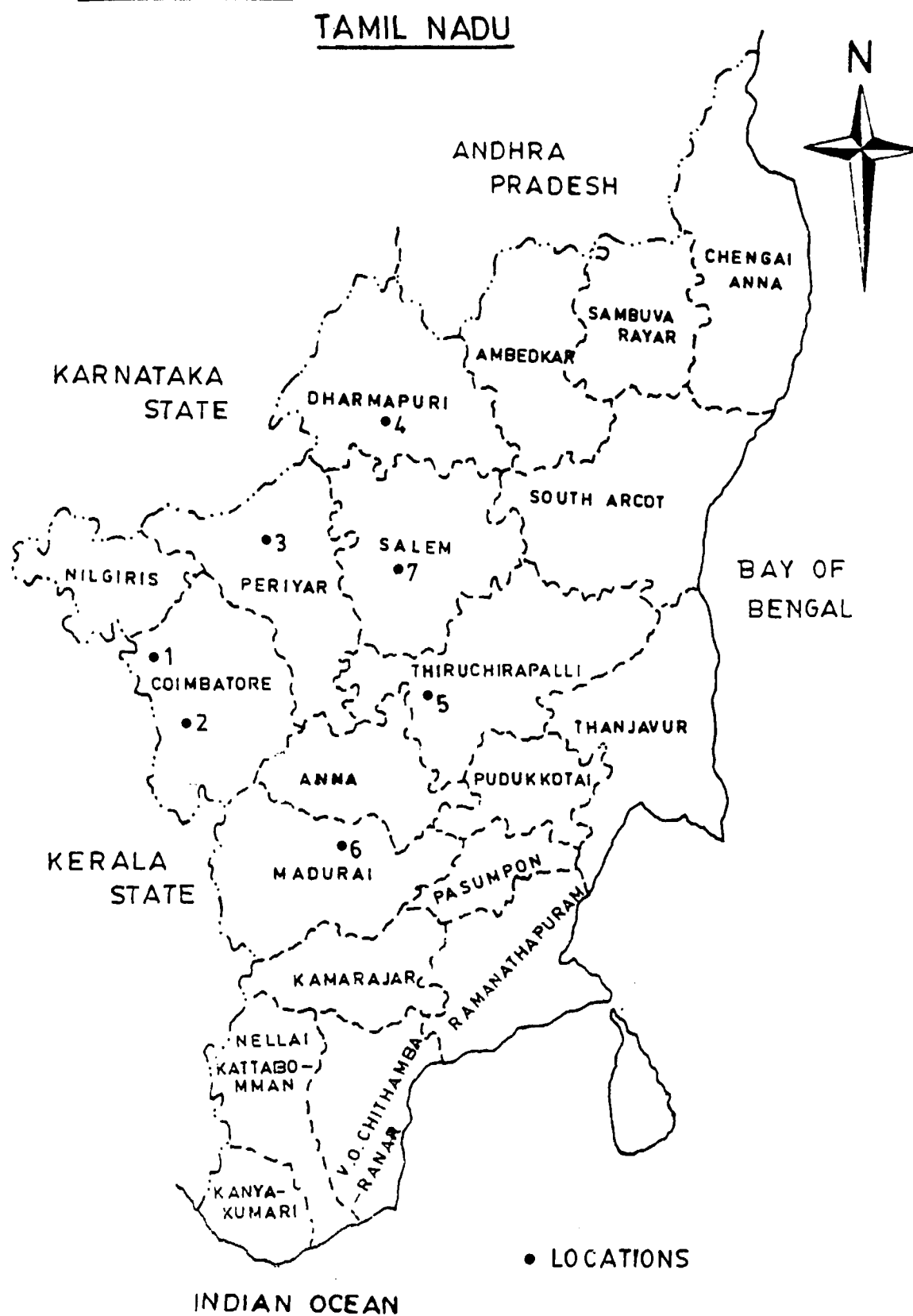
Fig. 2 Locations of seed collection for Pungam
Derris indica L. Leguminaceae
TAMIL NADU



8° 5' - 13° 10' - N. Latitude
 76° 45' - 80° 30' E. Longitude

Fig.3 Locations of seed collection for Ailanthus excelsa.Roxb.
Simarubaceae

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8° 5' - 13° 10' - N. Latitude

Agro-ecological zones of Tamil Nadu

1. The red soil regions of Coimbatore with rainfall ranging from 700-800 mm.
2. Red loam soils of Salem and North Arcot districts with the rainfall ranging from, 800-900 mm.
3. Red sandy soils of Madurai, Kamarajar and Nellore- Kattabomman districts with the rainfall of, 700-800 mm.
4. Black cotton soils of Coimbatore, Madurai districts with the rainfall ranging from, 650-800 mm.
5. Deep red soils of Madurai, Nellore-Kattabomman and Kanyakumari districts along the Western ghats with the high rainfall of more than 2000 mm.
6. River alluvium soils of Thanjavur and Tiruchirappalli districts with rainfall of 1000 mm and above.
7. Saline coastal alluvium soils of Chengai-Anna, South Arcot, Thanjavur and Chidambaram districts with rainfall ranging from 1000-2000 mm. Soil description fertility levels and rainfall particulars of Tamil Nadu is given in Annexure-II.

3.2. METHODS

3.2.1. Phenological study

3.2.1.1. Date of first flowering

The trees selected at Tamil Nadu Agricultural University, Coimbatore was utilised for the purpose and the date of first flowering was recorded based on the first flower primordia initiation.

Fig. 4 Floral discription of Azadirachta indica. Adr. Juss 27
Meliaceae



a. Bisexual flower. b. Flower panicle. c. Stem branch
bearing flower panicle. d. Fruit. e. Cross section of

Fig. 6 Floral discription of Ailanthus excelsa Roxb.
Simarubaceae

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<i>Azadirachta indica</i>	- 1st week of April
<i>Derris indica</i>	- 4th week of April
<i>Ailanthus excelsa</i>	- 2nd week of February

3.2.1.2. Duration of flowering

Right from the first flower primordia initiation to the completion of flowering, the observations were made and expressed in days.

<i>Azadirachta indica</i>	- 1 month
<i>Derris indica</i>	- 1 1/2 month
<i>Ailanthus excelsa</i>	- 10-15 days

3.2.1.3. Peak flowering period

This is referred to number of days taken for more than 50% flower opens, expressed in days, taken after the flower primordia initiation.

<i>Azadirachta indica</i>	- Middle of April
<i>Derris indica</i>	- First week of May
<i>Ailanthus excelsa</i>	- 2nd week of February

3.2.1.4. Maturity period

This is referred to days taken for more than 50% fruits/samara attains physiological maturity stage.

<i>Azadirachta indica</i>	- June-July
<i>Derris indica</i>	- August-September
<i>Ailanthus excelsa</i>	- May-June

3.2.1.5. 1000 Seed weight

The weight of 1000 seeds at 16, 12 and 12% moisture content for *Azadirachta indica*, *Derris indica* and *Ailanthus excelsa* respectively was taken using the top pan electric balance and expressed in grams.

3.2.2. Seed development and maturity studies in neem (*Azadirachta indica*)

From the existing tree stand available at the Tamil Nadu Agricultural University, Coimbatore-3, a tree approximately aged 20 years was selected for studying the physiological maturity status of seed. The flowers were tagged at the time of first flower primordia initiation for recording the observations during March, 1989. Atmost care was taken to tag more number of panicles to overcome the problem of heavy flower/fruit shedding. The fruits were collected from the tree tagged at weekly interval (ie., once in 7 days). One hundred fruits were forwarded at each stage for studying the development and maturation of fruit and seed.

Stages of S₁, S₂, S₃, S₄..... S₁₄ represents 7, 14, 21, 28, 35 98 days after anthesis.

3.2.2.1. Fruit and seed physical characters

The length of fruit and seed was measured by using a fine thread from the base to the tip of the fruit and seed separately; while the breadth of fruit and seed was measured by sending the thread round the fruit and seed surface, finally expressed in centimeter.

3.2.2.2. Fresh weight of fruit/seed

Immediately after the harvest, ten fruits were taken for measuring the weight using top pan electric balance and expressed in g/fruit.

3.2.2.3. Fresh weight of seed

The seeds were extracted by wet pulp extraction method and later the excess moisture was removed using blotter paper and weighed on the top pan electric balance and expressed in grams.

3.2.2.4. Moisture content of fruit/seed

Immediately after recording the fresh weight of the fruits/seeds, they were dried under the sun for 12 h and then transferred to the hot air oven maintained at 105°C for 6 h and was weighed on the top pan electric balance, after cooling it for 30 minutes and expressed in grams (Dry weight). The moisture content was expressed in percent on wet basis using the following formula:

$$MC \% = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.2.2.5. Germination test

One hundred seeds were taken for the study and germination test was conducted using sand medium in four replications each with 25 seeds.(Anon, 1985).

	<i>Azadirachta indica</i>	<i>Derris indica</i>	<i>Ailanthus excelsa</i>
First count on (days)	14	21	14
Final count on (days)	21	28	21

The experiment was carried out in a germination room at 25 ± 2°C with presence of cool light and expressed in percent.

3.2.2.6. Estimation of oil content

For estimating the oil, the seeds were decoated and the kernalns were dried at 50°C for 16 h and allowed to cool in a desiccator. Five grams of seeds were pulverished to a fine powder in a porcelain mortar. Ground sample was placed in a filter paper and fastened in such a fashion as to prevent escape of the meal and then carefully transferred to an extraction thimble. The thimble was then placed in a Soxhlet extractor to which sufficient quantity of solvent petroleum ether (40-60°C) was added and heated until seven siphonings were completed. The oil content was recorded by evaporating the petroleum ether at 60°C. The entire extraction process was carried out in Soxhlet extractor according to the procedure outlined in AOAC (1960). The percentage of oil content was then calculated by using the following formula.

$$\text{Oil percent} = \frac{\text{Oil weight (g)}}{\text{Sample weight (g)}} \times 100$$

3.2.2.7. Free fatty acid

Total free fatty acid content of the oil was estimated by volumetric method . A known quantity of about 1 to 1.5 g of oil was thoroughly mixed with 25ml of neutralised 95 per cent alcohol. This mixture was then heated to boiling and while hot it was titrated against 0.02N NaOH.solution to a faint pink end point using phenolphthalein as an indicator. The free fatty acid was calculated as per cent oleic acid using the following formula of Karon and Aetschul (1944).

$$\text{Per cent of total free fatty acid (as oleic acid)} = \frac{28.2 \times 0.02 \times \text{ml. of alkali used}}{\text{weight of oil}}$$

3.2.2.8. Protein content

The protein content of seed was estimated by the colorimetric method of Ali-khan and Youngs (1973). The estimation of the protein content was done by utilising the oil free meal of the ground material (after oil analysis). Sample of 100 mg of the oil free meal of the powdered seed material was taken in a 50 ml polythene screw cap bottle and 25 ml of 1N NaOH was added. The mixture was shaken for five minutes in a wrist action shaker, to disperse the protein. Then 10 ml of the suspension was poured into a graduated test tube and used as a blank to compensate for the difference, in the amount of natural pigments extracted. To the remaining suspension in the bottle, 0.25 ml of 10% copper sulphate was added and the bottle was reshaken for an additional duration of 5 min., to develop the color complex. The sample was then poured into a separate test tube left overnight to allow the dispersed material to settle down. The optical density (O.D. value) of the clear supernatant solution was measured at 600 nm against the blank in systronics photo electric colorimeter type 101. Protein percentage was calculated by using the following formula:

$$\text{Protein per cent} = 3.78 + (61.6 \times \text{O.D.value}).$$

3.2.2.9. Estimation of chlorophyll in Neem

Spectrophotometric method A.O.A.C. (1960) was followed.

Pigments--chlorophyll-a, chlorophyll-b and total chlorophyll were estimated.

One g of seed sample was macerated in a glass mortar with a pinch of calcium carbonate and quartz sand with the addition of 85% acetone little at a time. It was filtered under suction and the residue was washed with acetone till the tissues were free of green colour and final washing was transferred into a separating funnel containing 50 ml of ether. The extract was then passed through a column of distilled water in a

separating funnel. The pigment portion in the upper layer was retained and the lower layer of water was discarded. The washings were continued till the chlorophyll extract was free from acetone. The optical density of the extract was measured in a spectronic-20 spectrophotometer at 645 nm and 663 nm respectively. Chlorophyll a,b and total were calculated employing the following formula.

$$\text{Chl. a} = \frac{12.7 \times \text{O.D at 663} - 2.69 \times \text{O.D at 645}}{0.25 \times 1000} \times 25$$

$$\text{Chl. b} = \frac{22.9 \times \text{O.D at 645} - 4.68 \times \text{O.D at 663}}{0.25 \times 1000} \times 25$$

$$\text{Total chl.} = \text{chl a} + \text{chl b}$$

3.2.3. Seed Development and Maturation Studies in Pungam (*Derris indica*)

To trace the seed development and maturation in pungam, a tree aged about 15 years was selected from the existing stock at Tamil Nadu Agricultural University, Coimbatore-3, during April, 1989. At periodical interval of 7 days, 100 pods were collected and forwarded for conducting various tests.

The different stages of S₁, S₂, S₃, ... S₂₀ represents 7, 14, 21, 28, 35 140 days after anthesis respectively.

3.2.3.1. Study on fruit and seed characters

- i) Length of pod and seed as detailed in 3.2.2.1.
- ii) Breadth of pod and seed as detailed in 3.2.2.1.
- iii) Fresh weight of pod and seed as detailed in 3.2.2.2.
- iv) Dry weight of pod and seed as detailed in 3.2.2.2.

- v) Moisture content of pod and seed as detailed in 3.2.2.4.
- vi) Germination test as detailed in 3.2.2.5.

3.2.3.2. Biochemical studies

- i) Oil content (seed) as detailed in 3.2.2.6
- ii) Free fatty acid (seed) 3.2.2.7
- iii) Protein content (seed) 3.2.2.8

3.2.4. Seed Development and Maturation Studies in *Ailanthus excelsa*

To fix the optimal stage of seed harvest in *Ailanthus excelsa*, the seed development and maturation sequence was traced out from a tree tagged at Onnipalayam, Coimbatore District with the existing stand. The tagging was performed during February, 1990 and the study was completed during May, 1990. While tagging, utmost care was taken to tag more number of panicles to compensate the flower shedding. Each time 100 samaras were forwarded to carry out the following studies.

The stages S₁, S₂, S₃, ...S₁₄ refer to the days taken after anthesis viz., 7, 14, 21, 28, ... 98 days respectively.

3.2.4.1. Physiological tests

- i) Length of the samara as detailed in 3.2.2.1.
- ii) Breadth of the samara as detailed in 3.2.2.1.
- iii) Fresh weight of the samara as detailed in 3.2.2.2.
- iv) Dry weight of the samara as detailed in 3.2.2.4.
- v) Germination test as detailed in 3.2.2.5.

3.2.4.2. Biochemical tests

- i) Estimation of oil as detailed in 3.2.2.6.
- ii) Estimation of free fatty acid as detailed in 3.2.2.7.
- iii) Estimation of protein as detailed in 3.2.2.8.

3.2.5. Identification in Neem [*Azadirachta indica*] as to its recalcitrant nature

Seeds can be grouped into orthodox and recalcitrant based on their storage behaviour. However recently Chin *et al* (1984) reported that due to faulty drying method some of the orthodox are wrongly grouped or understood to be recalcitrant. So in order to find out whether or not neem belongs to the group of recalcitrant the following test was carried out.

Freshly harvested seeds were subjected for moisture content estimation by drying the seed at 105°C for 16 h in an oven after estimating the fresh weight. About 100 seeds were forwarded for conducting the germination in sand medium at 25°C $\pm$ 5°C, to test the initial viability (ISTA, 1985).

The cleaned seeds were then air dried at 20°C $\pm$ 3°C in an air conditioned room. After 24 h air drying, three samples of 50 seeds each were taken, the first for immediate germination, while the second and third samples were put in a refrigerator at 5°C and in freezer at -5°C respectively. After 24 h storage these were sown in sand to test the viability.

The balance of 500 seeds was left at 30°C in an oven and when seeds reached 10-15% moisture content, samples of 50 seeds were again taken and put in at 5°C in a refrigerator and freezer respectively for 24 h and their germination then tested by sowing in sand boxes.

Classification of recalcitrant seeds [model]

		Germination percentage	
Species		a	b
High M.C.	M.C %	53	-
	F	100	-
	A	70	-
	B	0	-
Intermediate M.C	M.C %	43	-
	F	0	-
	A	0	-
	B	0	-
Low M.C	M.C %	30	6
	F	0	96
	A	0	58
	B	0	32
Seed type	R	O	

Where: a and b species

MC - Moisture content

R - Recalcitrant

F - Freshly harvested

O - Orthodox

A - Stored at 5°C for 24 h.

B - Stored at -5°C for 24 h

In the present study following treatments were given

M1 - 50 % moisture content

M2 - 26 % moisture content

M3 - 16 % moisture content

- T1 - Freshly harvested seeds
- T2 - Seeds stored at 5°C for 24 h
- T3 - Seeds stored at -5°C for 24 h, latter seeds were tested for its germination as detailed in 3.2.2.5

3.2.6. Effect of seed drying on seed viability of Neem [*Azadirachta indica* Adr.Juss] seeds.

Fresh seeds of neem collected were extracted by using wet extraction method and 1000 seeds were dried under the direct sunlight for 12 h and the seed moisture content was brought down to 18 per cent (D1). Seeds were dried under shade till moisture content reaches 18 per cent (D2) and another 1000 seeds were dried under oven drying method at 30°C for 24 h till the M.C. was brought down to 18 per cent (D3) separately. Later, the seeds were subjected to the following tests.

- i) Moisture content estimation as detailed in 3.2.2.4
- ii) Germination test as detailed in 3.2.2.5
- iii) Root and shoot length

Ten normal seedlings were selected from each replication at random and carefully removed from the sand medium. The shoot length was measured from the collar region to the tip of the leaf and root length from the collar region to the tip of the primary root and expressed in centimeter.

- iv) Vigour index based on dry matter production.

After measuring the root and shoot length the seedlings were air dried in shade for 8 h and subsequently dried in a hot air oven maintained at 105°C for 16 h cooled in a desiccator for 30 min and weighed on the top pan electric balance and recorded in milligram.

The vigour index was calculated by using the formula (Abdul-Baki and Anderson-1973) as follows:

Germination percentage x total dry matter content (mg).

3.2.7. Effect of Crow feeding of Neem seeds on its Viability

Crow fed seeds were collected carefully from underneath the other trees during the season of maturity and dried under shade for 24 h to have the moisture reasonably for the seed storage. The seeds collected by then said procedure stored under ambient condition of 25°C $\pm$ 3°C in a cloth bag and periodically the following experiments were performed, by comparing with the control.

C1	-	Control.
C2	-	Crow fed seeds.
D0....D5	-	periods of storage.

3.2.7.1. Physiological test:

- i) Moisture content as detailed in 3.2.2.4
- ii) Germination as detailed in 3.2.2.5
- iii) Root and shoot length as detailed in 3.2.6(iii)
- iv) Dry matter production as detailed in 3.2.6(iv)
- v) Vigour index as detailed in 3.2.6(iv)

3.2.7.2. Biochemical tests:

- i) Estimation of Oil as detailed in 3.2.2.6
- ii) Estimation of free fatty acid levels as detailed in 3.2.2.7
- iii) Estimation of protein as detailed in 3.2.2.8
- iv) Estimation of total soluble carbohydrates (Nalewaja and Smith (1963)).

The weighed samples were forwarded for determination of dry matter content. This value was used to estimate the dry matter content of the seed sample to be analysed.

Extraction of ethanol soluble sugars from the seed material was accomplished by placing a frozen sample in a waring blender containing boiling ethanol. A ratio of 4 ml of 70% ethanol per gram of fresh material (V:W) was used. The amount of water present in the fresh material was taken into consideration in diluting 95% ethanol to the final extraction concentration of 70 per cent. A sealed container for sample extraction was considered to prevent solvent evaporation. The sample was then blended for 7 minutes.

The tissue homogenate is filtered under low vacuum, through a Buchner funnel containing a rapid filtering paper. The total volume of liquid in the homogenate can be calculated from the amount of extracting solvent added plus the water present in the sample tissue.

A measured aliquot was taken from the homogenate and used for carbohydrate determination.

An aliquot of the extract was diluted to obtain a sugar concentration of approximately 50 mg per 2 ml of solution. A 2 ml portion of the diluted extract was pipetted into a 16 mm test tube. The aqueous phenol (80%) were pipetted into a 16 mm. test tube @ 125 ul. To this 5 ml of concentrated sulphuric acid was added rapidly.

The tip of a burette was broken to increase the rate of deliveries that 5 ml of acid was delivered in less than 10 seconds with the acid stream being directed to the liquid surface in the test tube. After approximately 10 min, each test tube was shaken and the racks of tubes were placed in a water bath at 28°C for 20 minutes. The percentage transmittance was read at 490 nm and the amount of total sugar was determined from a glucose standard curve, later expressed as % total carbohydrates to the weight of the sample taken.

3.2.8. α -amylase test for old and fresh lots of Neem [*Azadirachta indica*]

The method adopted by Simpson and Naylor (1962) was suitably modified and followed. Two g of agar shred and 1 g of potato starch were mixed together in water to form a paste and the volume made up to 100ml. The homogenous solution of agar-starch mixture after boiling was poured into sterilised petridishes and allowed to cool and settle in the form of gel. Then, the embryos from the pre-soaked seeds of each treatment was placed in the petridishes in such a way that the embryo part remained in contact with agar-starch gel. The dishes were closed and kept at 30°C constant in darkness. After 24h, the dishes were uniformly irrigated with potassium iodide solution (0.88 g iodine, crystals and 40.016 g potassium iodide in 1000 ml distilled water) and excess solution was drained off after few min., and kept for further period of 24 h for semi quantitative assay. The diameter of halo (clear) zone formed around the embryo was measured and reported as α -amylase activity in mm; while the remaining area stained violet blue. This test was carried out on both old and fresh lots of the neem to find out the variability in their viability.

3.2.9. Effect of crown and ground collected seeds on seed quality in Neem and Pungam.

The matured seeds of neem and pungam were harvested from the tree crown at physiological maturity. Simultaneously the seeds/fruits left on the ground

underneath the tree, fallen earlier were collected separately to carry out the following experiments after extraction.

- C1 - Crown collection.
- C2 - Ground collection.

3.2.9.1. Physiological tests:

- i) Estimation of moisture content as detailed in 3.2.2.4
- ii) Germination test as detailed in 3.2.2.5
- iii) Root and shoot length measurement as detailed in 3.2.6 (iii)
- iv) Dry matter production as detailed in 3.2.6(iv)
- v) Vigour index as detailed in 3.2.6 (iv)

3.2.9.2. Biochemical tests:

- i) Estimation of oil as detailed in 3.2.2.6
- ii) Estimation of free fatty acid as detailed in 3.2.2.7.
- iii) Estimation of protein as detailed in 3.2.2.8
- iv) Estimation of total sugars or carbohydrates as detailed in 3.2.7.2(iv)

3.2.10. Effect of seed source on seed quality in Neem, Pungam and *Ailanthus*

Species	No. of locations collected	Season of collection
<i>Azadirachta indica</i>	20 (Formed 7 zones)	July, 1989
<i>Derris indica</i>	14 (Formed 7 zones)	December, 1989
<i>Ailanthus excelsa</i>	7 (formed 7 locations)	April, 1989

From the collected seeds, following experiments were performed.

3.2.10.1. Seed polymorphism study

Observations were made on the parameters like seed colour, structure, 100 seed weight, length and breadth, presence of mottlings and seed appendices such as wing etc. and tabulated for the seeds collected from various agro ecological zones.

3.2.10.2. X-ray contact therophy [Anatomical potential]

Neem seeds collected from different locations were subjected to the X-ray contact therophy by exposing the seeds to the X-ray field with the following prescriptions reported by Simak (1980).

Voltage used	:	55kv.
Current	:	100 mA
Distance	:	91.5cm
Exposure time	:	0.1 second (1/10 second).

After developing the positive film number of empty seeds and seed hollowness, double seededness etc., were revealed.

3.2.10.3. X-ray contrast therapy [Physiological potential]

For the above said X-ray field the seeds soaked in 20% Barium chloride solution for 3-4 h was exposed after shade drying. By this test, the presence of disease infested seeds was revealed (physiological potential) by counting the seeds that developed contrast picture to the X-ray.

3.2.10.4. Physiological tests for neem, pungam and Ailanthus

- i) Germination test as detailed in 3.2.2.5
- ii) Root and shoot length as detailed in 3.2.6(iii)
- iii) Dry matter production as detailed in 3.2.6(iv)
- iv) Vigour index as detailed in 3.2.6(iv)

3.2.10.5. Biochemical tests

- i) Estimation of Oil as detailed in 3.2.2.6
- ii) Free fatty acid as detailed in 3.2.2.7
- iii) Protein as detailed in 3.2.2.8
- iv) Total sugars (or) carbohydrates as detailed in 3.2.7.2(iv)
- v) Estimation of chlorophyll content in neem as detailed in 3.2.2.9

3.2.11. Seed storage studies in Neem, Pungam and Ailanthus

The bulk seeds of Neem, Pungam, and Ailanthus were collected from different agro ecological zones and stored in a cloth bag separately without any treatment. The moisture content of seeds were 16,12, and 12 per cent for neem, pungam and Ailanthus respectively. Over a period of six months the deterioration pattern was carefully assessed to make a perfect conclusion about the reasons for faster deterioration by keeping the seeds at different temperatures. Following tests were performed during storage at monthly intervals.

Factors taken for the study.

L1/Z1--- Locations/Zones.

D1 --- Duration of storage.

T1 --- Temperatures.

R1... Rn --- Replications.

3.2.11.1. Physiological tests

- i) Moisture estimation as detailed in 3.2.2.4
- ii) Germination test as detailed in 3.2.2.5
- iii) Root and shoot length as detailed in 3.2.6(iii)
- iv) Dry matter production as detailed in 3.2.6(iv)
- v) Vigour index as detailed in 3.2.6(iv)

3.2.11.2. Biochemical tests

- i) Oil estimation as detailed in 3.2.2.6
- ii) Estimation of free fatty acid as detailed in 3.2.2.7
- iii) Estimation of protein as detailed in 3.2.2.8
- iv) Estimation total sugars as detailed in 3.2.7.2(iv)

3.2.12. Quality Assessment on the seeds collected from off-season bearing in Neem

Off season bearing in neem is of frequent one and more related to the location specific, incidentally triggered by the climatic factor of that season. A study was conducted to assess the quality difference in the seeds collected from the off season bearing with that of the main season. Following tests were performed.

S1 --- Normal season

S2 --- Off season

3.2.12.1. Physiological tests

- i) Germination as detailed in 3.2.2.5
- ii) Root and shoot length as detailed in 3.2.6(iii)
- iii) Dry matter production as detailed in 3.2.6(iv)
- iv) Vigour index as detailed in 3.2.6(iv)

3.2.12.2. Biochemical tests

Estimation of

- i) Oil as detailed in 3.2.2.6
- ii) Free fatty acid as detailed in 3.2.2.7
- iii) Protein as detailed in 3.2.2.8
- iv) Total sugars as detailed in 3.2.7.2 (iv)

3.2.13. Azimuth influence in Neem

Positional influence on seed quality was studied in neem by collecting seeds from four directions viz. North(N), South(S), East(E) and West(W)

- i) Number of primary, secondary and tertiary branches/sq.m. One sq.m area was measured in four directions (East, West, North and South). Number of primary, secondary and tertiary branches were counted and recorded in number.
- ii) Number of inflorescence/sq.m. The same procedure as that of (i) was followed.
- iii) Number of flowers/inflorescence. Total number of flowers were counted in each inflorescence. Flowers in all the inflorescences in a sq.m were counted for total number of flowers.
- iv) Percentage of fruit set. The number of flowers were noted and number of fruits which carried to maturity was counted and the percentage was worked out.as under

$$= \frac{\text{Number of fruits carried to maturity}}{\text{Number of flowers present/sq.m}} \times 100$$

All the above observations were made on 4 directions in the tree.

v) Physiological tests

- a) Germination as detailed in 3.2.2.5
- b) Root and shoot length as detailed in 3.2.6(iii)
- c) Dry matter production as detailed in 3.2.6(iv)
- d) Vigour index as detailed in 3.2.6(iv)

vi) Biochemical tests.

- a) Oil content as detailed in 3.2.2.6
- b) Protein content as detailed in 3.2.2.8
- c) Chlorophyll content as detailed in 3.2.2.9

3.2.14. Effect of decoating in neem on seed quality during storage

The seeds of neem were decoated to find out the quality difference in storability. The decoated seeds (kernal) were stored in a cloth bag at ambient temperature of $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ as that of the seeds with coat. The following studies were made until 3rd month.

C	---	Control
DC	---	Decoated seeds
D0.....D3	---	Months of seed storage

3.2.14.1. Physiological tests

- i) Germination as detailed in 3.2.2.5.
- ii) Moisture content as detailed in 3.2.2.4
- iii) Root and shoot length as detailed in 3.2.6(iii)
- iv) Dry matter production as detailed in 3.2.6(iv)
- v) Vigour index as detailed in 3.2.6(iv)

3.2.14.2. Biochemical tests

- i) Oil content as detailed in 3.2.2.6
- ii) Free fatty acid as detailed in 3.2.2.7
- iii) Protein content as detailed in 3.2.2.8
- iv) Total sugars as detailed in 3.2.7.2 (iv)

3.3. Statistical methods.

The data collected from various experiments were analysed statistically adopting the procedure described by Panse and Sukhatme (1967) wherever necessary, the per cent values were first transformed to angular (Arcsine percentage) values before analysis.

The data were tested at 5 per cent level of significance and non significance data were indicated by the letter 'NS'. Five and one per cent levels of significance are indicated in the tables by single(*) and double (**) asterisks respectively.

Abbreviations used

CHO :	Carbohydrates	
cm :	Centimeter	
Chl :	Chlorophyll	
DMP :	Dry matter production	
Dwt :	Dry weight	
E :	East	
Fwt :	Fresh weight	
FFA :	Free fatty acid	
G% :	Germination percent	
g :	Grams	
h :	Hours	
L :	Location	
min., :	Minutes	
mm :	Millimeter	
mg :	Milligram	
mA :	Milli Amphere	
M.C :	Moisture content	
N :	North	
% :	Percentage	
RL :	Root length	
R :	Replication	
S :	South	
SL :	Shoot length	
S1..Sn :	Stages of seed development	
VI :	Vigour index	
W :	West	Z : Zone

RESULTS

CHAPTER IV

RESULTS

4.1. PHENOLOGY OF NEEM, PUNGAM AND AILANTHUS [TABLE 1]

In neem the flowering started during first week of April and continued for 30 days with peak flowering during the middle of April. The fruit/seed maturity started in June and attained full maturity in July with an average 2000 seed weight of around 20 gram.

The pungam trees started flowering during the last week of April and continued for about 45 days with peak flowering during the first week of May. The pod/seed maturity period coincide with August to September. The average 1000 seed weight of full matured seed was about 125 grams.

In *Ailanthus* the flowering started during second week of February and continued for about 15 days with peak flowering during the third week of February. The seed maturity started during May-June with an average 1000 seed weight of about 105 gms.

4.2. SEED DEVELOPMENT AND MATURATION IN NEEM (*Azadirachta indica*)

[Table 2; Fig.7 & 8]

To understand the sequence of seed maturation and changes in physiological and biochemical characterization and to fix the optimal stage of harvest the above study was carried out.

The results obtained significantly varied between the stages, for all the parameters recorded.

4.2.1. Fruit Length [mm]

Fruit length was as minimum as 3.0 mm at S1 and reached the maximum value (17.5 mm) at S10. Beyond the stage S10, it started decreasing and finally reached 12.5

Table 1. Information on date of first flowering, duration of flowering, peak flowering, maturity period and 1000 seed weight (g) of Azadirachta indica, Derris indica and Ailanthus excelsa

Species	Date of first flowering	Duration of flowering	Peak flowering period	Maturity period	1000 seed weight (g)
<u>Azadirachta indica</u>	First week of April (1-7)	30 days	Mid-April	June-July	20
<u>Derris indica</u>	Last week of April (April 25-30)	45 days	May First week	August-September	125
<u>Ailanthus excelsa</u>	February 2nd week (7-15)	15 days	February 3rd week	May-June	105

mm. The increase was steady upto S6 only and there after the increase was in decreasing rate.

4.2.2. Breadth of Fruit [mm]

Till S14 there was steady increase in the breadth of the fruit and ranged between 3.1 mm (S1) and 12.6 (S14).

4.2.3. Length of seed [mm]

The seed was separable at S2 only and at that stage it measured 4.3 mm. There was steep increase in length between S3 and S7 ; while the seed reached the maximum length of 14.6 at S7 itself. There after it maintained almost the same length till S14.

4.2.4. Breadth of seed [mm]

The maximum breadth of seed was obtained at S14 (5.9 mm) and the mean length was increasing steadily all through its development. The lowest value for the seed length was obtained at S2 (2.4 mm).

4.2.5. Fresh Weight of Fruit [g]

The rate of increase in fresh weight of the fruit was at slower rate and reached the maximum at S12 and subsequently started decreasing. The maximum and minimum ranged between 3.40 g and 0.44 g (for 10 seeds) at S12 and S1 respectively.

4.2.6. Fresh Weight of Seed [g] [Weight of 10 seeds]

The seeds were extracted only at S2 with the fresh weight of 0.37 g which reached the maximum weight at S12. The fresh weight increase was uniform and beyond S12 there was declining trend with 2.02 g at S14.

4.2.7. Dry Weight of Fruit

The rate of increase in dry weight was in high order between S5 and S12 and almost 55% increase in dry weight was between S5 and S10 stages. Subsequently, 44% contribution was made between the S10 and S12. The dry weight increased all through the developmental stages and reached the maximum of 0.36 g at S12 and there after remained constant

4.2.8. Dry Weight of Seed [g] [10 seeds]

Dry weight of the seed was as low as 0.04 g at S2 and reached the maximum level of 0.28 g at S12 which remained constant. There was steady increase in the dry weight of seeds.

4.2.9. Moisture content of fruit

There was no definite trend in respect of increase or decrease in fruit moisture content and it was oscillating between 88.00 and 91.95 %. The mean moisture content was low at S14 (88%) and high at S11 (91.95%).

4.2.10. Moisture content of seed

Seed moisture content was almost in the same level of 90% until S1 and then it started declining. The mean maximum Moisture content was at S4 and S11 (90.45%) ; while it was minimum at S14 with 86.1%.

4.2.11. Germination [%]

There was no seed germination upto S6 and at that stage it registered a germination of 11% and it reached the peak value of 97% at S13. There was 42% increase in germination over the S10 for S11.

4.2.12. Chlorophyll content [mg/g]

The chlorophyll content was as high as 0.44 mg at S3 and later it dropped to a level of 0.2 mg at S14. The decrease in the chlorophyll content was slow all through development.

4.2.13. Protein content [%]

Protein content increased over the stages of development. There was sharp raise between S3 & S5 which ranged between 5.5 (S3) and 15.2 % (S5). It decreased after S5 and reaches the level of 11.0% at S9 and again increased upto 14.7% at S12. Beyond S12 it started decreasing. The protein content at S14 was 14.5 per cent.

4.2.14. Total carbohydrates [%]

Carbohydrates accumulation was having increasing trend upto S8 (28.3%) from S3 (16.3%) after that it decreased to 24.7 at S9. Again it increased and there after reached the highest level of 34.4 % at S12.

4.2.15. Oil content [%]

Until S6 the oil content could not be estimated. At S6 it was 3.2% and reached 31.2% at S13. The sharp rise in oil content was between S6 and S12.

4.2.16. Free Fatty Acid [%]

It was only from S10, the free fatty acid was accountable. At S10 it was 1.2 % which increased steadily upto harvest that is S14 (1.6%).

Table 2. Changes in length and breadth (mm), fresh and dry weight (g), moisture content of fruit and seed (%), germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil content (%), free fatty acid (%), protein (%), chlorophyll content (mg/g) and carbohydrate content (%) during seed development and maturation in Azadirachta indica

Stages	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	SED	CD(5%)	CD(1%)
Fruit length (mm)	3.0	5.0	2.5	11.5	13.5	14.5	16.0	16.5	17.5	17.5	17.0	16.5	15.0	12.5	0.707	1.53	2.13**
Fruit breadth (mm)	3.1	3.7	4.4	6.3	7.5	8.5	9.5	10.3	10.7	11.3	11.7	12.5	12.5	12.6	0.176	0.38	0.53**
Seed length (mm)	-	4.3	6.5	10.5	12.4	13.3	14.6	14.2	14.3	14.2	14.3	14.1	14.6	12.6	0.215	0.46	0.65**
Seed width (mm)	-	2.4	3.3	3.3	3.5	3.9	4.2	4.8	4.8	4.9	5.3	5.7	5.7	5.9	1.114	3.05	4.26**
Fresh wt. of fruit (g)	0.44	0.66	0.73	0.87	1.08	1.41	1.71	1.90	2.15	2.50	3.10	3.40	3.20	3.00	0.99	0.22	0.30**
Fresh wt. of seed (g)	-	0.37	0.44	0.68	0.76	0.89	1.38	1.54	1.66	1.82	2.04	2.18	2.10	2.02	0.06	0.12	0.17**
Dry wt. of fruit (g)	0.05	0.06	0.08	0.09	0.09	0.14	0.18	0.19	0.20	0.22	0.25	0.36	0.36	0.36	0.03	0.07	0.10**
Dry wt. of seed (g)	-	0.04	0.05	0.06	0.08	0.09	0.15	0.16	0.17	0.17	0.19	0.28	0.28	0.28	-	-	-
M.C. of fruit (%)	89.80	90.15	89.75	90.20	91.15	90.05	89.50	90.00	90.50	91.15	91.95	89.40	88.80	88.0	0.46	0.99	1.38**
M.C. of seed (%)	-	89.15	89.85	90.45	90.10	89.85	89.15	89.90	90.05	90.40	90.45	87.20	86.65	86.10	-	-	-

Contd..

Contd.

Stages	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	SED	CD(5%)	CD(1%)
Germination (%) -	-	-	-	-	-	11 (19.35)	16 (23.54)	22 (27.95)	29 (32.58)	38 (37.75)	65 (53.78)	93 (74.32)	97 (79.47)	97 (80.17)	1.53	3.30	4.60**
Chlorophyll content mg/g	-	-	0.44	0.43	0.41	0.38	0.35	0.33	0.30	0.27	0.22	0.21	0.21	0.20	0.10	2.16	3.01**
Protein content (%)	-	-	5.5	10.9	12.0	15.2	12.9	11.9	11.0	12.3	13.4	14.7	14.4	14.5	0.06	0.12	0.17**
Carbohydrate %	-	-	16.3	19.2	19.0	25.3	26.4	28.3	24.7	27.4	32.2	34.4	34.4	34.0	1.44	3.05	4.26**
Oil (%)	-	-	-	-	-	3.2	4.7	6.3	10.8	17.2	23.4	30.7	31.2	31.0	1.96	4.24	5.91**
FFA (%)	-	-	-	-	-	-	-	-	-	1.2	1.3	1.2	1.3	1.6	0.02	0.046	0.065**

(Figures in parentheses indicate transformed values)

Fig.7. Changes in fresh and dry weight (g), moisture content of fruit and seed (%) during seed development and maturation in *Azadirachta indica*

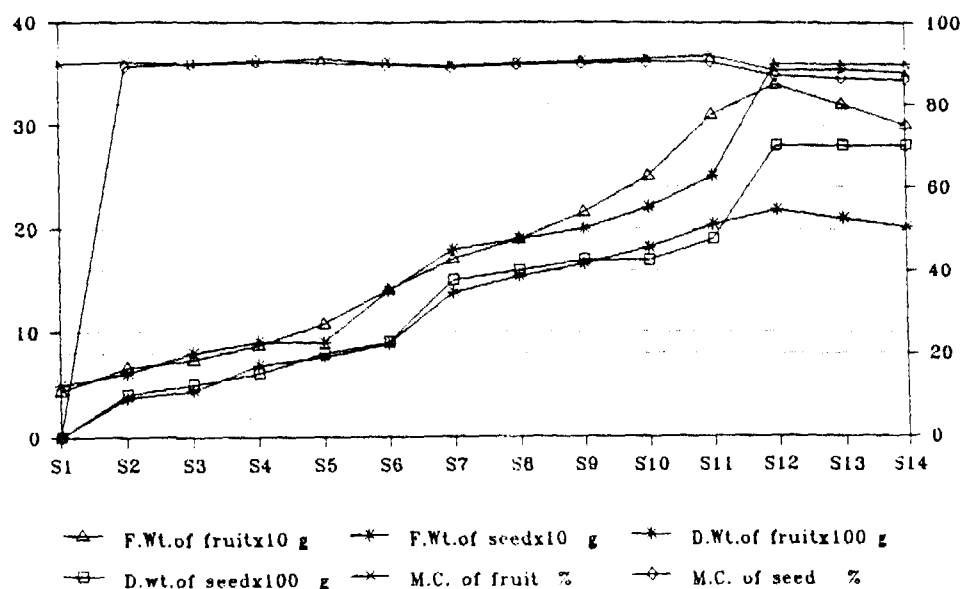
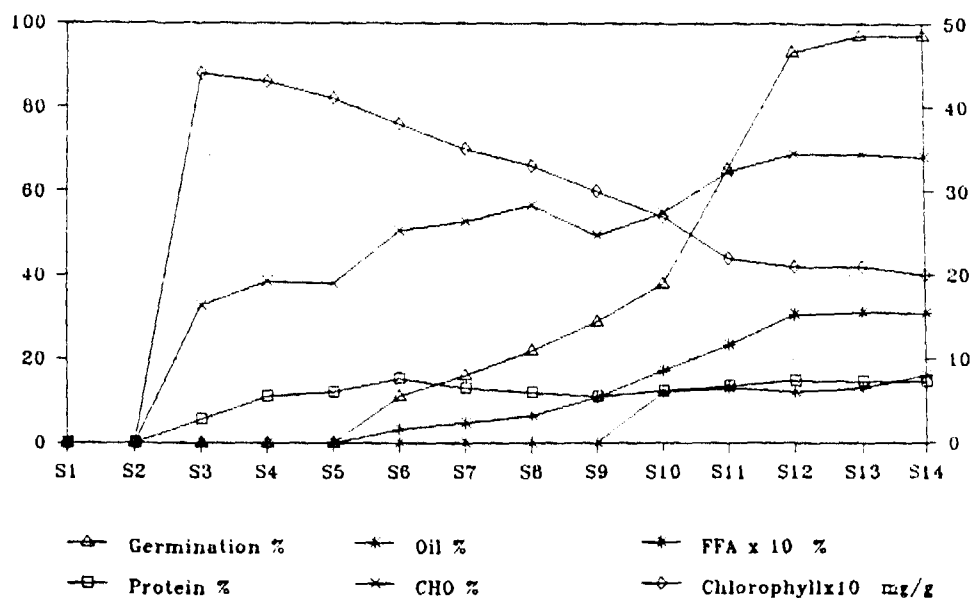


Fig.8. Changes in germination, oil, FFA, protein, CHO (%) and chlorophyll content (mg) during seed development and maturation in *Azadirachta indica*



4.3. SEED DEVELOPMENT AND MATURATION IN PUNGAM [*Derris indica*]

[Table.3; Fig.9 & 10]

Pod and seed development gave highly significant variation with results for pod length, seed length, pod breadth, breadth of seed, fresh weight, dry weight, Moisture content of pod and seed, Germination %, oil content, free fatty acid and protein content.

4.3.1. Length of pod [cm]

Pod length was 0.85 cm at S1 and reached the maximum length at S12 with 3.5 cm. From S9 to S11 it did not increase and remained constant at 3.40 cm. From S12 onwards it started decreasing gradually and reached 3.00 cm at S16 itself. There after the increase or decrease was at lower rate.

4.3.2. Seed length [cm]

Visible seed was obtained only at S10 where the seed length was just 0.22 cm. There after it started increasing at faster rate to reach the maximum length at S18 (2.55 cm). There after there was slight decrease and remained with 2.40 cm at S20.

4.3.3 Pod Breadth [cm]

Pod breadth increased upto 1.30 cm at S8 and there was slight decrease at S9. There after until S13 it didn't change. Further increase was seen only after S14 and reached the maximum value of 1.55 cm at S17. Again it dropped to 1.50 cm at S18 and remained constant upto S14.

4.3.4 Breadth of seed [cm]

Seed was visible only at S10 and at that stage the seed breadth was 0.13 cm and increased to 1.30 cm at S18. At S20 also it was measuring 1.30 cm.

4.3.5. Fresh weight of pod [mg]

The fresh weight of pod increased steadily right from S1 (33 mg) and reached 115 mg at S10. Pod fresh weight increased at increasing rate after the S10 and reached the maximum value with 276 mg at S17. There after it was reducing and finally at S20 it recorded 245 mg only.

4.3.6. Fresh weight of seed [mg]

Right from the seed visible stage of S10 it started increasing at a faster rate to reach the mean maximum weight of 209 mg at S18. However, after S18 there was declining trend.

4.3.7. Dry weight of pod [mg]

Accumulation of pod dry weight was at slower rate until S11 which started increasing at a faster rate and reached the maximum dry weight level of 166 mg (S17). The maximum and minimum ranged between 7 (S1) and 166 mg (S17). However, there was slight decrease in dry weight after S17.

4.3.8. Dry weight of seed [mg]

There was faster rate of seed dry weight accumulation right from S10 (3mg) to reach the maximum level of 115 mg (S18).

4.3.9. Moisture content of pod [%]

The highest moisture content at S1 (80%) was maintained till S5 and there after it dropped down to as low as 33.40 % at S20. During the entire pod development stages the drop in moisture content was steady and slow.

4.3.10. Moisture content of seed [%]

At first stage of seed development (S10) the seed recorded the mean moisture content of 82.83 % and it increased to 87.35% at S11. After a suspended period it started declining and at S20 it recorded 43.55%, which was the minimum.

4.3.11. Germination [%]

Seeds was germinable only at S12 (11%) and it reached the level of 50% germination at S16. The maximum germination was recorded at S19 (87%). There after it was maintaining a declining trend.

4.3.12. Oil content [%]

Oil content at S11 was 2.50 % and increased at a faster rate to reach the level of 35.80% at S18. The oil content accumulation was at a faster rate between S12 and S17.

4.3.13. Free Fatty Acid [%]

The lowest value of 1.00% free fatty acid was recorded at S16 and increased steadily there after. At S20 it recorded 3.00%.

4.3.14. Protein content [%]

The maximum protein content accumulation was recorded at S18 (25.25%) and the rate of accumulation was faster from S13 onwards. At S13 it was 8.40% and at S14 it was 14.30% which was three fold increase over the first stage of protein accumulation recording 4.40 % (S11).

3 changes in length and breadth (cm), fresh and dry weight (mg) moisture content of pod and seed (%), germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate content (%) during seed development and maturation in *Derris indica*

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	CD(5%)
length (cm)	0.85	1.30	1.70	2.40	2.80	2.70	2.90	3.10	3.40	3.40	3.40	3.50	3.35	3.30	3.15	3.00	3.10	3.10	3.00	3.00	0.37**
breadth (cm)	0.35	0.55	0.80	0.90	1.00	1.00	1.20	1.30	1.20	1.20	1.20	1.20	1.20	1.30	1.50	1.60	1.55	1.50	1.50	1.50	0.22**
weight (mg)	33	43	50	65	74	83	93	101	107	115	144	173	183	209	229	246	276	274	253	245	0.14**
weight of seed (mg)	7	9	10	13	15	19	24	26	27	29	31	63	73	99	119	136	166	164	161	163	0.10**
weight of pod (mg)	80	80	80	79.7	80.25	77.65	74.55	74.75	74.6	75.2	78.4	63.5	60.05	52.6	48	44.7	39.80	40.1	36.35	33.4	6.0**
length of pod (cm)	-	-	-	-	-	-	-	-	-	0.22	0.23	0.51	0.76	1.3	1.7	1.9	2.35	2.55	2.45	2.4	15.0**
height (cm)	-	-	-	-	-	-	-	-	-	0.13	0.13	0.24	0.39	0.56	0.78	0.97	1.1	1.3	1.2	1.3	3.0**
length of seed (cm)	-	-	-	-	-	-	-	-	-	15	60	70	92	126	161	172	207	209	206	203	7.0**
weight of seed (mg)	-	-	-	-	-	-	-	-	-	3	8	16	18	25	48	61	83	115	113	115	2.22**
weight of pod (mg)	-	-	-	-	-	-	-	-	-	82.85	87.35	77.77	80.3	79.4	70.4	64.6	59.95	44.95	45.35	43.55	4.43**
oil seed (%)	-	-	-	-	-	-	-	-	-	-	-	11	17	30	44	51	64	83	87	85	3.03**
germination (%)	-	-	-	-	-	-	-	-	-	-	(19.33)	(24.34)	(33.14)	(41.54)	(45.57)	(53.16)	(65.66)	(68.88)	(67.22)	-	-
moisture content (%)	-	-	-	-	-	-	-	-	-	-	2.3	8.3	12.1	18.4	22.8	25.5	33.7	35.8	35.1	35.0	0.50**
fatty acid (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	1.02	1.62	2.50	3.00	0.43**
protein (%)	-	-	-	-	-	-	-	-	-	-	4.40	6.65	8.40	14.30	14.40	16.40	20.35	25.23	24.90	24.00	2.16**

(figures in parenthesis indicate transformed values)

Fig.9. Changes in fresh and dry weight (g), moisture content of pod and seed (%) during seed development and maturation in *Derris indica*

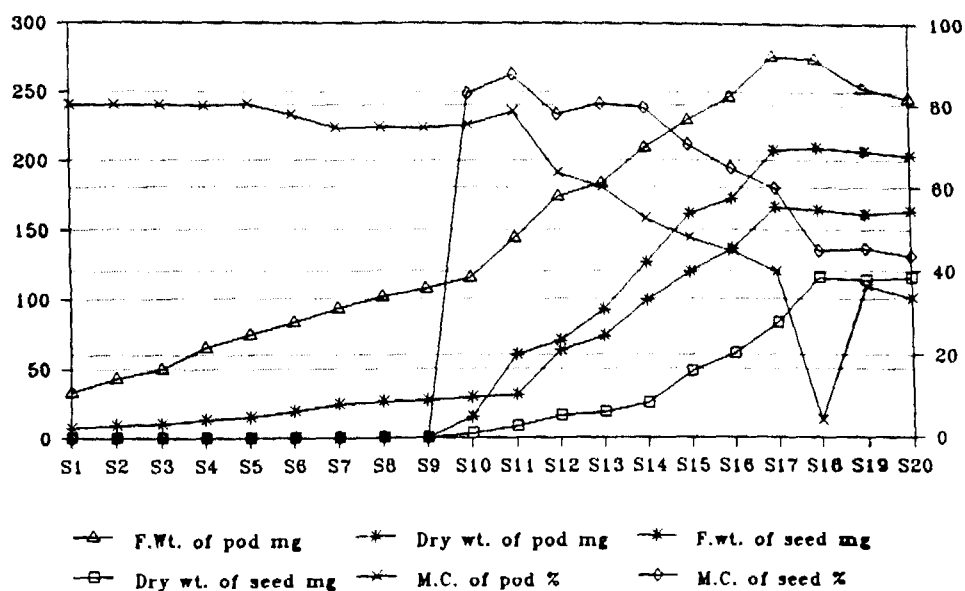
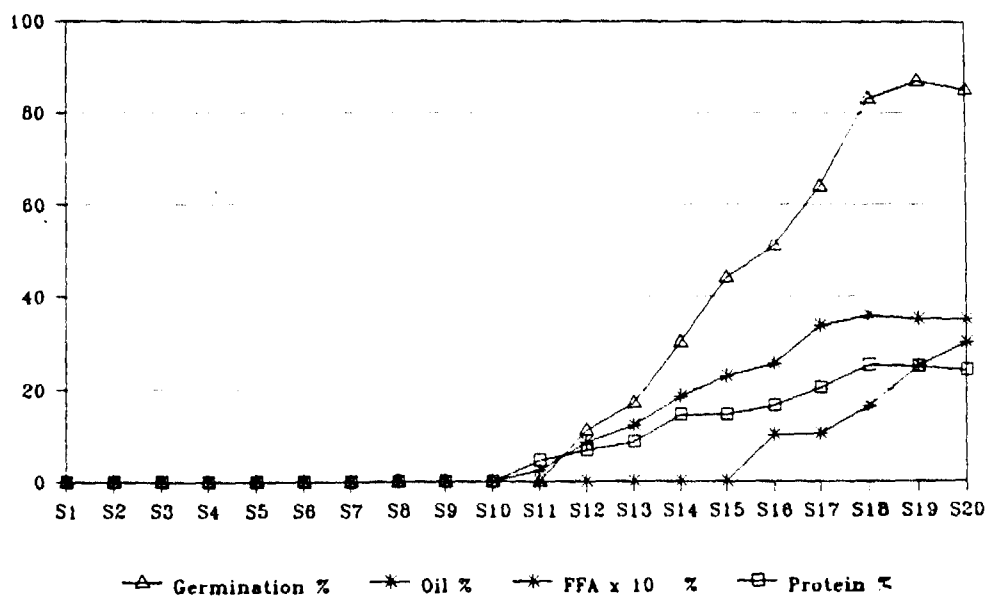


Fig.10. Changes in germination, oil, FFA and protein content (%) of pod and seed during seed development and maturation in *Derris indica*



4.4. SEED DEVELOPMENT AND MATURATION IN *Ailanthus excelsa* Roxb.

[Table.4; Fig.11 & 12]

Over the period/stages of development for both samara and seed there was highly significantly varied results obtained for length, breadth, fresh weight, dry weight and moisture content of samara and seed and germination, oil, free fatty acid, protein contents of seeds.

4.4.1. Length of samara [cm]

Length of samara (the indehiscent fruit) reached the maximum at S8 itself recording 5.30 cm. It varied between 0.53 cm and 5.50 cm at S1 and S8 respectively. However, at the at S8 stage there was slight fluctuation in samara length and at S14 it was 5.40 cm.

4.4.2. Breadth of samara [cm]

Samara breadth increased from as low as 0.30 cm (S1) to the highest breadth of 1.13 cm at S13. After S10 it didn't change much excepting at S14 where it recorded 1.11 cm.

4.4.3. Length of seed [cm]

The maximum length of seed was recorded at S9 (1.23 cm) and later it dropped to 1.07 at S14. The length of seed increased at an increasing rate until S3 and there after it increased at decreasing trend.

4.4.4. Breadth of seed [cm]

At S1 the seed breadth was 0.13 and gradually increased to reach the maximum breadth of 0.67 cm at S8 and there after it gradually decreased to reach the final value of 0.55 cm of S14.

4.4.5. Fresh weight of samara (mg)

The faster rate of fresh weight increase was between S1 and S2 recording 29 and 44 mg respectively and between S6 and S9 recording 85 to 136 mg respectively. The maximum mean fresh weight was recorded at S11 with 142 mg. After S11 it started falling 126 mg at S14.

4.4.6. Fresh weight of seeds [mg]

Fresh weight increased from 29 mg (S1) to 103 mg (S10) over the period of maturation and after S10 it maintained a declining trend and reached the 90 mg weight at S14.

4.4.7. Dry weight of samara [mg]

The rate of dry weight increase was maximum between S10 and S11 and it was nearly 28% increase in dry weight over the previous stage. The maximum dry weight recorded was 117 mg at S12 and there after it slightly decreased.

4.4.8. Dry weight of seed [mg]

Increase in dry weight was only upto S12 and there after it did not change. At S12 it weighed 85 mg. The lowest value of dry weight was at S1 with 3.00 mg.

4.4.9. Moisture content of samara [%]

The increase in moisture content was only between S1 and S2 with 84.50 % and 87.35% respectively. There after it gradually dropped to 40.25% at S10. Almost 50% drop in moisture content was recorded between S10 and S11 and finally it recorded 11.05% moisture content at S14.

4.4.10. Moisture content of seed [%]

There was slight increase in moisture content over the S1 (only 1.25%) in S2. The second stage of development and maturation onwards the moisture content decreased gradually upto S6 and there after it fell at faster rate to reach the low level of 8.85% at S14.

4.4.11. Germination [%]

Seed germination was recorded only after S11 stage. At S12 it recorded 11% and 50% germination was obtained at S16 stage. The maximum germination was obtained at S19 with 87 per cent. After S19 it declined and S20 registered 85 per cent.

4.4.12. Oil content [%]

The lowest oil content of 2.30 % was registered at S11 and it steeply rise to 35.8% at S18. The change in oil content after S18 was not significant.

4.4.13. Free Fatty Acid [%]

The maximum and minimum Free Fatty Acid ranged between 1.00 % and 3.00 % at S16 and S20 respectively. Increase in free fatty acid content was gradual throughout the stages of seed maturation.

4.4.14. Protein content [%]

Increase in protein content was at higher rate between S13 and S14 which registered nearly 41% raise. There after until S17 it was maintaining the same level and rise to 25.33% at S18. After S18 stage it started declining.

Table 4 Changes in length and breadth (cm), fresh and dry weight (mg), moisture content (%), of samara and seed, germination (%), root and shoot length (cm) dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate content (%) during seed development and maturation in Ailanthus excelsa

Stages	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	SED	CD(5%)	CD(1%)
Length of samara (cm)	0.55	1.10	2.25	3.70	4.40	4.90	5.30	5.50	5.50	5.45	5.50	5.40	5.40	5.40	0.10	0.22	0.30**
Breadth of samara (cm)	0.30	0.55	0.50	0.55	0.70	0.80	0.90	1.05	1.12	1.13	1.13	1.13	1.13	1.11	0.06	0.12	0.17**
Length of seed (cm)	0.13	0.18	0.44	0.66	0.83	0.94	1.00	1.13	1.23	1.13	1.07	1.08	1.08	1.07	0.02	0.04	0.05**
Breadth seed (cm)	0.13	0.14	0.28	0.53	0.60	0.64	0.66	0.67	0.65	0.64	0.64	0.65	0.56	0.55	0.02	0.05	0.06**
Fresh weight of samara (mg)	29	44	54	66	73	85	103	129	136	139	142	138	131	126	3	7	10**
Fresh weight of seed (mg)	19	24	31	54	64	76	83	96	99	103	101	94	93	90	2	4	5**
Dry weight of samara (mg)	5	6	11	16	19	27	36	57	73	83	115	117	113	112	2	4	5**
Dry weight of seed (*mg)	3	4	7	11	22	32	45	53	62	77	83	85	85	85	1	3	4**
M.C.% of samara	84.5	87.35	79.7	76.55	74.00	68.2	65.05	55.60	46.15	40.25	18.95	15.10	13.70	11.05	6.32	13.66	19.05**
M.C. of seed	83.90	85.15	77.50	79.55	65.65	57.60	45.75	44.70	37.40	24.90	17.80	9.60	9.75	8.85	3.16	6.83	9.52**
Germination (%)	-	-	-	-	-	-	9	9	10	13	19	52	51	48	0.86	1.86	2.59**
							(17.43)	(17.43)	(18.43)	(21.12)	(25.83)	(46.15)	(45.57)	(43.85)			
Oil content (%)	-	-	-	-	-	-	7.5	8.3	9.6	14.7	17.3	19.2	20.7	19.4	0.68	1.47	2.05**
Free fatty acid (%)	-	-	-	-	-	-	-	-	-	1.00	1.20	1.13	1.18	1.20	0.01	0.02	0.03**
Protein (%)	-	-	-	-	10.40	11.80	18.90	21.20	22.80	25.85	29.20	31.30	29.40	28.50	0.68	1.47	2.05**

(Figures in Parenthesis indicate transformed values)

Fig.11. Changes in fresh and dry weight (mg), moisture content (%) of samara and seed during seed development and maturation in *Ailanthus excelsa*

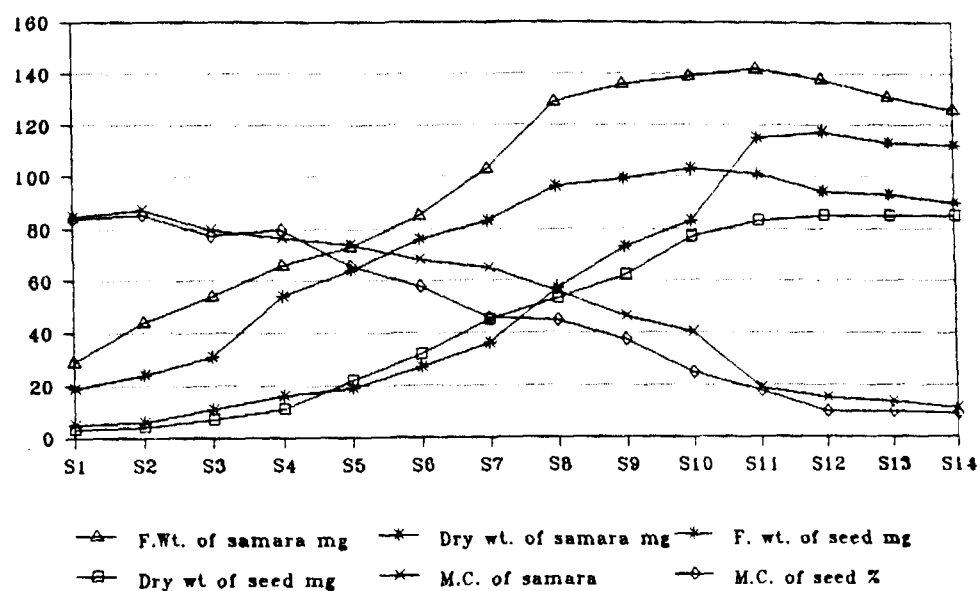
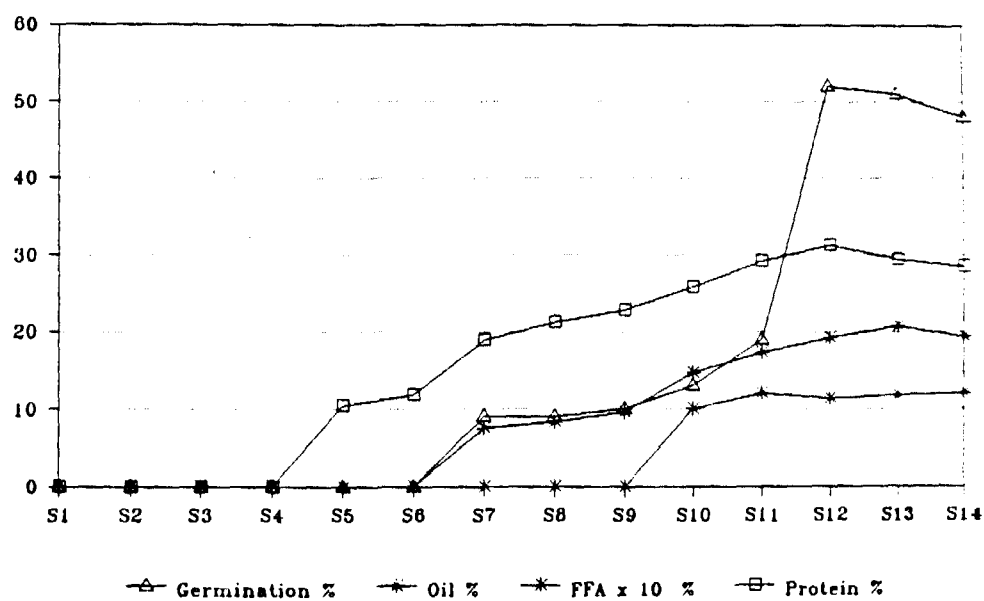


Fig.12. Changes in germination, oil, FFA and protein content (%) during seed development and maturation in *Ailanthus excelsa*



4.5. IDENTIFICATION IN NEEM AS TO ITS RECALCITRANT NATURE

[Table.5; Fig.13]

The variation in germination percentage was highly significant for the treatments viz. temperature and moisture levels. The interaction between the temperature levels and moisture content was also significant.

The mean germination % was 88 at T1 and 78 at T3 irrespective of moisture levels. At M1 the Germination % was highest in T1 (97) and dropped to 82% at T3. At each moisture level there was decrease in germination with decrease in temperature. The mean germination % varied between 88 and 79% at M1 and M3 respectively, irrespective of the temperature levels. Reduction in moisture content and temperature together reduced the germination to the tune of 10 per cent.

4.6. EFFECT OF SEED DRYING IN NEEM [Table.6; Fig.14]

The results obtained for the effect of seed drying was highly significant for germination, root length, shoot length, dry matter production and vigour index.

4.6.1. Germination [%]

Sun drying (D1) resulted in the reduction of germination of 10% over D3 which recorded 95 per cent. The D2 registered 91% germination.

4.6.2. Root length [cm]

The length of root was maximum at D3 (10.86 cm) and however it was on par with the D2 (10.33 cm). The shortest root was at D1 with 9.34 cm.

4.6.3. Shoot length [cm]

The maximum and minimum shoot length ranged between 9.90 cm and 7.20 cm in D3 and D1 respectively.

Table 5 Germination results to test the Recalcitrancy in Azadirachta indica seeds

Moisture (M)	T1	T2	T3	M-MEAN
M1	97.0 (81.47)	86.0 (68.05)	82.0 (64.91)	88.3 (71.48)
M2	87.0 (68.88)	82.5 (65.28)	76.8 (61.18)	82.1 (65.11)
M3	79.5 (63.10)	80.3 (63.70)	76.0 (60.69)	78.6 (62.50)
T-MEAN	87.8 (71.15)	82.9 (65.68)	78.3 (62.26)	83.0 (66.36)

SEd 1.77
 CD (5%) 3.63
 CD (1%) 4.90

Correlation matrix

	Recalcitrant	Moisture	Temperature
Recalcitrant	1.000	0.634**	0.605**
Moisture	0.634	1.000	0.000 NS
Temperature	0.605	0.000	1.000

R² = 0.77**

Regression equation : $Y = 71.451 + 0.286 (\text{Moisture}) + 0.309 (\text{Temperature})$

Table 6 Effect of seed drying on germination (%), root and shoot length (cm), dry matter production (g) and vigour index in Azadirachta indica

	Germination	Root Length	Shoot Length	Dry Matter Production	Vigour Index
D1	85	9.34	7.20	3.66	310
D2	91	10.23	8.46	3.63	331
D3	95	10.86	9.90	4.80	459
CD (5%)	3**	NS	1.48**	0.81**	82**
CD (1%)	5	NS	2.07**	1.13	114**

Fig.13. Germination (%) results to test the Recalcitrancy with different temperatures and moisture levels of *Azadirachta indica* seeds

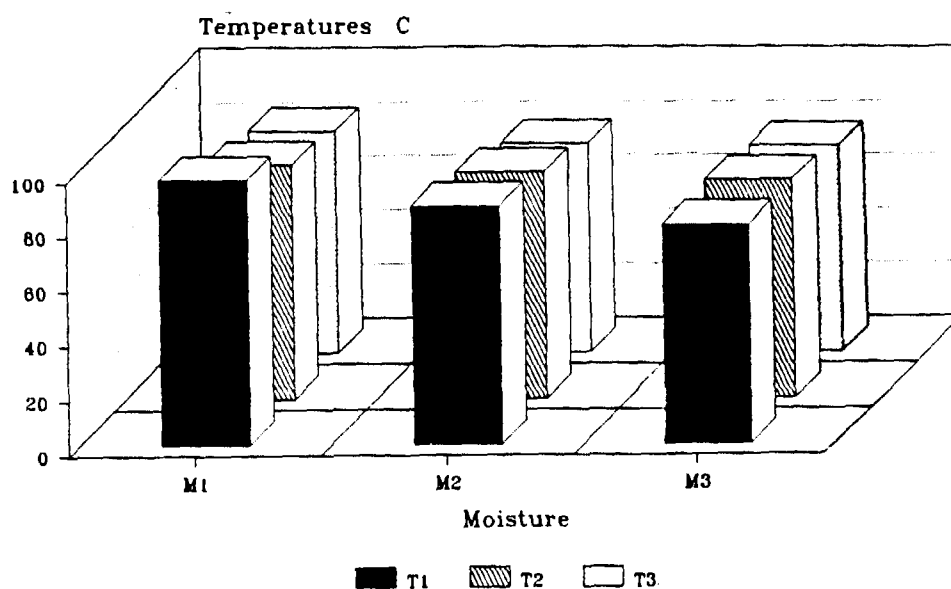
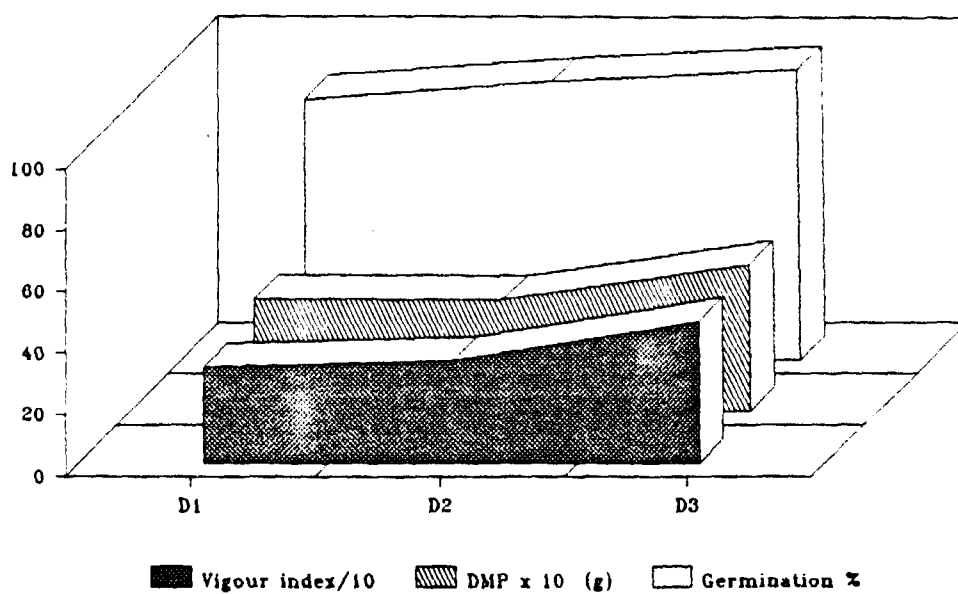


Fig.14. Effect of seed drying on germination, dry matter production and vigour index in *Azadirachta indica*



4.6.4. Dry Matter Production [g]

Highest dry weight of seedlings was at D3 with 4.80 g and the sun drying (D1) reduced the dry matter production to 3.66 g.

4.6.5. Vigour Index

Vigour index ranged between 459 and 310 between D3 and D1. However, D1 and D2 was on par with each other.

4.7. Effect of crow feeding in Neem over the period of storage [Table.7; Fig.15 & 16]

4.7.1. Moisture content [%]

The mean moisture content was maximum in C1 at D0 with 17.15 per cent. Over the periods of storage from D0 to D6 the mean moisture content ranged between 17.15 and 12.40% in C1 and it was 15.25 % and 13.75 % at D0 and D6 respectively in C2.

4.7.2. Germination [%]

Evaluating the period of storage, the mean germination % started declining and in C1 it reached to the nil % at D6 and it was 15% in C2 at D6. The difference in germination % over the control (C1) in C2 over the period of storage was 2, 9, 21, 24, 18, 19 and 15 at D0, D1, D2, D3, D4, D5 and D6 respectively.

4.7.3. Root length [cm]

During storage both control (C1) and crow fed seeds resulted in the reduced root length and it was nil at D6 in C1. The maximum and minimum root length over the period of storage for C1 ranged between 11.40 and 0.00 cm. However, it was 5.95 cm in C2 at D6. The decrease in length of root was gradual in crow fed seeds than the C1 (control). The mean root length over the period of storage irrespective of the directions

ranged between 7.08 (C1) and 8.59 cm (C2). The significant reduction in root length in C1 over the C2 was critical at D4 and D6.

4.7.4. Shoot length [cm]

The decline in shoot length in C1 over the C2 during storage was significant only at D6 where it was 4.25 cm in C2. The mean shoot length of 5.53 and 6.49 cm was recorded in C1 and C2 respectively.

4.7.5. Dry Matter Production [g]

The significant reduction in dry matter production was registered in C1 over C2 only at D6. Where it was 1.80 g in C2 and nil in C6. However, the mean shoot length was maximum in C1 irrespective of the storage periods and it was 2.87 cm and C2 registered 2.84 cm only.

4.7.6. Vigour Index

The reduction in vigour index was prominent in C1 over the C2 during storage at D2, D3 D5 and D6. The variation in vigour index between C2 and C1 at D2 was 58 and at D3 it was 50. The mean vigour index irrespective of the durations ranged between 158 and 183 in C1 and C2 respectively.

4.7.7. Oil content [%]

The reduction in oil content for the crow fed seeds over the C1 was 3.60, 1.95, 1.55 and 2.60 % at D0, D1, D3 and D4 respectively. The mean oil % over the period of storage ranged between 25.14 (C1) and 23.35 (D2).

Table 7 Effect of crow feeding on moisture content (%), germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil content (%) free fatty acid (%), protein (%) and carbohydrate (%) in Azadirachta indica seeds during storage.

	MC %		G%		RL (cm)		SL (cm)		DMP (g)		V _i		Oil %		FFA %		Protein %		CHO %	
	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
D0	17.15	15.25	94	96	11.40	11.25	8.80	9.10	4.78	4.20	450	403	31.35	27.75	5.93	5.57	17.90	17.25	36.58	36.80
			(75.92)	(78.94)							(23.41)	(22.42)								
D1	15.55	14.82	78	87	9.75	10.75	7.80	8.60	3.97	3.75	309	326	27.60	25.65	7.18	6.38	16.27	16.75	35.35	35.70
			(62.10)	(68.68)							(20.20)	(20.63)								
D2	14.55	14.90	51	72	8.70	9.85	7.15	6.90	3.50	3.30	180	238	26.15	24.90	7.18	8.20	16.10	15.60	32.45	33.90
			(45.58)	(57.82)							(16.69)	(18.34)								
D3	13.10	14.25	29	53	7.85	8.10	5.38	6.00	3.10	2.65	90	140	24.35	22.80	8.48	8.98	14.68	14.80	31.05	33.80
			(32.57)	(46.44)							(13.78)	(15.46)								
D4	12.75	13.05	20	38	6.40	8.00	5.13	5.55	2.72	2.18	55	82	23.83	21.23	10.02	9.57	13.68	13.65	29.02	31.10
			(26.66)	(38.03)							(12.44)	(13.50)								
D5	12.55	14.05	12	31	5.45	6.25	4.47	5.05	2.00	2.00	25	62	21.70	21.13	10.50	10.20	13.00	13.90	26.25	28.10
			(19.60)	(33.82)							(11.14)	(12.73)								
D6	12.40	13.75	0	15	0	5.95	0	4.25	0	1.80	0	27	21.00	20.00	11.48	10.50	11.70	12.55	24.35	25.25
			(0.29)	(22.84)							(10.00)	(11.28)								
SED	0.57		1.82		0.66		0.40		0.30		0.57		0.66		0.36		0.52		0.99	
CD (5%)	1.15		3.69		1.33		0.81		0.61		1.15		1.33		0.74		1.04		2.02	
CD (1%)	1.54**		4.93**		1.79**		1.09**		0.82**		1.55**		1.78**		0.99**		1.39**		2.71**	

(figures in parenthesis indicate transformed values)

Fig.15. Effect of crow feeding on moisture content (%), germination (%) and vigour index in *Azadirachta indica* seeds

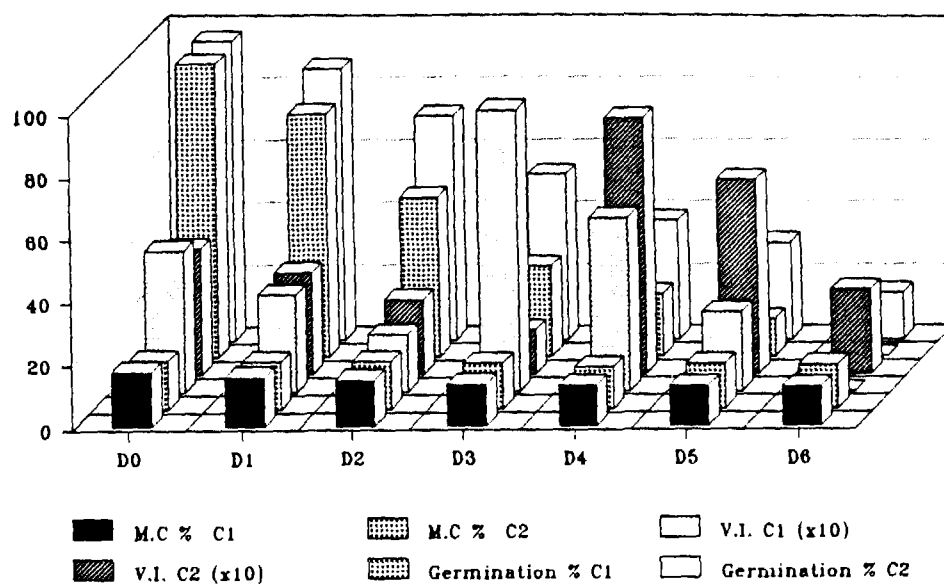
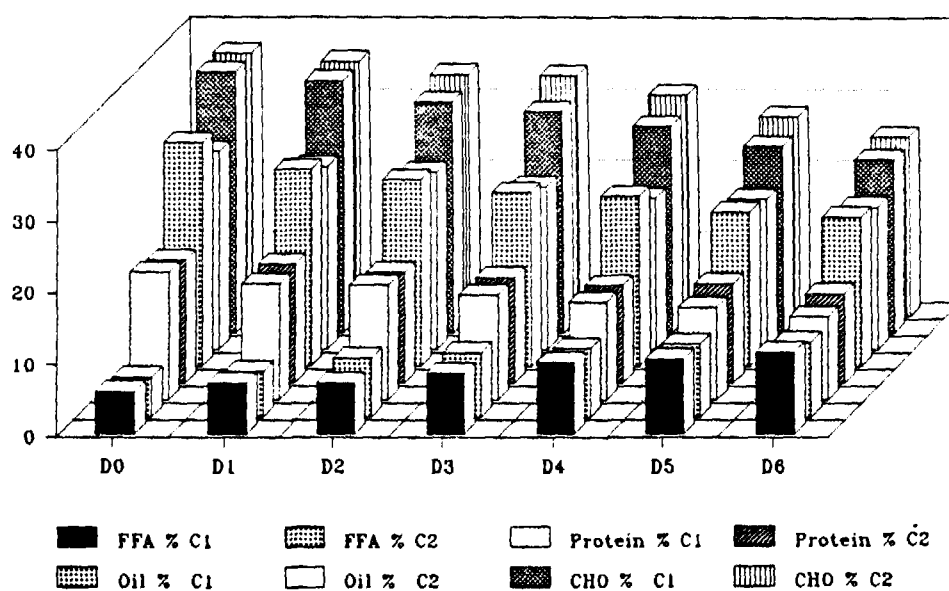


Fig.16. Effect of crow feeding on oil, FFA, protein and CHO content (%) in *Azadirachta indica* seeds



4.7.8. Free Fatty Acid [%]

The free fatty acid content increased in both C1 and C2 right from D₀ and it reached the maximum value of 11.48 % in C1 and 10.50% in C2 at D₆. The difference in free fatty acid content between C1 and C2 was significant at D₁ and D₂ only.

4.7.9. Protein content [%]

The protein content ranged between 17.90 and 11.70 % in C1 and 17.25 and 12.55 % in C2 during the periods of storage. However, the crow feeding did not bring significant results at each storage period, but variation within the periods of storage was significant separately in C1 and C2.

4.7.10. Total carbohydrates [%]

The rate of reduction in carbohydrate was high in C1 than C2 during storage. The reduction in carbohydrate over C2 in C1 was 0.22, 0.35, 1.45, 2.75, 2.07, 1.85 and 0.90 % at D₀, D₁, D₂, D₃, D₄, D₅ and D₆ respectively. The mean carbohydrate content was 30.72% in C1 and 32.09 % in C2.

4.8. α -amylase test for old and Fresh lots of Neem [mm] [Table 8; Fig.17]

α -amylase test was performed in six levels of neem seeds. Highly significant variation in results were obtained for the α -amylase.

Increase in duration of storage reduced the α -amylase activity which results in the reduction of the diameter of the spot measured. It was 15 mm at D₁ (control - fresh seeds) and reached the lowest value of 2 mm at D₆. Reduction in diameter over the control was 6, 9, 11, 12 and 13 mm at D₁, D₃, D₄, D₅ and D₆ respectively. Highest rate of reduction was between D₁ and D₂.

Table 8 Changes in α -amylase content (mm) during storage of Azadirachta indica.

Treatment	Means	Difference
D 1 (Control)	15	-
D 2	9	-6 **
D 3	6	-9 **
D 4	4	-11 **
D 5	3	-12 **
D 6	2	-13 **
MEAN	6	
SEd	1.05	
CD (5%)	2	
CD (1%)	3	
Correlation matrix		
	Alpha amylase	Duration
Alpha amylase	1.000	-0.912 **
Duration	-0.912	1.000
$R^2 = 0.83^{**}$		
Regression equation : $Y = 12.524 - 2.493(\text{Duration})$		

4.9. INFLUENCE OF CROWN AND GROUND COLLECTION IN NEEM AND PUNGAM

4.9.1. Influence of crown [C1] and ground collection [C2] on Neem seeds

[Table 9; Fig 18]

Significantly varied results were obtained for all the parameter excepting for shoot length and total Carbohydrates.

4.9.1.1. Moisture content [%]

The initial moisture content % was highest in crown collected (C1) seeds with mean moisture content of 20.36% and the ground collected (C2) seeds registered 16.79% resulting in the variation of 2.5 per cent.

4.9.1.2. Germination [%]

In C2 the mean germination % was 86 and in C1 it was 94 with the different of 8% germination.

4.9.1.3. Root length [cm]

The length of root for C2 was 12.56 cm lesser which was significantly than the C1, C1 (13.7 cm).

4.9.1.4. Dry matter production [g]

Crown collected seeds produced 5.31 g dry matter production with the reduction of 0.39 g comparing with the C2.

4.9.1.5. Vigour index

The seedling vigour was more predominantly expressed in the C1 than the C2 and it was 501 and 422 for C1 and C2 respectively.

Table 9 Effect of crown and ground collection on moisture content (%), germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Azadirachta indica

	Moisture content	Germination	Root length	Shoot length	Dry matter production	Vigour index	Oil content	Free fatty acid	Protein	Carbohydrate
Crown Collection	20.36	94	13.70	9.24	5.31	501	23.43	5.00	17.52	35.89
Ground Collection	16.79	86	12.56	8.34	4.92	422	25.07	6.66	16.93	35.78
CD (5%)	1.45	3	0.9*	NS	0.34*	29	1.35*	0.20	0.54*	NS
CD (1%)	2.02**	5**	1.26NS	NS	0.47NS	40**	1.88NS	0.29**	0.76NS	NS

Fig.17. Change in α - amylase content (mm) during storage of *Azadirachta indica* seeds

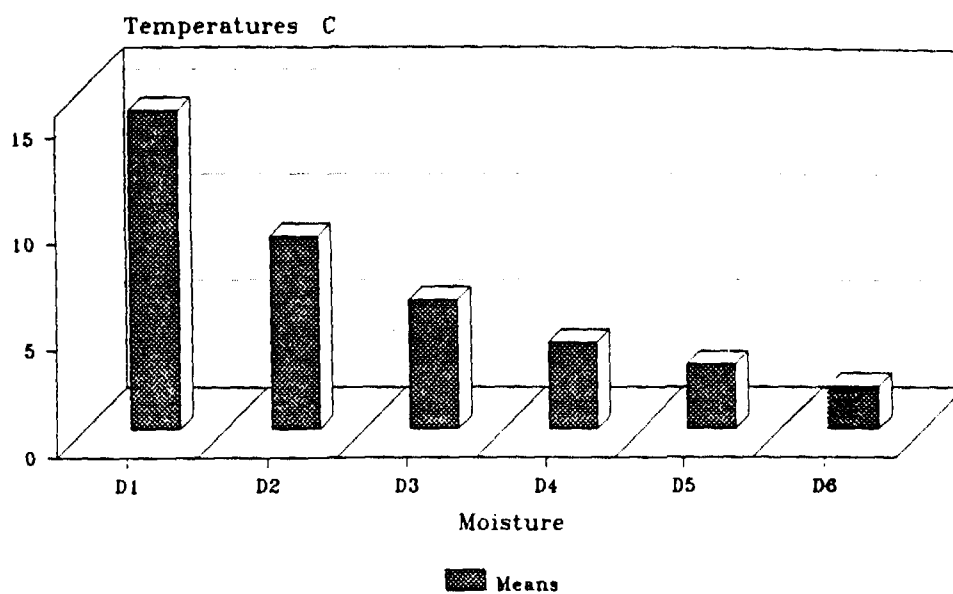
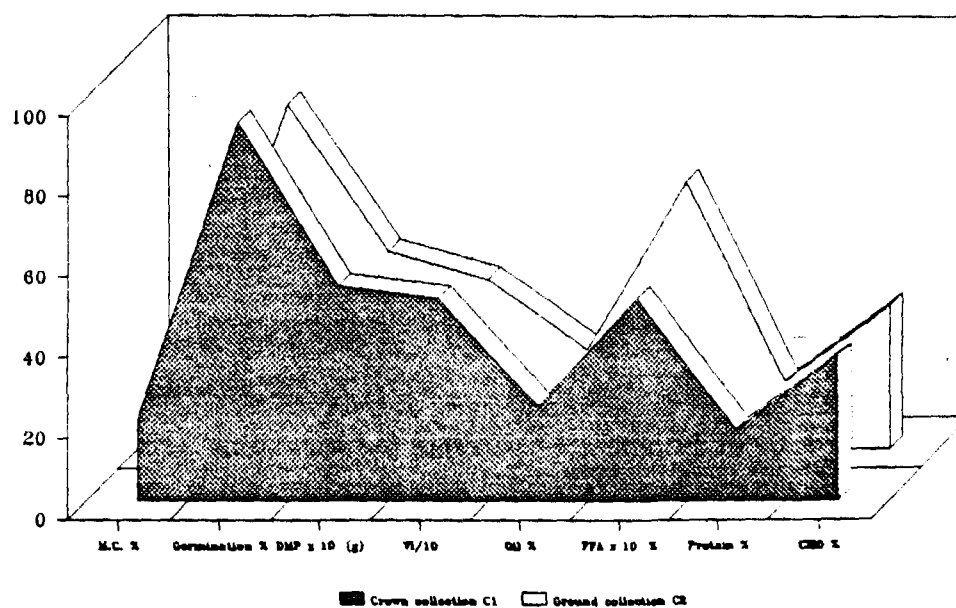


Fig.18. Influence of crown and ground collection on M.C, germination, VI, DMP, oil, FFA, protein, CHO (%) content of *Azadirachta indica* seeds



4.9.1.6. Oil content [%]

Crown collected seeds contained lesser oil than the ground collected one and it was 23.43% for C1 and 25.07 % for C2 and increase in oil content is 1.64% in the ground collected seeds.

4.9.1.7. Free Fatty Acid [%]

Higher percentage of free fatty acid was estimated from the seeds collected from the ground than the crown collected ones. There was 1.66% increase in free fatty acid in C2 than the C1 was remarkable.

4.9.1.8. Protein content [%]

The percentage of protein was higher in C1 than the C2, which significantly varied between these two. In C1 the mean protein content was 17.52 % and it was 16.93 % in C2.

4.9.2. Influence of crown and ground collection on seed quality in Pungam

[Table 10;Fig 19]

The results obtained were significantly varied among the seed collection methods tried for all the parameters excepting for oil and carbohydrate.

4.9.2.1. Moisture content [%]

The moisture content ranged between 13.33 and 15.76 % among C1 and C2 and there was 2.43 % difference for C1 with C2.

4.9.2.2. Germination [%]

There was 7 % variation among the seed collection and the lowest in C2 recorded 75%; while it was 82% in C1.

4.9.2.3. Root length [g]

Increase in root length was evident for the crown collected seeds measured longest root of 22.29 cm and it was 18.20 cm in C2.

4.9.2.4. Shoot length [cm]

Shoot length variation due to crown and ground collected seeds was significant and the C1 registered the highest value of 30.66 cm while it was 23.91 cm in C2.

4.9.2 5. Dry matter production [g]

The dry matter production was high in C1 with 11.83 g and it was low in C2 with 9.93 grams. The difference in weight was 2.10 grams. Which was nearly 16% of the C1.

4.9.2.6. Vigour Index

Vigourous seedlings production was resultant of the crown collection registering highest vigour index of 970 where it was just 746 in ground collected seeds.

4.9.2.7. Free Fatty Acid [%]

The free fatty acid content was more in C2 than C1 recording 8.04 and 5.89 % respectively.

4.9.2.8. Protein content [%]

The percentage reduction in protein content of C2 was 2.1 % and the maximum and minimum ranged between 25.23 and 23.17 per cent.

Table 10 Effect of crown and ground collection on moisture content (%), germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Derris indica seeds

	Moisture content	Germination	Root length	Shoot length	Dry matter production	Vigour index	Oil	Free fatty acid	Protein	Carbohydrate
Crown Collection	15.76	82	22.29	30.66	11.83	970	31.09	5.89	25.23	35.07
Ground Collection	13.33	75	18.20	23.91	9.93	746	31.16	8.04	23.17	33.79
CD (5%)	1.22	3	2.31	4.32	1.19	97	3.37	0.88	1.70*	NS
CD (1%)	1.70**	5**	3.22*	6.03**	1.66**	1.35**	4.49**	1.22*	2.37NS	NS

Fig.19. Influence of crown and ground collection on M.C, germination, VI, DMP, oil, FFA, protein, CHO (%) content of *Derris indica* seeds

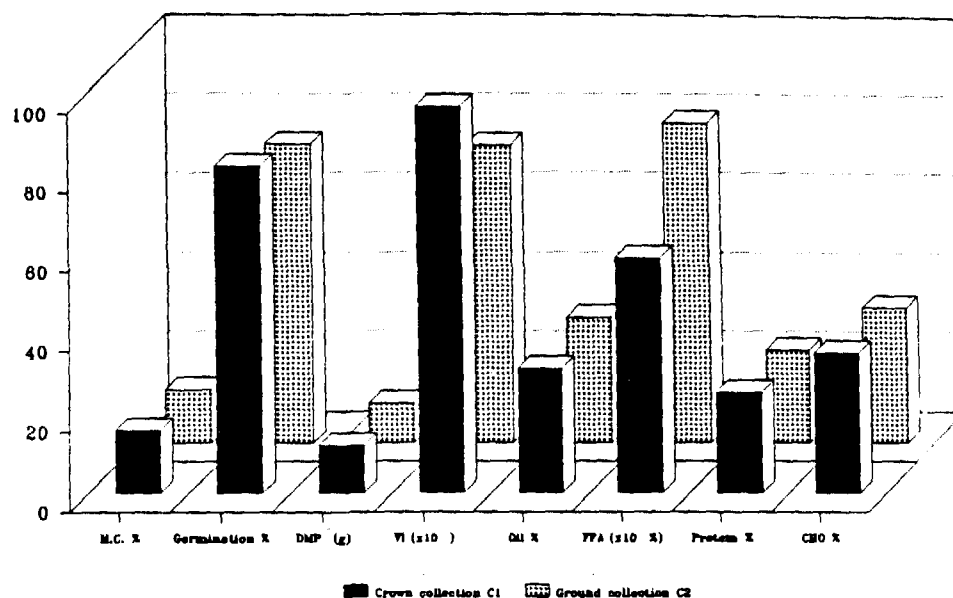


Fig.20. Influence of seed zones on germination, oil, FFA protein, CHO and chlorophyll contents in *Azadirachta indica* seeds

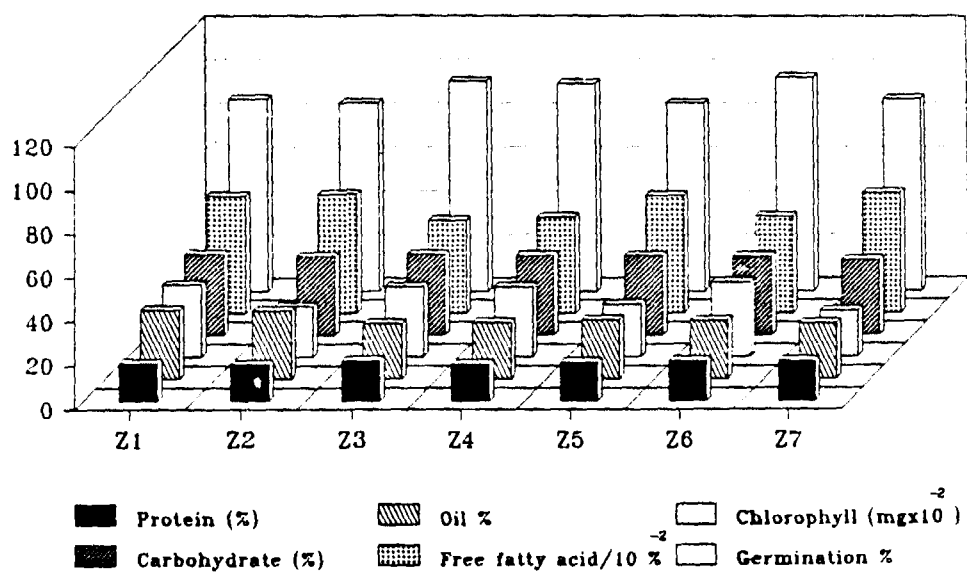


Table 11 Influence of seed source on seed length and breadth (cm), 1000 seed weight (g) of Azadirachta indica, Derris indica and Ailanthus excelsa

Location	Azadirachta indica			Derris indica			Ailanthus excelsa		
	Seed length (cm)	Seed breadth (cm)	1000 Seed weight (g)	Seed length (cm)	Seed breadth (cm)	1000 Seed weight (g)	Seed length (cm)	Seed breadth (cm)	1000 Seed weight (g)
L1	1.48	0.68	17.3	3.49	1.12	135.4	5.50	1.20	102.4
L2	1.46	0.63	21.2	3.51	1.09	135.0	5.48	1.18	106.5
L3	1.50	0.70	20.4	3.16	1.08	91.2	5.62	1.23	97.8
L4	1.43	0.62	21.5	3.39	1.30	126.7	5.58	1.45	106.0
L5	1.50	0.65	20.6	3.43	1.37	132.6	5.55	1.01	105.3
L6	1.44	0.63	22.4	3.67	1.12	128.4	5.45	1.02	98.4
L7	1.43	0.62	17.0	3.54	1.16	113.8	5.39	1.31	95.0
L8	1.46	0.57	20.4	3.97	1.01	123.2	-	-	-
L9	1.57	0.57	22.7	3.50	1.32	145.0	-	-	-
L10	1.46	0.66	20.7	3.12	1.17	88.1	-	-	-
L11	1.37	0.62	20.8	3.48	1.29	141.7	-	-	-
L12	1.38	0.60	21.7	3.54	1.28	138.4	-	-	-
L13	1.43	0.64	22.1	3.51	1.30	127.8	-	-	-
L14	1.25	0.63	21.8	3.88	1.62	111.6	-	-	-
L15	1.41	0.56	22.6	-	-	-	-	-	-
L16	1.58	0.58	20.3	-	-	-	-	-	-
L17	1.31	0.64	21.8	-	-	-	-	-	-
L18	1.40	0.63	18.7	-	-	-	-	-	-
L19	1.28	0.68	19.6	-	-	-	-	-	-
L20	1.41	0.69	20.8	-	-	-	-	-	-

4.10. SEED SOURCE VARIATION [Table 11]

4.10.1. Seed polymorphism [seed physical characteristics]

The influence of soil and edaphic factors expressed clear variation in seed size (length and breadth) and in 1000 seed weight. From the observations made in *Azadirachta indica* the length of seed was minimum in L14 with 1.25 cm and the maximum length was in L9 with 1.57 cm and the rest ranged only between the values of these two locations. However the breadth of the seed did not vary much. The 1000 seed weight ranged between 17.0 and 22.7 g in L7 and L9 respectively.

In the case of *Derris indica* seed length ranged between 3.12 and 3.88 cm at L10 and L14 respectively. The seed breadth was maximum in L14 and the minimum was in L8. Thousand seed weight ranged between 91.2 and 145.0 g at L3 and L9 respectively.

In the case of *Ailanthus excelsa* the seed length and breadth did not vary much in the 1000 seed weight ranged between 95.0 and 106.5 g at L7 and L2 respectively.

4.10.2. X-ray analysis of neem seeds [Contact and contrast therophy] [Table.12; Plates]

The presence of empty seeds, double seededness, shrivelled seeds, split cotyledons and disease infested seeds were revealed by the technique of contact and contrast therophy. (Plates)

From the positive film developed, the presence of double seededness (D) was evident of the cavity between the shell and kernal indicated the dryness of the seeds. Location-1 seeds had nearby 20% double seededness with the mean germination of 85 per cent.

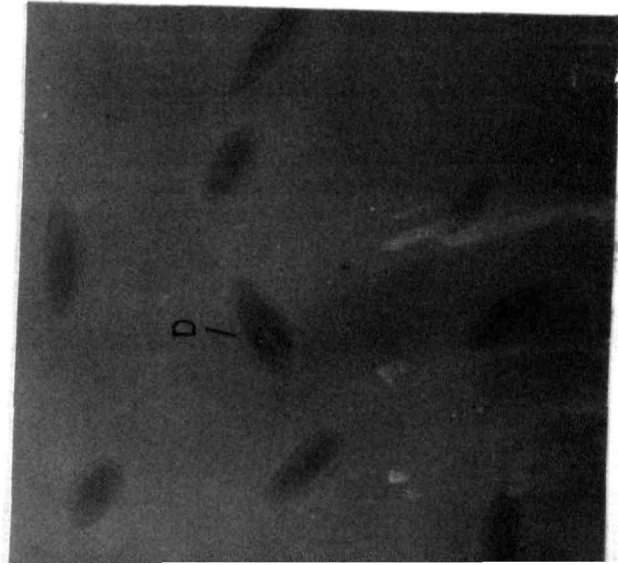
L2 does not have any mal-function by revealing through the contact therophy resulted in the 92% germination. However the reduction over the normal seeds can be described to the reason of disease infestation revealed by x-ray contrast therophy. The percentage of shrivelled seeds was high in L4 than other locations and presence of empty

Table 12 Presence of empty seeds, double seediness, split cotyledons, shrivelled seeds, diseased seeds as revealed by the X-ray contact and contrast therapy in the Azadirachta indica seeds collected from different locations

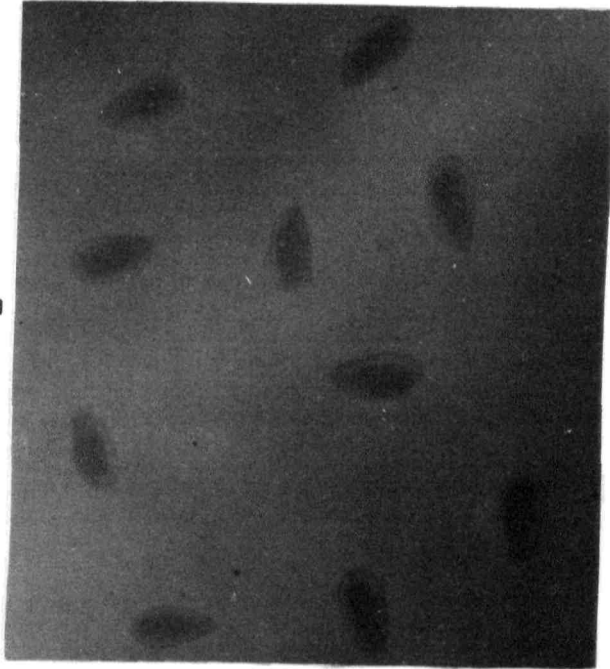
	L1	L2	L3	L4	L5
1. Empty seeds CT/CR	-	-	-	-	-
2. Split cotyledons CT/CR	-	-	P	P	-
3. Shrivelled seeds CT/CR	-	-	P	P	P
4. Double seediness CT/CR	P	-	-	P	P
5. Disease infection CR	P	P	P	P	P
Germination %	85	92	78	62	55

L1 - Coimbatore
L2 - Onnipalayam
L3 - Madurai (AC&I)
L4 - Vamban
L5 - Nagarkoil

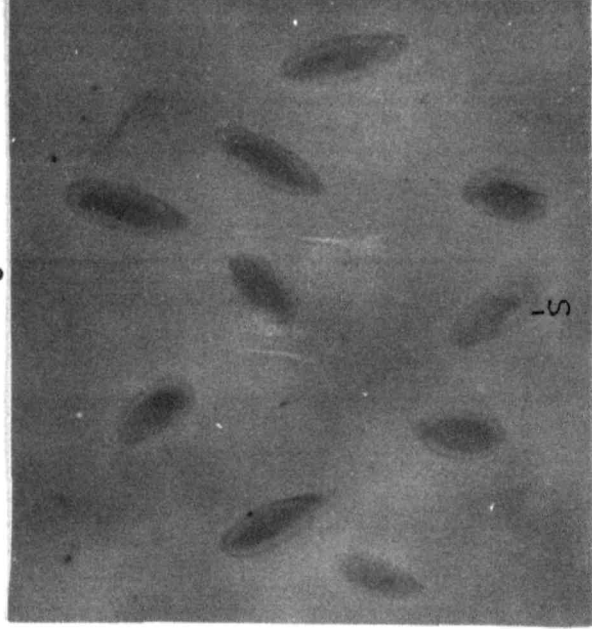
P - Present ;
CT - Contact therapy;
CR - Contrast therapy.



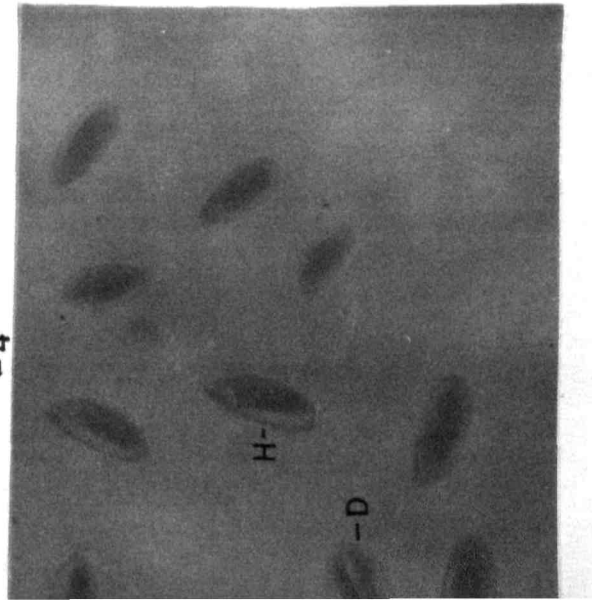
L2



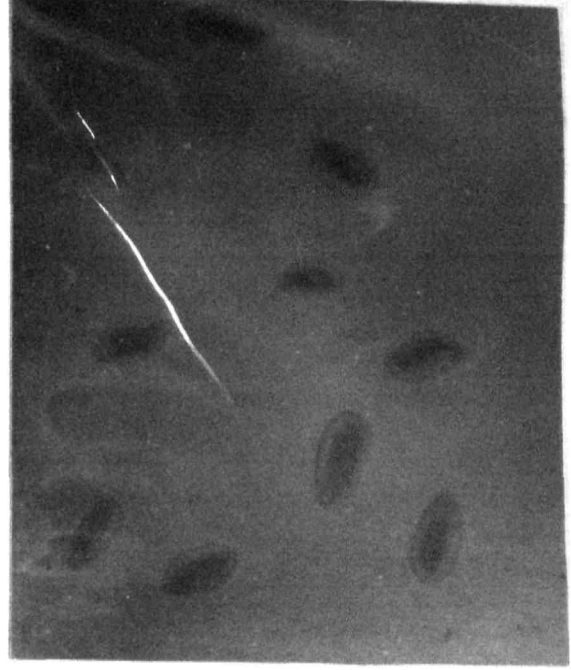
L3



L4

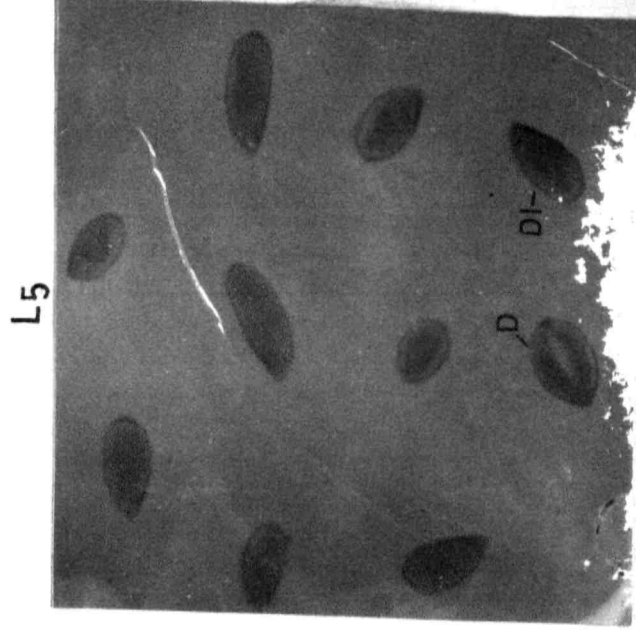
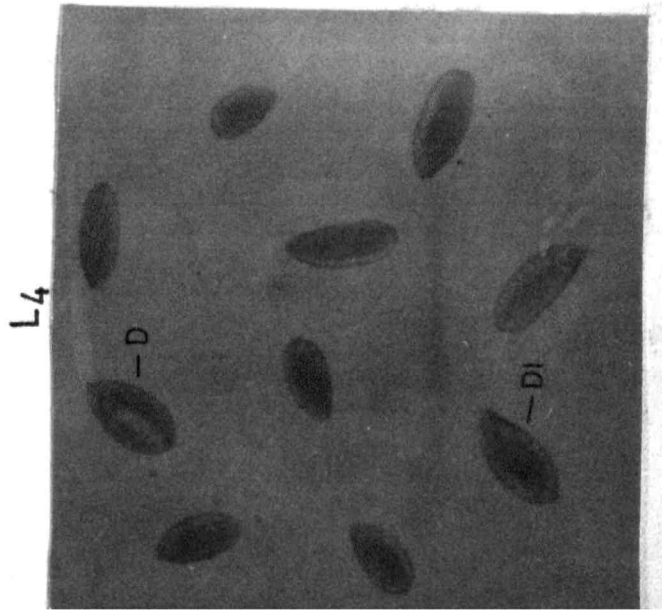
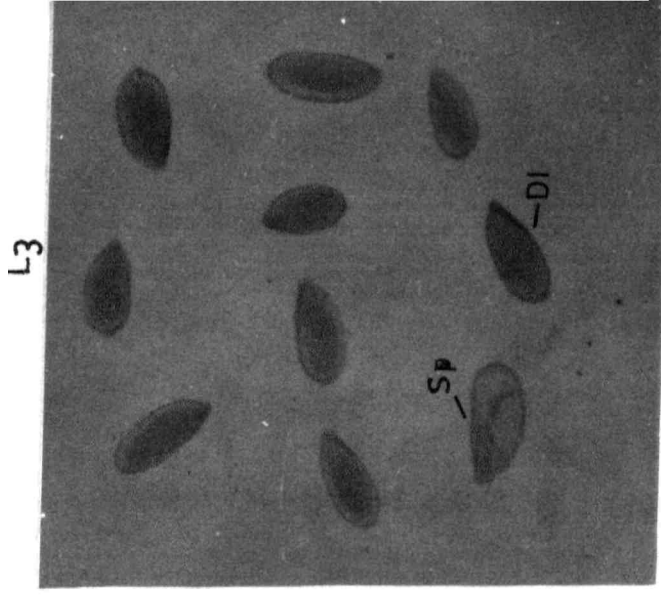
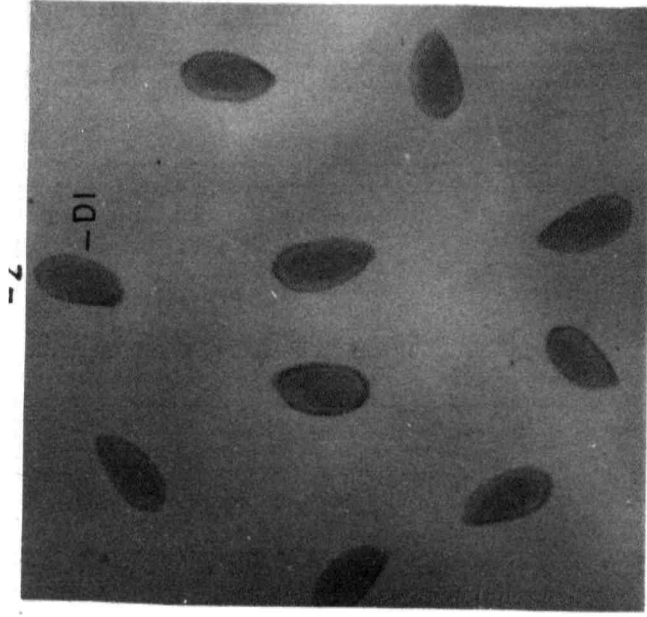
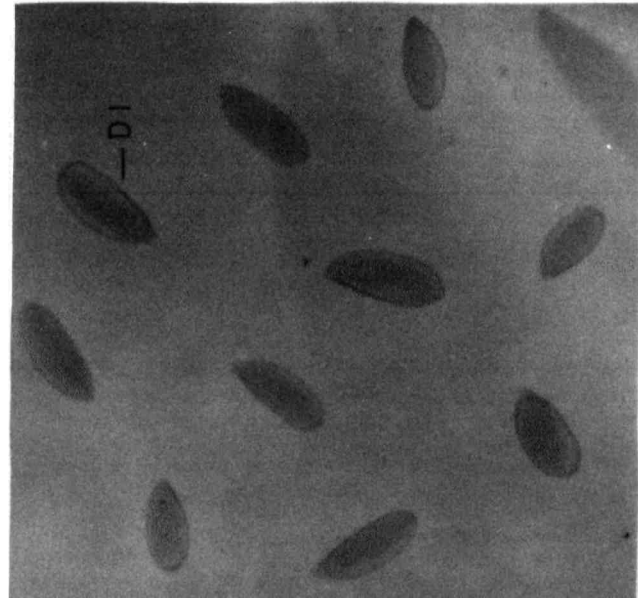


L5



LEGEND :

- H = HOLLOWNESS
- D = DOUBLE SEEDEDNESS
- S = SHRIVELLED SEEDS
- Sp = SPLIT COTYLEDON
- DI = DISEASE INFESTATION



LEGEND:

- H= HOLLOWNESS
- D= DOUBLE SEEDEDNESS
- S= SHRIVELLED SEEDS
- Sp= SPLIT COTYLEDON
- DI= DISEASE INFESTATION

seeds, shrivelled seeds and disease infestation resulted in the drastic reduction of germination to 55 per cent.

4.10.3. Physiological and biochemical studies of seed source variations

4.10.3.1 *Azadirachta indica*. [Table.13; Fig.20]

The seed source variations exhibited the highly significant results for all the parameters taken excepting for shoot length, dry matter production, vigour index and carbohydrates content.

4.10.3.1.1. Germination [%]

Germination results indicated that there was distinct variation in germination among the seed zones, gave maximum germination % of 98 for Z6 followed by 96 and 95 in Z3 and Z4 respectively. The mean minimum and maximum germination ranged between 86 and 98 per cent.

4.10.3.1.2. Root length [cm]

The lowest value for root length was recorded in Z3 and highest was in Z5.

4.10.3.1.3 Oil content [%]

The highest oil content was recorded in the Z1 with 31.42 % and the lowest was with Z3 in 25.11 per cent. The percentage variation in oil content for these amounted to 6.31 % which was nearly 20% of the maximum oil content.

4.10.3.1.4 Free Fatty Acid [%]

The percentage of free fatty acid varied between 4.26 and 5.50 % in Z3 and Z7 respectively. There was critical difference in free fatty acid content between all the zones tested, indicated the zone variation.

Table 13 Influence of seed source on germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil content (%), free fatty acid (%), protein (%), carbohydrate (%) and chlorophyll (mg/g) in Azadirachra indica seeds

Germination Root length Shoot length Dry matter production Vigour index Oil content Free fatty acid Protein content Carbohydrate Chlorophyll										
Z1	88	12.86	8.61	5.62	497	31.42	5.37	17.14	37.03	0.33
Z2	86	12.83	8.55	5.05	435	31.09	5.44	16.67	36.02	0.23
Z3	96	12.41	9.19	5.66	512	25.11	4.26	18.25	36.88	0.32
Z4	95	13.69	9.03	5.22	499	25.77	4.41	16.85	36.39	0.32
Z5	86	14.93	9.33	5.35	463	26.96	5.39	17.65	36.34	0.24
Z6	98	14.47	10.49	5.15	505	26.56	4.44	18.26	35.79	0.34
Z7	88	14.20	8.89	5.57	489	25.54	5.50	18.36	34.33	0.21

CD (5%)	4	1.48	NS	NS	NS	3.71	0.30	0.92	NS	0.06
CD (1%)	6**	2.07**	NS	NS	NS	5.21**	0.42**	1.29**	NS	0.10**

4.10.3.1.5 Protein [%]

The mean protein % was 17.14, 16.6, 18.25, 16.85, 17.65, 18.26 and 18.36 in Z1, Z2, Z3, Z4, Z5, Z6 and Z7 respectively. The maximum and minimum ranged between Z7 and Z1 with the variation of 1.69 per cent.

4.10.3.1.6 Chlorophyll content [mg]

Seed chlorophyll content critically varied between the zones and it was maximum in Z1 with 0.33 mg and minimum in Z7 with 0.21 mg with the difference of 0.12 mg amounting for 26% of the Z1 value 0.33 mg.

4.10.3.2. Seed Source variation in Pungam [*Derris indica*] [Table 14;Fig 21]

Leaving the shoot length all other parameters gave significantly varied results for the seed source variations.

4.10.3.2.1. Germination [%]

The maximum germination % was obtained in Z5 with 98% and the minimum was in Z6 with 62% accounting for 36% variation in germinability of seeds. The germination critically different between the zones.

4.10.3.2.2. Root length [cm]

The root length was maximum in Z2 (25.27 cm) followed by Z3 (22.8 cm) and the minimum was in Z5 with 18.

4.10.3.2.3. Dry matter production [g]

The weight of seedlings was highest in Z7 with 14.07 g and it was lowest in Z3 with 10.60 g. There exist critical difference in dry matter production among the zones.

ble 14. Influence of seed source on germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Derris indica seeds

	Germi- nation	Root length	Shoot length	Dry matter production	Vigour index	Oil	Free fatty acid	Protein	Carbo- hydrate
	86	22.80	29.80	12.40	1070	37.53	6.80	25.80	37.97
	77	25.27	33.07	12.33	869	31.60	7.63	24.73	36.43
	67	21.67	37.27	10.60	714	31.93	5.90	25.60	33.63
	94	21.00	30.33	10.73	1009	28.33	5.3	24.70	35.07
	98	18.13	31.27	11.73	1149	36.93	5.20	25.63	38.90
	62	20.40	34.33	12.60	781	27.00	4.97	23.40	36.40
	76	22.80	36.93	14.07	1068	27.20	7.50	21.43	35.10
) (5%)	5	2.58	NS	1.78	76	4.82	0.92	2.83*	2.25
) (1%)	8**	3.61**	NS	2.50**	1.6**	6.76**	1.30**	3.47NS	3.16**

4.10.3.2.4. Vigour Index

Z5 registered the highest vigour index value among the zones. It was 1149 in Z5 and it was 714 in Z3. The variation in vigour index value was 435.

4.10.3.2.5. Oil content [%]

The variation in oil content among the zones amounted to 10.53 % and the maximum value was recorded in Z1 and the lowest oil content was in Z7.

4.10.3.2.6. Free Fatty Acid [%]

The zone variation resulted in the free fatty acid contents too and it ranged between 4.97 and 7.63% for Z6 and Z2 respectively.

4.10.3.2.7. Protein [%]

The maximum and minimum protein content varied between Z1 and Z7 with 25.80 and 21.43 % respectively. The variation was to the tune of 24.37 per cent.

4.10.3.2.8. Carbohydrates [%]

The mean carbohydrate in Z1 to Z7 was in the order of 37.97, 36.43, 33.63, 35.07, 38.90, 36.40 and 35.10 % and the variation was 5.27 % between the maximum and minimum in Z5 and Z3 respectively.

4.10.3.3. Seed source variation in *Ailanthus excelsa* [Table.15;Fig 22].

The results obtained were having significant variation for all the parameters studied due to the influence of seed source.

4.10.3.3.1 Germination [%]

The maximum and minimum germination % ranged between L1 and L3 with 73 and 62 % respectively. The difference in mean germination was 11 per cent.

4.10.3.3.2. Root length [cm]

The highest root length was measured in L1 with 9.13 cm and the shortest being at L2 with 7.67 cm amounting for 1.46 cm difference.

4.10.3.3.3..Shoot length [cm]

Among the locations tested there was significant variation in shoot length and it was 1.07 (cm) between the maximum and minimum at L1 and L4 respectively.

4.10.3.3.4 Dry matter production [g]

The mean dry matter production was highest in L1 with 0.22 g and it was lowest in L7 with 0.15 gram. The percentage of variation was 32% among these two.

4.10.3.3.5 Vigour Index

The maximum and minimum vigour index was ranging between L1 and L7 with 16 and 10 value accounting in the vigour index variation of 6.

4.10.3.3.6 Oil content [%]

Unlike other parameters the maximum and minimum oil content ranged between L4 and L5 recording 26.0 and 23.40 % oil content respectively. The variation in oil content was 2.6 per cent.

Table 15. Influence of seed source on germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Ailanthus excelsa seeds

	Germi- nation	Root length	Shoot length	Dry matter production	Vigour index	Oil	Free fatty acid	Protein	Carbo- hydrate
	73	9.13	8.17	0.22	16	25.77	6.37	39.23	19.87
	69	7.67	7.80	0.18	12	23.60	6.17	36.23	18.93
	62	8.63	7.73	0.18	11	24.33	7.03	41.20	18.53
	66	8.33	7.10	0.17	11	26.00	7.37	39.08	16.00
	64	8.20	7.47	0.18	12	23.40	7.77	36.03	14.53
	63	7.87	8.10	0.17	11	23.47	7.37	33.50	16.73
	68	8.00	8.13	0.15	10	25.70	7.23	36.40	17.87
(5%)	6	0.86*	0.38	0.03	2	2.26*	0.14	1.82	0.84*
(1%)	8**	1.21NS	0.53**	0.04**	3**	3.17	0.19**	2.55**	1.18**

Fig.21. Influence of seed zones on germination vigour index, oil, FFA Protein and carbohydrate content in *Derris indica*

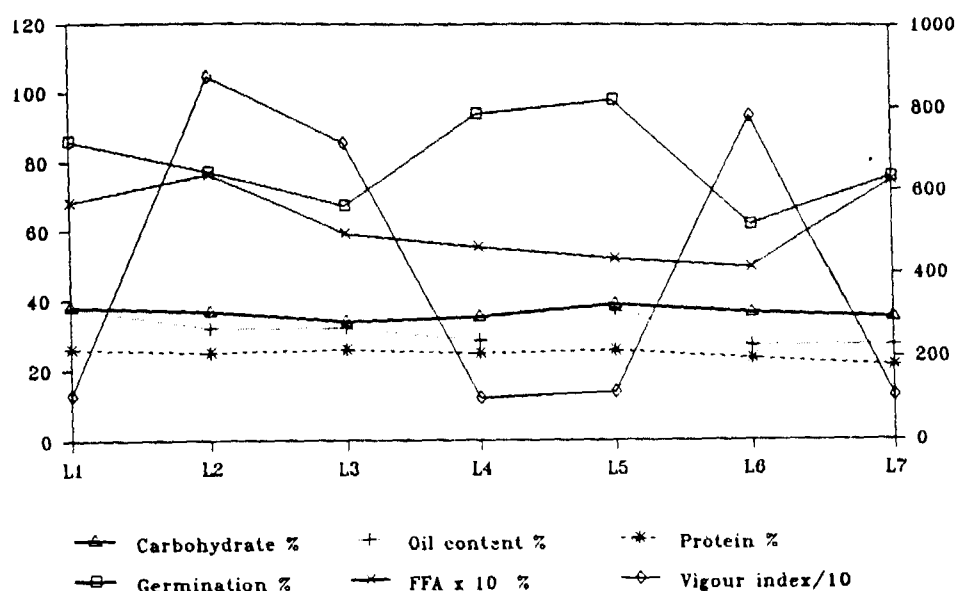
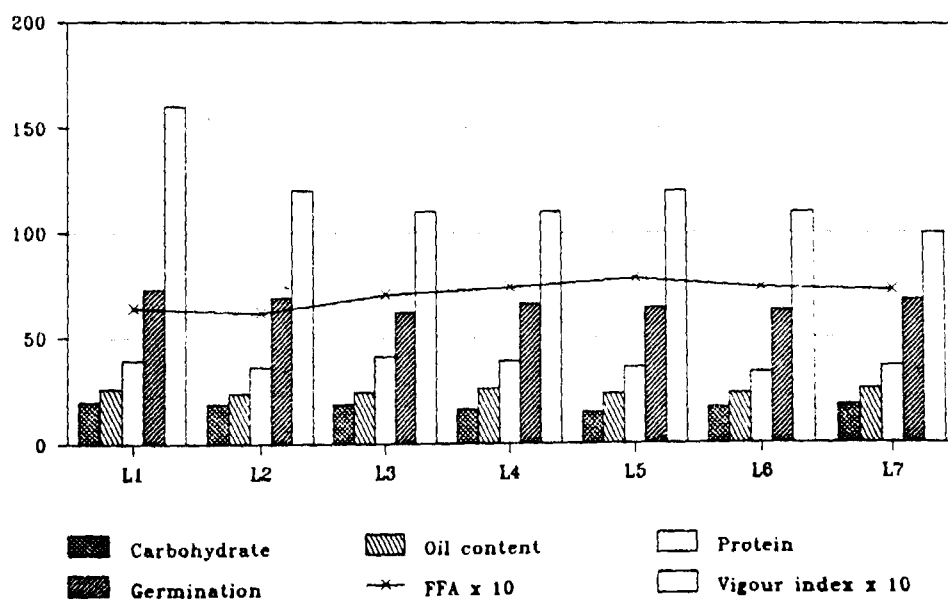


Fig.22. Influence of seed zones on germination % vigour index, oil %, FFA %, Protein and carbohydrate content % in *Ailanthus excelsa*



4.10.3.3.7 Free Fatty Acid [%]

The highest percentage of free fatty acid was recorded in L5 with 7.77% and the lowest being L2 with 6.17 per cent. However in L4 and L6 was on par with each other with 7.37 % free fatty acid.

4.10.3.3.8 Protein content [%]

The location variation clearly resulted in the marked difference in protein content. Between the maximum and minimum there was 4.70 % variation in protein content. The protein content was maximum (41.20 %) in L3 and minimum in L6 with 33.50 per cent.

4.10.3.3.9 Carbohydrates [%]

The percentage of carbohydrate variation among the locations was 27% and the maximum and minimum ranged between 19.87% and 14.53% in L1 and L5 respectively.

4.11. STORAGE STUDIES

4.11.1. Storage studies in Neem [*Azadirachta indica* Adr.Juss]

4.11.1.1. Germination [%] [Table.16;Fig.23]

Highly significant results was obtained for the variation in storage for different locations (here after zones), storage temperatures and duration of storage. The interaction effect was significant for zones with temperature and duration of storage seperately and temperature with duration. However the three way interaction of zone with duration and temperature were non-significant.

Among the zones, Z6, the control, registered the highest germination of 99% and the minimum was in Z2 and Z5, with 87% each.

Table 16 Influence of seed zones on seed germination (%) at different temperatures during storage of Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	89 (70.65)	89 (70.65)	89 (70.65)	89 (70.65)
D ₂	84 (66.06)	71 (57.11)	43 (40.97)	66 (54.71)
D ₃	74 (59.35)	60 (50.77)	29 (32.27)	54 (47.46)
D ₄	57 (49.03)	45 (41.84)	18 (25.10)	40 (38.66)
D ₅	32 (34.45)	22 (27.97)	8 (16.40)	21 (26.27)
D ₆	13 (21.14)	10 (18.42)	0 (0.29)	8 (13.28)
D ₇	0 (0.29)	0 (0.29)	0 (0.29)	0 (0.29)
Z₂				
D ₁	87 (68.47)	87 (68.47)	87 (68.47)	87 (68.47)
D ₂	82 (64.53)	72 (57.74)	41 (39.53)	65 (53.93)
D ₃	65 (53.73)	52 (46.15)	24 (29.33)	47 (43.07)
D ₄	53 (46.72)	38 (38.06)	16 (23.58)	36 (36.12)
D ₅	33 (35.06)	19 (25.47)	6 (14.18)	19 (24.90)
D ₆	13 (20.67)	8 (16.40)	0 (0.29)	7 (12.45)
D ₇	1 (3.02)	0 (0.29)	0 (0.29)	0 (1.20)
Z₃				
D ₁	97 (79.48)	97 (79.48)	92 (74.54)	95 (77.83)
D ₂	90 (71.57)	78 (62.04)	57 (48.74)	75 (60.78)
D ₃	80 (63.08)	68 (55.55)	31 (33.83)	60 (50.82)
D ₄	72 (57.74)	52 (45.86)	19 (25.84)	47 (43.15)
D ₅	39 (38.65)	25 (29.67)	9 (16.95)	24 (28.42)
D ₆	21 (26.92)	14 (21.53)	0 (0.29)	11 (16.25)
D ₇	2 (7.86)	0 (0.29)	0 (0.29)	1 (2.81)
Z₄				
D ₁	95 (76.45)	95 (76.45)	95 (76.45)	95 (76.45)
D ₂	88 (69.30)	79 (62.38)	49 (44.43)	72 (58.70)
D ₃	75 (60.07)	62 (51.65)	26 (30.66)	54 (47.46)
D ₄	66 (54.33)	46 (42.70)	17 (24.35)	43 (40.46)
D ₅	37 (37.17)	22 (27.97)	8 (16.40)	22 (27.18)
D ₆	17 (24.32)	10 (17.95)	0 (0.29)	9 (14.18)
D ₇	2 (8.13)	0 (0.29)	0 (0.29)	1 (2.90)
Z₅				
D ₁	87 (68.88)	87 (68.88)	87 (68.88)	87 (68.88)
D ₂	83 (65.33)	75 (60.00)	53 (46.44)	70 (57.26)
D ₃	72 (57.74)	60 (50.77)	28 (31.92)	53 (46.80)
D ₄	65 (53.73)	47 (42.99)	17 (24.34)	43 (40.36)
D ₅	38 (37.76)	21 (27.27)	7 (15.30)	22 (26.78)
D ₆	20 (26.56)	10 (18.44)	0 (0.29)	10 (15.09)
D ₇	3 (9.84)	0 (0.29)	0 (0.29)	1 (3.47)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	99 (85.79)	99 (85.79)	99 (85.79)	99 (85.79)
D ₂	95 (76.45)	81 (64.17)	62 (51.95)	79 (64.19)
D ₃	83 (65.66)	66 (54.33)	28 (31.95)	59 (50.65)
D ₄	74 (59.35)	53 (46.72)	19 (25.84)	49 (43.97)
D ₅	44 (41.27)	25 (29.99)	9 (16.94)	26 (29.40)
D ₆	25 (29.99)	12 (19.82)	0 (0.29)	12 (16.70)
D ₇	7 (15.34)	0 (0.29)	0 (0.29)	2 (5.30)
Z₇				
D ₁	90 (71.52)	90 (71.52)	90 (71.52)	90 (71.52)
D ₂	88 (69.30)	75 (59.67)	52 (45.86)	71 (58.28)
D ₃	75 (60.00)	62 (51.95)	26 (30.66)	54 (47.54)
D ₄	66 (54.03)	48 (43.57)	16 (23.58)	43 (40.39)
D ₅	36 (36.57)	22 (27.61)	6 (14.18)	21 (26.12)
D ₆	16 (23.18)	9 (17.43)	0 (0.29)	8 (13.64)
D ₇	2 (6.94)	0 (0.29)	0 (0.29)	1 (2.50)
T-MEAN	53 (46.60)	44 (39.49)	28 (27.38)	42 (37.83)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	1.84	1.84	1.84	1.068	0.699	0.699	-
CD (5%)	3.05	3.05	3.05	2.110	1.381	1.881	NS
CD (1%)	4.80**	4.80**	4.80**	2.785**	1.823**	1.823**	NS

Correlation matrix

	Germination	Temperature	Duration	Zones
Germination	1.000	0.298**	-0.909**	0.042NS
Temperature	0.298	1.000	0.000NS	0.000NS
Duration	-0.909	0.000	1.000	0.000NS
Zones	0.042	0.000	0.000	1.000

$$R^2 = 0.92^{**}$$

Regression equation : $Y = 78.052 + 0.805 (\text{Temperature})$
 $- 15.285 (\text{Duration}) + 0.702 (\text{Zones})$

Fig.23. Influence of seed zones on germination (%) at different temperatures during storage of *Azadirachta indica* seeds

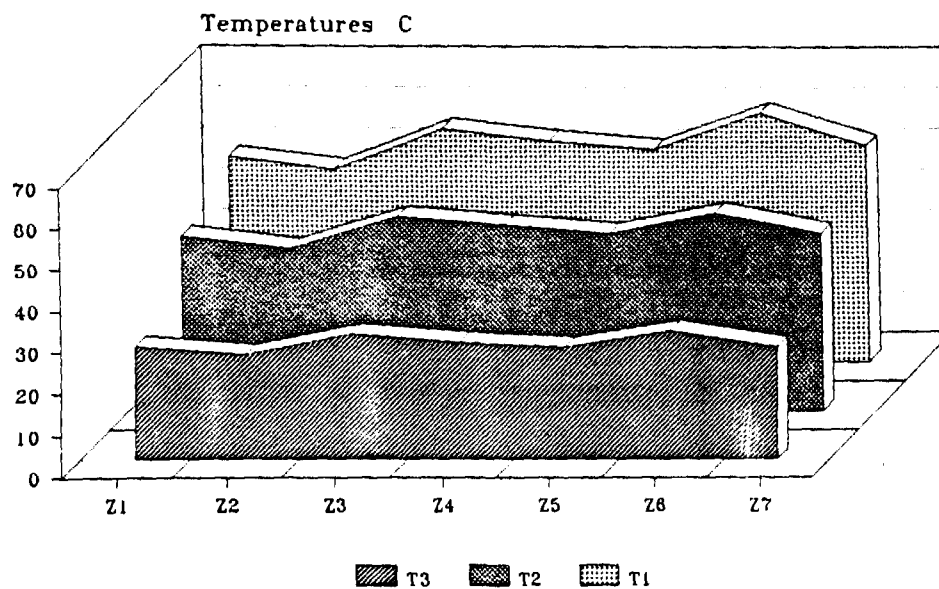
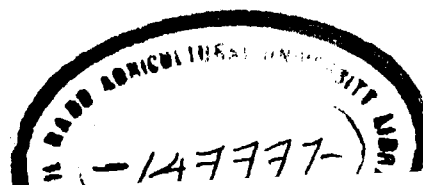
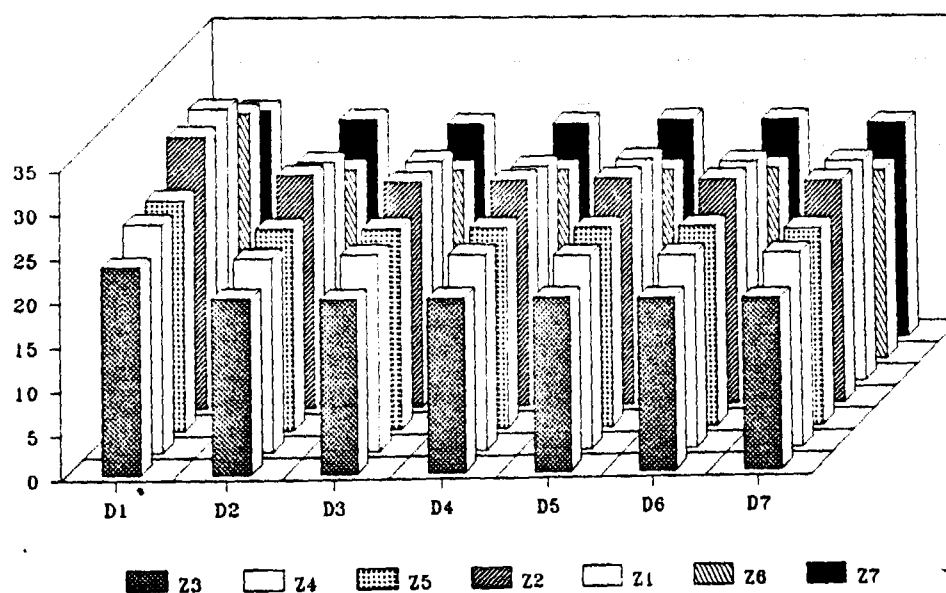


Fig.24. Influence of seed zones and duration of storage on oil content (%) in *Azadirachta indica* seeds



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The duration of storage reduced the germination, irrespective of the included zones, and it was gradual upto D4 and reduced at a faster rate which subsequently reached zero per cent at D7.

Irrespective of the zones and temperature at D1, the mean germination ranged from 95 to 87% in (Z3 and Z4) and (Z5 and Z2) respectively. At D2 it was 79% and 65% in Z6 and Z2 respectively. However, the germination was 60% and 47% in Z3 and Z2 respectively at D3. There after the maximum and minimum ranged only between Z6 and Z2 in respect of the included durations.

Regarding the effect of storage temperature, in respect of the three temperatures, the highest germination was registered in Z6; while the lowest was registered in Z2. The germination percentage ranged between 61 and 47% in T1; 48 and 39% in T2 and 31 and 25% in T3. Among the temperatures, T1 irrespective of the zones registered higher germination; whereas T3 registered the lowest.

The overall evaluation of interaction between temperature and duration revealed that the T1 registered the highest mean germination with 53% ; while the lowest was in T3 (28%). Interestingly, in T3, the germination dropped to zone at D5 itself.

The germination clearly broughtout the negative association and germination with duration and storage and positive association with temperature.

4.11.1.2. Root Length [cm] [Table.17]

Highly significant results were obtained for different zones, temperatures and duration and storage and their interactions.

At D1, Z5 registered the largest root (15.00 cm) irrespective of the storage temperature. The maximum and minimum ranged between Z3 and Z5. There after the maximum and minimum ranged between Z1 (10.37 cm) and Z3 (12.28 cm) at D2; Z1 (9.80 cm) and Z7 (10.68 cm) at D3; Z1 (9.38) and Z5 (10.65) at D4; Z2 (9.58 cm) and Z5 (10.47 cm) at D5; Z1 (5.77 cm) and Z5 (6.95 cm) at D6 and Z2 (0.50 cm) and Z6 (3.20)

Table 17 Influence of seed zones on root length (cm) at different temperatures during storage of *Azadirachta indica* seeds.

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	12.90 (4.79)	12.90 (4.79)	12.90 (4.79)	12.90 (4.79)
D ₂	11.40 (4.63)	10.35 (4.51)	9.35 (4.40)	10.37 (4.51)
D ₃	11.30 (4.62)	9.05 (4.36)	9.05 (4.36)	9.80 (4.45)
D ₄	9.75 (4.44)	9.30 (4.39)	9.10 (4.37)	9.38 (4.40)
D ₅	9.20 (4.38)	8.45 (4.30)	8.50 (4.30)	8.72 (4.33)
D ₆	8.95 (4.35)	8.35 (4.28)	0.00 (3.16)	5.77 (3.93)
D ₇	2.30 (3.49)	0.00 (3.16)	0.00 (3.16)	0.77 (3.27)
Z₂				
D ₁	12.75 (4.77)	12.65 (4.76)	12.65 (4.76)	12.68 (4.76)
D ₂	12.45 (4.74)	10.80 (4.56)	9.85 (4.46)	11.03 (4.58)
D ₃	12.00 (4.69)	10.40 (4.52)	9.20 (4.28)	10.53 (4.53)
D ₄	10.90 (4.57)	9.70 (4.44)	9.75 (4.44)	10.12 (4.48)
D ₅	10.40 (4.52)	9.30 (4.39)	9.05 (4.36)	9.58 (4.42)
D ₆	9.75 (4.44)	9.15 (4.38)	0.00 (3.16)	6.30 (3.99)
D ₇	1.50 (3.38)	0.00 (3.16)	0.00 (3.16)	0.55 (3.24)
Z₃				
D ₁	12.30 (4.72)	12.30 (4.72)	12.30 (4.72)	12.30 (4.72)
D ₂	13.30 (4.83)	12.35 (4.73)	11.20 (4.60)	12.28 (4.72)
D ₃	13.40 (4.84)	11.15 (4.60)	10.25 (4.50)	11.60 (4.65)
D ₄	11.50 (4.64)	10.40 (4.52)	9.95 (4.47)	10.62 (4.54)
D ₅	11.15 (4.60)	9.60 (4.43)	8.90 (4.35)	9.88 (4.46)
D ₆	10.35 (4.51)	9.50 (4.42)	0.00 (3.16)	6.62 (4.03)
D ₇	4.65 (3.82)	0.00 (3.16)	0.00 (3.16)	1.55 (3.38)
Z₄				
D ₁	13.90 (4.89)	13.90 (4.89)	13.90 (4.89)	13.90 (4.89)
D ₂	13.40 (4.84)	12.40 (4.73)	10.75 (4.56)	12.18 (4.71)
D ₃	13.45 (4.84)	10.35 (4.51)	9.55 (4.42)	11.12 (4.59)
D ₄	11.35 (4.62)	9.95 (4.47)	9.20 (4.38)	10.17 (4.49)
D ₅	10.85 (4.57)	9.15 (4.38)	9.10 (4.37)	9.70 (4.44)
D ₆	10.40 (4.52)	9.00 (4.36)	0.00 (3.16)	6.47 (4.01)
D ₇	4.60 (3.82)	0.00 (3.16)	0.00 (3.16)	1.53 (3.38)
Z₅				
D ₁	15.00 (5.00)	15.00 (5.00)	15.00 (5.00)	15.00 (5.00)
D ₂	13.80 (4.88)	11.65 (4.65)	10.70 (4.35)	12.05 (4.69)
D ₃	13.50 (4.85)	10.30 (4.51)	9.95 (4.47)	11.25 (4.61)
D ₄	12.00 (4.69)	10.20 (4.49)	9.75 (4.44)	10.65 (4.54)
D ₅	11.95 (4.69)	9.75 (4.44)	9.70 (4.44)	10.47 (4.52)
D ₆	11.15 (4.60)	9.70 (4.44)	0.00 (3.16)	6.95 (4.07)
D ₇	5.25 (3.91)	0.00 (3.16)	0.00 (3.16)	1.75 (3.41)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	14.30 (4.93)	14.30 (4.93)	14.30 (4.93)	14.30 (4.93)
D ₂	13.30 (4.83)	11.85 (4.67)	11.30 (4.62)	12.15 (4.71)
D ₃	12.50 (4.74)	10.65 (4.54)	10.30 (4.51)	11.15 (4.60)
D ₄	11.45 (4.63)	9.55 (4.43)	9.30 (4.39)	10.10 (4.48)
D ₅	10.55 (4.53)	9.15 (4.38)	9.40 (4.40)	9.70 (4.44)
D ₆	9.85 (4.46)	9.25 (4.39)	0.00 (3.16)	6.37 (4.00)
D ₇	9.60 (4.43)	0.00 (3.16)	0.00 (3.16)	3.20 (4.58)
Z₇				
D ₁	14.40 (4.94)	14.40 (4.94)	14.40 (4.94)	14.40 (4.94)
D ₂	12.70 (4.76)	12.10 (4.70)	10.90 (4.57)	11.90 (4.68)
D ₃	12.10 (4.70)	10.05 (4.48)	9.90 (4.46)	10.68 (4.55)
D ₄	11.35 (4.62)	9.60 (4.43)	9.35 (4.40)	10.10 (4.48)
D ₅	11.80 (4.67)	9.20 (4.38)	9.00 (4.36)	10.00 (4.47)
D ₆	10.55 (4.53)	9.05 (4.36)	0.00 (3.16)	6.53 (4.02)
D ₇	2.70 (3.56)	0.00 (3.16)	0.00 (3.16)	0.90 (3.30)
-MEAN	10.82 (4.55)	9.11 (4.34)	7.51 (4.14)	9.14 (4.34)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
Ed	1.04	1.04	1.04	0.59	0.32	0.32	1.04
(5%)	2.04	2.04	2.04	1.17	0.63	0.63	2.03
(1%)	2.69**	2.69**	2.69**	1.55**	0.69**	0.69**	2.69**

rrrelation matrix

	Root length	Duration	Temperature	Zones
ot length	1.000	-0.793**	0.306**	0.085NS
ration	-0.793	1.000	0.000NS	0.000NS
perature	0.306	0.000	1.000	0.000NS
es	0.085	0.000	0.000	1.000

= 0.73**

ression equation " Y = 12.686 - 1.724 (Duration)
+ 0.107 (Temperature) + 0.184 (Zones)

at D7. The decrease in root length was evident with decrease in storage temperature. The initial mean value of (T1) 10.82 cm was reduced to 7.51 cm at T3.

The interaction of zones with different durations was highly significant. The mean root length was longest at D1 in Z5 with 15.1 cm and it was shortest at D7 in Z2 with 0.15 cm. Storing the seeds for six months drastically reduced the root length beyond D5, irrespective of the zones. The mean maximum root length ranged between 13.70 cm (D1) 0.49 cm (D7), irrespective of the zones and temperature. Irrespective of durations and temperatures the Z1 caused production of root length of 7.0 cm; while Z5 registered 8.5 cm. Over the periods of storage, the root length at D1, with 13.70 cm dropped to just 0.49 cm at D7.

The evaluation based on the interaction of zone and temperature revealed that the decrease in temperature drastically reduced the root length to 5.6 cm (T3) from 10.4 cm (T1) irrespective of the zones and durations. With different temperatures, the mean root length for different zones varied from 7.00 cm (Z1) to 8.5 cm (Z5).

Temperature and duration interaction significantly reduced the root length both over the storage period and temperatures. The mean root length at T1 (10.4 cm) as brought down to 5.6 cm at T3, irrespective of zones and durations. The drop in the value was great between D6 and D7.

Negative correlation existed between the root length and durations of storage; while positive correlation between temperature and root length were obtained with r^2 value of 0.73.

4.11.1.3. Shoot Length [cm] [Table 18]

The results based on the effect of Zone, Temperature and Duration of storage and also the interaction effect of temperature with duration of storage were highly significant. The interaction of zone with temperature and duration and the three way interaction was not significant.

Table 18 Influence of seed zones on shoot length (cm) at different temperatures during storage of *Azadirachta indica* seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	8.80 (4.33)	8.80 (4.33)	8.80 (4.33)	8.80 (4.33)
D ₂	8.65 (4.32)	8.15 (4.26)	5.40 (3.92)	7.40 (4.17)
D ₃	9.80 (4.45)	6.05 (4.00)	6.65 (4.08)	7.50 (4.18)
D ₄	8.20 (4.27)	5.60 (3.95)	5.75 (3.97)	6.52 (4.06)
D ₅	6.40 (4.05)	4.35 (3.79)	4.65 (3.83)	5.12 (3.89)
D ₆	6.25 (4.03)	4.95 (3.87)	0.00 (3.16)	3.73 (3.69)
D ₇	1.50 (3.38)	0.00 (3.16)	0.00 (3.16)	0.50 (3.24)
Z₂				
D ₁	8.65 (4.32)	8.65 (4.32)	8.65 (4.32)	8.65 (4.32)
D ₂	8.70 (4.32)	7.10 (4.13)	6.95 (4.11)	7.58 (4.19)
D ₃	7.75 (4.21)	5.70 (3.96)	5.95 (3.99)	6.47 (4.06)
D ₄	7.55 (4.19)	5.30 (3.91)	4.80 (3.85)	5.58 (3.98)
D ₅	7.05 (4.13)	4.40 (3.79)	4.90 (3.86)	5.45 (3.93)
D ₆	5.00 (3.87)	4.30 (3.78)	0.00 (3.16)	3.10 (3.61)
D ₇	0.70 (3.27)	0.00 (3.16)	0.00 (3.16)	0.23 (3.20)
Z₃				
D ₁	9.40 (4.40)	9.40 (4.40)	9.40 (4.40)	9.40 (4.40)
D ₂	8.70 (4.32)	8.10 (4.25)	7.10 (4.14)	7.97 (4.24)
D ₃	10.65 (4.54)	5.10 (3.89)	6.85 (4.10)	7.53 (4.18)
D ₄	9.60 (4.43)	5.15 (3.89)	5.85 (3.98)	6.87 (4.10)
D ₅	7.90 (4.23)	5.05 (3.88)	5.15 (3.89)	6.03 (4.00)
D ₆	6.30 (4.04)	4.70 (3.83)	0.00 (3.16)	3.67 (3.68)
D ₇	2.40 (3.52)	0.00 (3.16)	0.00 (3.16)	0.80 (3.28)
Z₄				
D ₁	9.40 (4.40)	9.40 (4.40)	9.40 (4.40)	9.40 (4.40)
D ₂	5.90 (3.99)	7.75 (4.21)	7.25 (4.15)	6.97 (4.12)
D ₃	5.50 (3.94)	6.00 (4.00)	7.25 (4.15)	6.25 (4.03)
D ₄	5.65 (3.96)	5.50 (3.94)	6.80 (4.10)	5.98 (4.00)
D ₅	7.00 (4.12)	5.15 (3.89)	4.80 (3.85)	5.65 (3.95)
D ₆	6.20 (4.02)	4.95 (3.87)	0.00 (3.16)	3.72 (3.68)
D ₇	2.20 (3.49)	0.00 (3.16)	0.00 (3.16)	0.73 (3.27)
Z₅				
D ₁	9.95 (4.47)	9.95 (4.47)	9.95 (4.47)	9.95 (4.47)
D ₂	7.30 (4.15)	9.70 (4.44)	7.75 (4.21)	8.25 (4.27)
D ₃	6.80 (4.10)	7.30 (4.15)	6.80 (4.10)	6.97 (4.12)
D ₄	9.25 (4.39)	6.20 (4.02)	5.10 (3.89)	6.85 (4.10)
D ₅	8.30 (4.28)	5.95 (3.99)	5.35 (3.92)	6.53 (4.06)
D ₆	6.05 (4.01)	5.05 (3.88)	0.00 (3.16)	3.70 (3.68)
D ₇	4.10 (3.75)	0.00 (3.16)	0.00 (3.16)	1.37 (3.36)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	10.05 (4.48)	10.05 (4.48)	10.05 (4.48)	10.05 (4.48)
D ₂	9.10 (4.37)	6.55 (4.07)	6.55 (4.07)	7.40 (4.17)
D ₃	8.65 (4.32)	5.40 (3.92)	7.20 (4.15)	7.08 (4.13)
D ₄	8.75 (4.33)	4.75 (3.84)	4.65 (3.83)	6.05 (4.00)
D ₅	6.70 (4.09)	4.55 (3.81)	5.50 (3.94)	5.58 (3.95)
D ₆	5.45 (3.93)	4.40 (3.79)	0.00 (3.16)	3.28 (3.63)
D ₇	2.90 (3.58)	0.00 (3.16)	0.00 (3.16)	0.97 (3.30)
Z₇				
D ₁	8.50 (4.30)	8.50 (4.30)	8.50 (4.30)	8.50 (4.30)
D ₂	8.40 (4.29)	7.35 (4.17)	5.40 (3.92)	7.05 (4.13)
D ₃	9.05 (4.36)	6.30 (4.04)	6.05 (4.01)	7.13 (4.14)
D ₄	7.55 (4.19)	5.85 (3.98)	5.95 (3.99)	6.45 (4.05)
D ₅	7.05 (4.13)	4.50 (3.81)	4.85 (3.85)	5.47 (3.93)
D ₆	5.45 (3.93)	4.50 (3.81)	0.00 (3.16)	3.32 (3.63)
D ₇	1.05 (3.32)	0.00 (3.16)	0.00 (3.16)	0.35 (3.21)
T-MEAN	6.98 (4.11)	5.44 (3.91)	4.73 (3.31)	5.72 (3.94)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	1.37	1.37	1.37	-	-	0.52	-
CD (5%)	2.70	2.70	2.70	NS	NS	1.02	NS
CD (1%)	3.58**	3.58**	3.58**	NS	NS	1.35**	NS

Correlation matrix

	Shoot length	Temperature	Duration	Zones
Shoot length	1.000	0.305**	-0.810**	0.012NS
Temperature	0.305	1.000	0.000NS	0.000NS
Duration	-0.810	0.000	1.000	0.000NS
Zones	0.012	0.000	0.000	1.000

$$R^2 = 0.75^{**}$$

$$\text{Regression equation : } Y = 8.765 + 0.75 (\text{Temp}) - 1.248 (\text{Duration}) + 0.018 (\text{Zones})$$

Irrespective of storage temperature and duration of storage the longest shoot was obtained in Z5; while the shortest was in Z2. The longest shoot of 10.05 cm was registered in Z6, at D1; whereas the shortest was recorded in Z7 at D1. The period of storage reduced the shoot length irrespective of zones and the storage temperature. The mean root length was 10.05 cm at D1 in Z6 and 0.35 cm at D7 in Z7.

Interestingly, the interaction effect of temperature with duration gave reduced shoot length (4.73 cm) which increased with temperature (T3). The longest and shortest roots ranged between 6.98 cm and 4.73 cm in T1 and T3 respectively. The mean root length irrespective of storage time ranged between 9.25 cm and 0.71 cm in D1 and D7 respectively. However, the duration D2 and D3 was on par with each other; while D3 was on par with D4.

The correlation matrix clearly indicated the positive correlation of shootlength with temperature; whereas it gave a negative association with duration of storage.

4.11.1.4. Dry matter production [g] [Table.19]

The dry matter production was significantly influenced by zones, temperatures and duration of storage and their interactions. Excepting for Z x T interaction, the rest was highly significant.

In Z1, the mean dry matter production (g) decreased from 5.70 g (D1) to Nil (D7) while in all other zones the maximum and minimum ranged only between D7 and D1. However the mean Dmp for different zones remained on par with rest of the zones irrespective of the durations in all but D6 and D7. At D6, the maximum and minimum ranged between 2.30 and 1.62 grams.

Interaction effect of zones with duration indicated that with increase in duration of storage the Dmp reduced and reached the lowest of 0.11 g at D7, irrespective of the zones. The interesting feature here is the reduction in Dmp was at highest order between D5, D6, and D6, D7 where the drop was more than 50 per cent.

Table 19 Influence of seed zones on dry matter production (g) at different temperatures during storage of *Azadirachta indica* seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	5.70 (3.96)	5.70 (3.96)	5.70 (3.96)	5.70 (3.96)
D ₂	5.50 (3.94)	4.65 (3.83)	4.10 (3.75)	4.75 (3.84)
D ₃	4.80 (3.85)	3.90 (3.73)	3.45 (3.67)	4.05 (3.75)
D ₄	4.05 (3.75)	3.50 (3.67)	3.30 (3.65)	3.62 (3.69)
D ₅	3.85 (3.72)	3.40 (3.66)	3.25 (3.64)	3.50 (3.67)
D ₆	3.45 (3.67)	3.00 (3.61)	0.00 (3.16)	2.15 (3.48)
D ₇	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)
Z₂				
D ₁	5.10 (3.89)	5.10 (3.89)	5.10 (3.89)	5.10 (3.89)
D ₂	5.00 (3.87)	4.80 (3.85)	4.45 (3.80)	4.75 (3.84)
D ₃	4.30 (3.78)	4.30 (3.78)	3.95 (3.73)	4.18 (3.77)
D ₄	4.15 (3.76)	3.40 (3.66)	3.35 (3.65)	3.63 (3.69)
D ₅	3.55 (3.68)	3.40 (3.66)	3.15 (3.63)	3.37 (3.66)
D ₆	3.30 (3.65)	1.55 (3.39)	0.00 (3.16)	1.62 (3.40)
D ₇	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)
Z₃				
D ₁	5.55 (3.94)	5.55 (3.94)	5.55 (3.94)	5.55 (3.94)
D ₂	5.45 (3.93)	5.50 (3.94)	4.60 (3.82)	5.18 (3.90)
D ₃	4.70 (3.83)	4.40 (3.79)	3.90 (3.73)	4.33 (3.79)
D ₄	5.05 (3.88)	3.55 (3.68)	2.95 (3.60)	3.85 (3.72)
D ₅	3.80 (3.71)	4.30 (3.78)	3.05 (3.61)	3.72 (3.70)
D ₆	3.35 (3.65)	3.05 (3.61)	0.00 (3.16)	2.13 (3.48)
D ₇	0.70 (3.27)	0.00 (3.16)	0.00 (3.16)	0.23 (3.20)
Z₄				
D ₁	5.10 (3.89)	5.10 (3.89)	5.10 (3.89)	5.10 (3.89)
D ₂	5.00 (3.87)	4.20 (3.77)	4.70 (3.83)	4.63 (3.83)
D ₃	4.20 (3.77)	4.35 (3.79)	3.75 (3.71)	4.10 (3.75)
D ₄	4.45 (3.80)	3.85 (3.72)	2.50 (3.54)	3.60 (3.69)
D ₅	4.10 (3.75)	4.45 (3.80)	3.35 (3.65)	3.97 (3.74)
D ₆	3.45 (3.67)	3.00 (3.61)	0.00 (3.16)	2.15 (3.48)
D ₇	1.05 (3.32)	0.00 (3.16)	0.00 (3.16)	0.35 (3.22)
Z₅				
D ₁	5.15 (3.89)	5.15 (3.89)	5.15 (3.89)	5.15 (3.89)
D ₂	5.15 (3.89)	5.60 (3.95)	4.30 (3.78)	5.02 (3.87)
D ₃	4.10 (3.76)	4.00 (3.74)	3.95 (3.73)	4.02 (3.74)
D ₄	4.60 (3.82)	3.90 (3.73)	3.15 (3.63)	3.88 (3.73)
D ₅	4.00 (3.74)	4.15 (3.76)	2.95 (3.60)	3.70 (3.70)
D ₆	3.60 (3.69)	3.30 (3.65)	0.00 (3.16)	2.30 (3.50)
D ₇	1.10 (3.33)	0.00 (3.16)	0.00 (3.16)	0.37 (3.22)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	5.00 (3.87)	5.00 (3.87)	5.00 (3.87)	5.00 (3.87)
D ₂	4.75 (3.84)	5.65 (3.96)	4.50 (3.81)	4.97 (3.87)
D ₃	4.10 (3.76)	4.00 (3.74)	3.40 (3.66)	3.83 (3.72)
D ₄	4.65 (3.83)	3.65 (3.69)	2.20 (3.63)	3.83 (3.72)
D ₅	3.80 (3.71)	4.10 (3.75)	3.10 (3.62)	3.67 (3.70)
D ₆	3.50 (3.67)	3.35 (3.65)	0.00 (3.16)	2.28 (3.50)
D ₇	2.00 (3.46)	0.00 (3.16)	0.00 (3.16)	0.67 (3.26)
Z₇				
D ₁	5.55 (3.94)	5.55 (3.94)	5.55 (3.94)	5.55 (3.94)
D ₂	5.35 (3.92)	4.85 (3.85)	4.50 (3.81)	4.90 (3.86)
D ₃	4.90 (3.86)	3.90 (3.73)	3.65 (3.69)	4.15 (3.76)
D ₄	4.30 (3.78)	3.45 (3.67)	3.25 (3.64)	3.67 (3.70)
D ₅	3.65 (3.69)	3.60 (3.69)	3.15 (3.63)	3.47 (3.67)
D ₆	3.45 (3.67)	3.05 (3.61)	0.00 (3.16)	2.17 (3.48)
D ₇	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)	0.00 (3.16)
T-MEAN	3.91 (3.72)	3.56 (3.67)	2.82 (3.57)	3.43 (3.66)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.72	0.72	0.72	0.42	0.27	0.27	0.72
CD (5%)	1.42	1.42	1.42	0.82	0.54*	0.54	1.42
CD (1%)	1.87**	1.87**	1.87**	1.10**	NS	0.70**	1.87**

Correlation matrix

	DMP	Temperature	Duration	Zones
DMP	1.000	0.235**	-0.852**	0.017NS
Temperature	0.235	1.000	0.000NS	0.000NS
Duration	-0.852	0.000	1.000	0.000NS
Zones	0.017	0.000	0.000	1.000

$$R^2 = 0.78^{**}$$

$$\text{Regression equation : } Y = 5.36 + 0.034(\text{Temperature}) - 0.759(\text{Duration}) + 0.015(\text{Zones})$$

From the zone and temperature interaction, it become evident in that decrease in temperature levels clearly reduced the Dmp ranged in all the zones and the mean Dmp ranged between 3.6 (g) (T1) and 2.2 g (T3). Among the zones Z3 registered the maximum mean dry matter production (10.02 g); while the minimum was in Z2 with 9.36 gram.

From the interaction between temperature and duration the mean dry matter production was 13.31 g at D1 and 0.11 g at D7. Almost 100% of drop in dry matter production occurred over the period of storage. With temperature levels the drop was around 20 per cent.

There was positive correlation between Dmp and temperature; while negative association existed between durations of storage and dry matter production.

4.11.1.5. Vigour Index [Table 20.].

Highly significant results were obtained for all the included treatments and their interactions.

Among the control, in D1, the mean vigour index was the highest in Z3 (535); whereas it was the lowest in Z2 (441). Right from the D2 the effect of duration and temperature was prominent. The mean maximum and minimum vigour index ranged between Z3 (9392) and Z2 (311) at D2; Z3 (263) and Z2 (200) at D3; Z3 (200) and Z2 (137) at D4, Z6(99) and Z2 (66) at D5; Z6 (41) and Z2 (23) at D6 and Z1 (5) and Z2 (D) at D7. Irrespective of the durations Z2 recorded the lowest value.

The interaction between zone and duration revealed that with increase in storage period the vigour index reduced gradually upto D4 and further reduced at a faster rate. The mean maximum VI was 786 at D1 and minimum was at D7, irrespective of the zones and temperatures. The mean VI ranged between 215 (Z3) and 167 (Z2) among the zones at different durations.

Table 20 Influence of seed zones on vigour index at different temperatures during storage of Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	507 (32.51)	507 (32.51)	507 (32.51)	507 (32.51)
D ₂	460 (31.78)	326 (29.59)	175 (26.43)	320 (29.43)
D ₃	352 (30.03)	234 (28.00)	92 (25.34)	226 (27.79)
D ₄	238 (28.07)	155 (26.55)	58 (24.65)	150 (26.43)
D ₅	122 (25.91)	74 (24.99)	25 (23.99)	74 (24.96)
D ₆	43 (24.36)	31 (24.10)	00 (23.45)	25 (23.97)
D ₇	2 (23.48)	00 (23.45)	00 (23.45)	1 (23.46)
Z₂				
D ₁	442 (31.49)	442 (31.49)	442 (31.49)	442 (31.49)
D ₂	405 (30.91)	345 (29.91)	183 (27.08)	311 (29.30)
D ₃	279 (28.79)	225 (27.84)	96 (25.41)	200 (27.34)
D ₄	220 (27.75)	135 (26.18)	54 (24.58)	137 (26.17)
D ₅	117 (25.83)	63 (24.76)	19 (23.85)	66 (24.81)
D ₆	40 (24.30)	25 (23.98)	00 (23.45)	22 (23.91)
D ₇	1 (23.48)	00 (23.45)	00 (23.45)	00 (23.45)
Z₃				
D ₁	535 (32.94)	535 (32.94)	535 (32.94)	535 (32.94)
D ₂	483 (32.14)	429 (31.29)	263 (28.51)	392 (30.65)
D ₃	375 (30.41)	292 (29.02)	122 (25.91)	263 (28.45)
D ₄	361 (30.19)	184 (27.08)	56 (24.92)	200 (27.30)
D ₅	146 (26.39)	105 (25.59)	25 (23.99)	92 (25.32)
D ₆	68 (24.87)	41 (24.31)	00 (23.45)	36 (24.21)
D ₇	4 (23.54)	00 (23.45)	00 (23.45)	1 (23.48)
Z₄				
D ₁	482 (32.12)	482 (32.12)	482 (32.12)	482 (32.12)
D ₂	436 (31.40)	316 (29.14)	232 (27.96)	328 (29.59)
D ₃	312 (29.35)	265 (28.54)	98 (25.45)	225 (27.78)
D ₄	240 (28.09)	176 (26.95)	50 (24.49)	155 (26.51)
D ₅	148 (26.42)	97 (25.44)	26 (24.01)	91 (25.29)
D ₆	42 (24.33)	29 (24.06)	00 (23.45)	24 (23.95)
D ₇	4 (23.54)	00 (23.45)	00 (23.45)	1 (23.48)
Z₅				
D ₁	448 (31.59)	448 (31.59)	448 (31.59)	448 (31.59)
D ₂	421 (31.15)	420 (31.14)	226 (27.86)	356 (30.05)
D ₃	290 (28.99)	242 (28.14)	111 (25.72)	215 (27.62)
D ₄	246 (28.21)	182 (27.05)	54 (24.57)	160 (26.61)
D ₅	150 (26.46)	88 (25.26)	19 (23.85)	86 (25.19)
D ₆	70 (24.90)	33 (24.14)	00 (23.45)	34 (24.16)
D ₇	7 (23.60)	00 (23.45)	00 (23.45)	2 (23.50)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	495 (32.32)	495 (32.32)	495 (32.32)	495 (32.32)
D ₂	399 (30.79)	459 (31.76)	275 (28.73)	378 (30.43)
D ₃	342 (29.86)	264 (28.53)	99 (25.48)	235 (27.96)
D ₄	344 (29.91)	191 (27.21)	61 (24.73)	199 (27.28)
D ₅	168 (26.80)	101 (25.50)	27 (24.03)	99 (25.44)
D ₆	87 (25.24)	36 (24.21)	00 (23.45)	41 (24.30)
D ₇	14 (23.75)	00 (23.45)	00 (23.45)	5 (23.55)
Z₇				
D ₁	497 (32.35)	497 (32.35)	497 (32.35)	497 (32.35)
D ₂	470 (31.94)	413 (31.03)	230 (27.92)	371 (30.30)
D ₃	368 (30.30)	254 (28.36)	99 (25.48)	241 (28.05)
D ₄	283 (28.86)	165 (26.74)	52 (24.53)	167 (26.71)
D ₅	136 (26.20)	78 (25.06)	20 (23.88)	78 (25.05)
D ₆	53 (24.55)	28 (24.04)	00 (23.45)	27 (24.02)
D ₇	5 (23.56)	00 (23.45)	00 (23.45)	2 (23.49)
T-MEAN	248 (28.08)	202 (27.25)	128 (25.86)	193 (27.06)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.33	0.33	0.33	0.19	0.13	0.13	0.33
CD (5%)	0.66	0.66	0.66	0.38*	0.25	0.25	0.66
CD (1%)	0.87	0.87	0.87	NS	0.34**	0.34**	0.87**

Correlation matrix

	VI	Temp	Duration	Zones
VI	1.000	0.264**	-0.899**	0.032NS
Temp.	0.264	1.000	0.000NS	0.000NS
Duration	-0.899	0.000	1.000	0.000NS
Zones	0.032	0.000	0.000	1.000

$$R^2 = 0.88^{**}$$

$$\text{Regression equation : } Y = 389.906 + 3.77 (\text{Temp}) - 80.064 (\text{Duration}) + 2.876 (\text{Zones})$$

The temperature interaction with duration resulted in the decreased VI with decrease in the storage temperature. Excepting D1, in all the other durations the reduction was phenomenal. The mean VI at T1 was 248 and the same occurred as 128 at T3. Similarly for durations also the reduction was significant in all the levels, irrespective of the storage temperatures studied.

The interaction effect of temperatures on different zones was evident from the results evidently documented. Increase in storage temperature increased the VI significantly. At different temperatures tested, the mean aVI was maximum in Z3 (9295); while minimum in Z1 (140).

Interestingly, VI was having a positive association with temperature and negatively associated with duration of storage with r^2 value of 0.88.

4.11.1.6. Oil content [%] [Table 21; Fig. 24]

Highly significant results were obtained for the effect of zones duration of storage and the interaction of zones with duration of storage in respect of the oil content per cent.

Over the storage, the oil content decreased steadily irrespective of the storage temperatures and zones of seeds. Among the zones, Z1 registered the maximum oil content with 31.50 %; while the lowest was in Z3 with 23.45% at D1 (the control). Almost in all the zones, the maximum and minimum ranged only between D1 and D7 except in Z1, Z4 and Z5 where the lowest was in D6.

The interaction of zones and durations clearly indicated the maximum rate of oil content between D1 and D2 and there after it was kept almost at a steady state. The mean oil content (27.49%) was in D1 and the lowest (22.98%) was in D7. The rate of reduction was 4.51% only. Between various zones the mean oil content was in Z2 (26.45%) and the lowest was in Z3 (20.25%).

Table 21 Influence of seed zones on oil content (%) at different temperatures during storage of Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	31.50	31.50	31.50	31.50
D ₂	25.50	25.05	25.45	25.33
D ₃	25.40	25.45	25.35	25.40
D ₄	25.40	24.00	24.75	24.72
D ₅	25.95	25.40	25.10	25.48
D ₆	25.20	25.15	25.05	25.13
D ₇	25.30	25.35	24.80	25.15
Z₂				
D ₁	30.80	30.80	30.80	30.80
D ₂	26.55	26.20	26.40	26.38
D ₃	25.75	25.70	25.10	25.52
D ₄	25.75	25.70	25.50	25.65
D ₅	26.40	25.85	25.20	25.82
D ₆	25.75	25.55	25.50	25.60
D ₇	25.80	25.45	24.90	25.38
Z₃				
D ₁	23.45	23.45	23.45	23.45
D ₂	19.65	19.80	20.20	19.88
D ₃	19.50	19.95	19.70	19.72
D ₄	20.15	19.65	19.50	19.77
D ₅	20.25	19.40	19.75	19.80
D ₆	19.85	19.65	19.40	19.63
D ₇	19.50	19.50	19.50	19.50
Z₄				
D ₁	25.80	25.80	25.80	25.80
D ₂	22.15	22.05	21.60	21.93
D ₃	22.15	22.45	22.20	22.27
D ₄	21.70	22.30	22.75	22.25
D ₅	22.10	21.95	22.15	22.07
D ₆	22.20	22.10	21.85	22.05
D ₇	22.05	22.50	22.10	22.22
Z₅				
D ₁	26.05	26.05	26.05	26.05
D ₂	22.95	22.95	22.50	22.80
D ₃	22.50	22.70	23.05	22.75
D ₄	23.15	22.40	22.80	22.78
D ₅	22.65	22.45	23.05	22.72
D ₆	22.85	22.90	22.70	22.82
D ₇	22.40	22.55	22.50	22.48

Contd..

Contd...

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	28.50	28.50	28.50	28.50
D ₂	21.95	21.95	22.15	22.02
D ₃	21.60	21.80	22.10	21.83
D ₄	22.05	21.55	21.85	21.82
D ₅	22.00	21.75	21.55	21.77
D ₆	21.85	22.00	21.85	21.90
D ₇	22.05	21.45	21.25	21.58
Z₇				
D ₁	26.35	26.35	26.35	26.35
D ₂	25.25	25.40	25.10	25.25
D ₃	24.60	24.95	24.50	24.68
D ₄	24.75	24.85	24.55	24.72
D ₅	25.40	25.25	24.55	25.07
D ₆	25.40	24.75	25.00	25.05
D ₇	24.50	24.65	24.45	24.53
T-MEAN	23.88	23.77	23.71	23.79

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.62	-	0.62	0.36	-	-	-
CD (5%)	1.22	NS	1.22	0.70	NS	NS	NS
CD (1%)	1.62**	NS	1.61**	0.94**	NS	NS	NS

Correlation matrix

	Oil content	Temperature	Duration	Zones
Oil Content	1.000	0.027ns	-0.372**	-0.199**
Temperature	0.027	1.000	0.000ns	0.000ns
Duration	-0.372	0.000	1.000	0.000ns
Zones	-0.199	0.000	0.000	1.000

$$R^2 = 0.18^{**}$$

Regression equation: $Y = 26.288 + 0.006 (\text{Temperature}) - 0.495 (\text{Duration}) - 0.265 (\text{zones})$

The correlation matrix clearly indicated the negative association of oil content with duration of storage. It was highly varying between the zones with r^2 value of 0.188.

4.11.1.7. Free Fatty Acid [%] [Table.22; Fig 25]

The effect of zones, temperature, duration and their interaction gave highly significant results with FFA.

The free fatty acid level increased irrespective of the zones over the period of storage and the mean FFA% was 5.34 as low at D1 and the maximum was 13.21% at D7 in Z1. As evidently obtained the maximum and minimum ranged between D7 and D1 and it was 12.95 and 5.42% in Z2, 13.54 and 4.34% in Z3; 13.57 and 4.57% in Z4, 13.57 and 5.39 in Z5, 13.06 and 4.54% in Z6 and 13.68 and 5.39 in Z7 respectively. Decrease in temperature level augmented the free fatty acid levels in almost all the durations irrespective of zones and temperatures, excepting at D2 and T2 in Z4 and Z5. Though the reduction in FFA was not uniform with the zones at D7 the maximum of 13.68% was recorded which is an par with all the zones excepting Z1, Z2 and Z6.

Among the zones irrespective of the temperatures the mean value was the highest in Z2 at D1, Z1 at D2, D3 and D4, Z2 at D5 and Z7 at D6 and D7, indicating the faster deterioration of Z7 during later part of the storage.

The interaction effect of zone and duration significantly increased the FFA% at D7 with the maximum value of 13.68% at D7 Z7. Among the durations the mean minimum and maximum values ranged between D1 and D7 with 5.00 and 13.37% respectively. Irrespective of the temperatures and durations of storage the Z1 registered the highest value of 8.94% and the lowest was in Z4. However the percentage increase was maximum in Z3, Z4 and Z6. The increase in the levels was gradual upto D6.

The interaction of zone with temperatures revealed that decrease in temperature increased the free fatty acid levels irrespective of the zones and durations. The minimum (7.91%) was in T1; while the maximum (9.22%) was in T3. This was the case

Table 22 Influence of seed zones on free fatty acid content (%) at different temperatures during storage of Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	5.34	5.34	5.34	5.34
D ₂	7.47	7.62	7.80	7.63
D ₃	7.68	8.22	8.48	8.13
D ₄	8.23	8.52	9.09	8.61
D ₅	8.67	9.49	10.10	9.42
D ₆	9.57	10.43	10.70	10.24
D ₇	11.23	13.52	14.87	13.21
Z₂				
D ₁	5.42	5.42	5.42	5.42
D ₂	6.92	6.94	7.20	7.02
D ₃	7.16	7.60	8.45	7.74
D ₄	7.79	8.63	9.26	8.56
D ₅	9.02	9.74	10.21	9.65
D ₆	9.87	10.33	10.77	10.32
D ₇	11.60	12.62	14.64	12.95
Z₃				
D ₁	4.34	4.34	4.34	4.34
D ₂	6.28	6.32	6.64	6.41
D ₃	6.36	6.95	7.54	6.95
D ₄	7.63	8.02	8.72	8.12
D ₅	8.07	8.80	10.10	8.99
D ₆	8.85	10.44	11.42	10.23
D ₇	11.67	13.82	15.13	13.54
Z₄				
D ₁	4.57	4.57	4.57	4.57
D ₂	6.30	6.22	6.53	6.35
D ₃	6.75	6.95	7.26	6.99
D ₄	7.09	7.43	8.20	7.57
D ₅	7.50	8.20	9.07	8.26
D ₆	8.30	9.15	9.99	9.14
D ₇	11.35	14.23	15.11	13.57
Z₅				
D ₁	5.39	5.39	5.39	5.39
D ₂	7.15	6.59	7.12	6.95
D ₃	7.34	7.51	8.23	7.69
D ₄	7.75	8.32	8.96	8.35
D ₅	8.46	8.81	10.23	9.17
D ₆	9.09	10.74	11.60	10.48
D ₇	11.81	13.72	15.19	13.57

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	4.54	4.54	4.54	4.54
D ₂	6.02	6.24	6.48	6.25
D ₃	6.64	6.82	7.66	7.04
D ₄	7.19	7.90	8.14	7.74
D ₅	8.04	8.56	9.65	8.75
D ₆	9.25	9.94	11.14	10.11
D ₇	11.31	13.23	14.65	13.06
Z₇				
D ₁	5.39	5.39	5.39	5.39
D ₂	6.47	6.68	6.96	6.70
D ₃	6.86	7.24	8.19	7.43
D ₄	7.59	8.27	8.80	8.22
D ₅	8.41	9.27	10.11	9.26
D ₆	9.56	10.40	11.35	10.44
D ₇	12.16	13.77	15.13	13.68

T-MEAN	7.91	8.56	9.22	8.56

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.14	0.14	0.14	0.08	0.05	0.05	0.14
CD (5%)	0.28	0.28	0.28	0.16	0.11	0.11	0.28
CD (1%)	0.37**	0.37**	0.37**	0.21**	0.13**	0.13**	0.37**

Correlation matrix

	FFA	Temperature	Duration	Zones
FFA	1.000	-0.201**	0.915**	-0.038 NS
Temperature	-0.201	1.000	0.000 NS	0.000 NS
Duration	0.915	0.000	1.000	0.000 NS
Zones	-0.038	0.000	0.000	1.000

$$R^2 = 0.88^{**}$$

Regression equation : $Y = 5.52 - 0.042(\text{Temp}) + 1.197(\text{Duration}) - 0.05(\text{Zones})$

with all the zones with included temperature levels. Similarly Z1 at three temperature levels registered the mean maximum free fatty acid content and Z4 with minimum value (8.07%).

Similar results were obtained as evaluated with interaction between temperature and durations. The D1 registered the lowest value of 5% and D7 with 13.37% which was the highest.

There was negative correlation between FFA% and temperatures and positive association with durations of storage.

4.11.1.8. Protein content [%] [Table 23; Fig. 26]

Significant results were obtained for storage protein with zones, temperatures and duration and their interaction as well. However the three way interaction was not significant.

The maximum protein content was registered in Z7 with 18.33 % and it was on par with Z3 and Z6. The lowest protein content was in Z2 with 16.69 which was on par with Z1, Z4 and Z5. Irrespective of the durations the maximum and minimum ranged between D1 and D7. The mean maximum protein was 17.10%; while the minimum was 11.66% in Z1 and Z2. It was 16.59 and 11.88% in Z3; 18.27 and 12.19% in Z4; 16.91 and 11.67 in Z5; 17.31 and 12.12% in Z6 and in Z7 18.33 and 12.60 per cent. Between the temperature T1 registered the maximum value; while the minimum was in T3.

The interaction of zone with duration of storage gave maximum protein % in Z7; whereas the minimum was 14.56% . Among the durations D1 registered maximum with 17.51% and the minimum was in D7 with 12.09 per cent.

The effect of storage temperature on different zones indicated that decrease in temperature significantly reduced the oil content per cent. In T1 the maximum and minimum ranged between 16.19% and 14.87% in T2 it was 15.36 and 14.66% and in T3 it was 15.29 and 14.23 per cent.

Table 23 Influence of seed zones on protein content (%) at different temperatures during storage of Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	17.10	17.10	17.10	17.10
D ₂	16.53	16.35	15.69	16.19
D ₃	16.27	15.74	15.15	15.72
D ₄	15.72	14.94	14.43	15.03
D ₅	15.01	14.12	13.76	14.30
D ₆	14.14	13.60	12.98	13.57
D ₇	12.14	11.67	11.18	11.66
Z₂				
D ₁	16.69	16.69	16.69	16.69
D ₂	16.54	16.42	16.14	16.36
D ₃	16.57	16.17	15.43	16.05
D ₄	16.12	15.36	14.97	15.48
D ₅	15.26	14.39	14.20	14.62
D ₆	14.26	13.77	13.05	13.69
D ₇	12.60	11.70	11.35	11.88
Z₃				
D ₁	18.27	18.27	18.27	18.27
D ₂	17.74	17.73	17.59	17.69
D ₃	17.16	16.67	16.25	16.69
D ₄	15.71	15.23	14.94	15.30
D ₅	14.79	14.17	13.96	14.31
D ₆	13.21	13.15	12.90	13.09
D ₇	12.52	12.31	11.74	12.19
Z₄				
D ₁	16.91	16.91	16.91	16.91
D ₂	16.56	16.37	16.02	16.32
D ₃	15.94	15.76	15.11	15.60
D ₄	15.44	14.77	14.60	14.94
D ₅	14.06	13.73	13.39	13.73
D ₆	13.44	12.70	12.17	12.77
D ₇	11.90	11.69	11.44	11.67
Z₅				
D ₁	17.31	17.31	17.31	17.31
D ₂	17.13	16.49	16.20	16.61
D ₃	15.49	15.39	15.19	15.36
D ₄	15.23	14.56	14.20	14.66
D ₅	14.42	14.17	13.44	14.01
D ₆	13.02	12.54	12.19	12.58
D ₇	12.22	12.16	11.97	12.12

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	18.02	18.02	18.02	18.02
D ₂	17.45	16.89	16.50	16.95
D ₃	16.78	16.17	15.67	16.21
D ₄	16.05	15.44	14.97	15.49
D ₅	15.54	14.35	13.81	14.57
D ₆	14.64	14.16	13.55	14.12
D ₇	12.98	12.47	12.10	12.52
Z₇				
D ₁	18.33	18.33	18.33	18.33
D ₂	18.08	17.82	17.26	17.72
D ₃	17.37	17.02	16.16	16.85
D ₄	16.19	15.69	15.27	15.72
D ₅	15.47	14.85	14.30	14.87
D ₆	14.60	14.23	13.56	14.13
D ₇	13.31	12.37	12.13	12.60
T-MEAN	15.47	15.06	14.68	15.07

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.25	0.25	0.25	0.14	0.09	0.09	-
CD (5%)	0.48	0.48	0.48	0.28	0.18*	0.18	NS
CD (1%)	0.64**	0.64**	0.64**	0.37**	0.24	0.24**	NS

Correlation matrix

	Protein	Temperature	Duration	Zones
Protein	1.000	0.169**	-0.935**	0.116*
Temperature	0.169	1.000	0.000NS	0.000 NS
Duration	-0.935	0.000	1.000	0.000 NS
Zones	0.116	0.000	0.000	1.000

$$R^2 = 0.92^{**}$$

Regression equation: $Y = 17.074 + 0.026 (\text{Temperature}) - 0.885 (\text{Duration}) + 0.11 (\text{Zones})$

Fig.25. Influence of seed zones on Free Fatty acid content % at different temperatures during storage of *Azadirachta indica* seeds

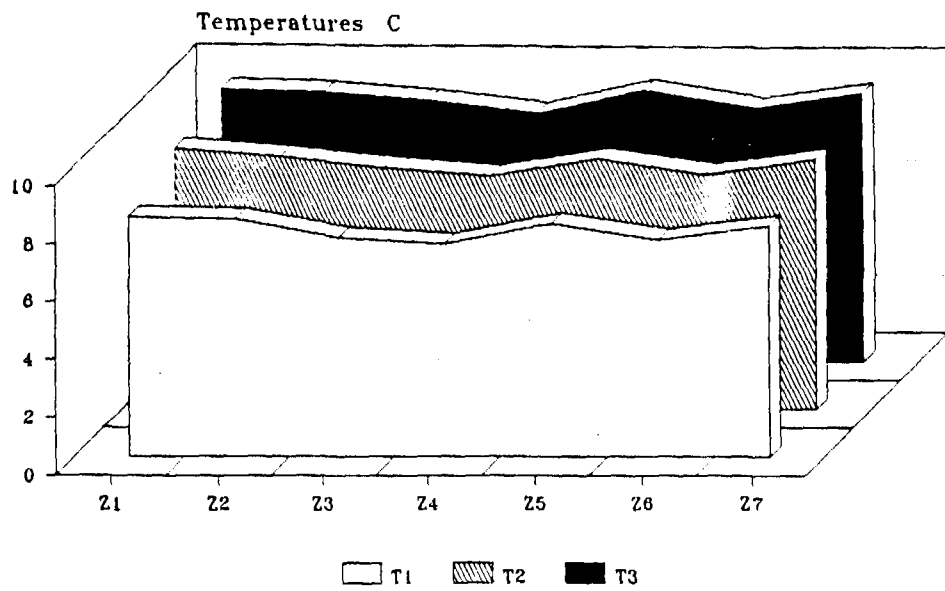
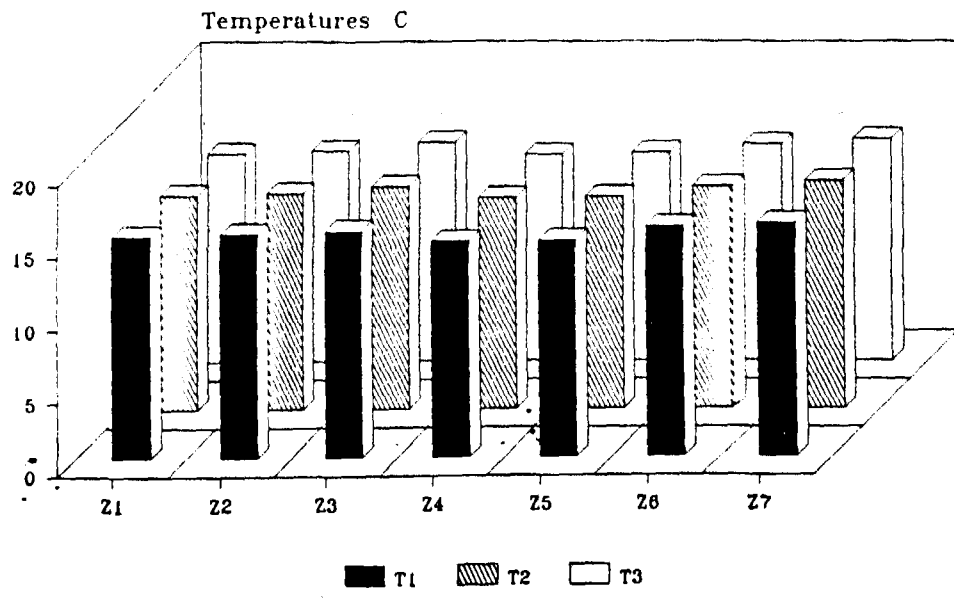


Fig.26. Influence of seed zones on Protein content % at different temperatures during storage of *Azadirachta indica* seeds



Irrespective of temperatures the duration of storage reduced the oil content and it was maximum in D1 and minimum in D7 with mean protein % of 17.51 and 12.09 respectively. At different durations of storage, T1 registered the highest protein % and the lowest was in T3 in all the durations. The mean protein % ranged between 15.47 and 14.68 % in T1 and T3 respectively.

The storage protein content was significant, positively correlated with temperature and negatively correlated with duration of storage.

4.11.1.9. Carbohydrates content [%] [Table 24; Fig. 27]

Excepting for the interaction of zone with temperature and three way interaction the rest was highly significant for carbohydrate level.

Over the storage at each duration and temperature the carbohydrate level decreased with increase in storage duration and temperature. The maximum carbohydrate content was registered in D1T1 with 36.80% and the lowest was in D7T3 with 22.05 per cent. The rate of decrease was gradual upto D5 in Z1; D6 in Z2 and Z3; D5 in Z6 and D6 in Z7 and thereafter the reduction was steep. However the reduction in carbohydrate was steady upto D7 in Z4 and Z5.

The interaction effect studied for zone with duration revealed that the reduction in carbohydrate level was not consistent for all the zones tested. Though the maximum and minimum ranged between 36.80% and 35.50% at D1 it ranged between 28.92 and 22.88% at D7. However, the mean carbohydrate level, irrespective of durations was ranging from 32.46% to 29.98% in Z7 and Z5. Similarly, the mean carbohydrate% between duration ranged from 36.13 to 25.70 % in D1 and D7 respectively, irrespective of the included zones.

The interaction of temperature with duration gave significant results with mean maximum carbohydrate in D1. The mean minimum was in D7 (36.13 %) while recorded 70 per cent. Among the storage temperatures, T1 registered maximum carbohydrate %

Table 24 Influence of seed zones on carbohydrate content (%)
at different temperatures during storage of
Azadirachta indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	36.80	36.80	36.80	36.80
D ₂	34.45	34.45	33.30	34.07
D ₃	34.50	32.70	31.45	32.88
D ₄	32.75	31.20	29.05	31.00
D ₅	33.05	29.20	28.35	30.20
D ₆	27.80	26.10	25.40	26.43
D ₇	25.85	24.10	23.35	24.43
Z₂				
D ₁	35.85	35.85	35.85	35.85
D ₂	35.25	34.65	33.10	34.33
D ₃	33.60	31.70	30.55	31.95
D ₄	31.55	29.90	28.25	29.90
D ₅	29.85	28.20	27.40	28.48
D ₆	27.60	26.30	24.90	26.27
D ₇	23.95	23.20	24.30	26.13
Z₃				
D ₁	36.60	36.60	36.60	36.60
D ₂	36.85	36.10	34.65	35.87
D ₃	35.60	34.10	32.65	34.12
D ₄	33.90	32.65	31.30	32.62
D ₅	32.50	30.35	28.70	30.52
D ₆	30.50	27.95	27.20	28.55
D ₇	27.60	26.00	24.30	26.13
Z₄				
D ₁	36.35	36.35	36.35	36.35
D ₂	36.50	35.35	34.60	35.48
D ₃	35.55	33.80	32.30	33.88
D ₄	33.70	32.15	31.25	32.37
D ₅	32.05	30.75	29.65	30.82
D ₆	31.00	29.50	28.65	29.72
D ₇	28.80	29.90	27.15	28.62
Z₅				
D ₁	35.90	35.90	35.90	35.90
D ₂	36.85	36.30	36.30	36.48
D ₃	36.20	34.40	34.15	34.92
D ₄	34.70	33.90	33.00	33.87
D ₅	33.95	32.70	31.30	32.65
D ₆	33.50	31.35	30.50	31.78
D ₇	30.10	28.80	27.65	28.92

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	35.90	35.90	35.90	35.90
D ₂	35.30	33.75	32.85	33.97
D ₃	33.55	33.05	31.75	32.78
D ₄	32.15	30.60	30.15	30.97
D ₅	30.45	28.15	26.45	28.35
D ₆	26.35	24.95	23.80	25.03
D ₇	23.90	22.70	22.05	22.88
Z₇				
D ₁	35.50	35.50	35.50	35.50
D ₂	36.30	36.05	34.90	35.75
D ₃	35.70	33.80	32.70	34.07
D ₄	33.50	32.30	30.85	32.22
D ₅	32.55	30.45	28.10	30.37
D ₆	30.20	27.95	26.90	28.35
D ₇	27.10	25.45	24.50	25.68
T-MEAN	32.65	31.43	30.44	31.51

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.69	0.69	0.69	0.40	-	0.26	-
CD (5%)	1.36	1.36	1.36	0.79	NS	0.51	NS
CD (1%)	1.80**	1.80**	1.80**	1.04**	NS	0.68**	NS

Correlation matrix

	CHO	Temperature	Duration	Zones
CHO	1.000	0.266**	-0.878**	0.077 NS
Temperature	0.226	1.000	0.000 NS	0.000 NS
Duration	-0.878	0.000	1.000	0.000 NS
Zones	0.073	0.000	0.000	1.000

$$R^2 = 0.83^{**}$$

Regression equation: $Y = 35.562 + 0.072 (\text{Temperature}) - 1.745 (\text{Duration}) + 0.144 (\text{Zones})$

irrespective of the temperatures and the minimum was in T3. The rate of reduction increased with decrease in temperature levels. The mean maximum was 32.65 % in T1 and 30.44% in T3 irrespective of the duration of storage.

There was positive correlation of temperature with carbohydrate and negative association of duration with carbohydrate. The r^2 value was 0.83.

4.11.2. Storage studies in Pungam [*Derris indica* L.]

4.11.2.1. Germination [%] [Table 25; Fig. 28]

Highly significant results were obtained due to zones, temperatures and duration. The interaction was also significant for (i) zones with temperatures and duration and (ii) temperature with duration.

It became evident in that each zones behaved differently in relation to storage capacity. There was no specific influence of temperature or duration of storage on germination for each zones. In Z1 the maximum germination was at D1, irrespective of the temperatures. The minimum was in D7 T1, and the maximum and minimum ranged between 87 and 43% in D1 and D7 respectively. However, irrespective of zones, the lowest germination was registered only in respect of D7 T1. In Z1, the reduction in germination was not uniform for all the 3 imposed temperatures and it was faster in T1 and gradual upto D5 in T2 which then reduced steeply. In respect of T3 there was no significant reduction upto D4 and the same subsequently dropped at a faster rate. Irrespective of the temperatures tried, T2 registered the highest germination per cent at D7 when compared to zones as well.

For the interaction with duration, the different zones expressed almost with uniform results. The mean maximum germination was in Z5, in all the temperatures studied excepting in D5, D6 and D7 where it was in Z4. Similarly the minimum was registered in Z6 of the chosen duration, excepting in D2, where it was with Z3. The mean maximum germination ranged between 80 and 46 in Z5 and Z6 respectively,

Table 25 Influence of seed zones on seed germination (%) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	87 (68.45)	87 (68.45)	87 (68.45)	87 (68.45)
D ₂	83 (65.32)	84 (66.05)	88 (69.39)	85 (66.92)
D ₃	83 (65.32)	84 (66.05)	81 (63.80)	82 (65.06)
D ₄	73 (58.39)	83 (65.32)	81 (64.17)	79 (62.63)
D ₅	60 (50.77)	78 (61.72)	70 (56.79)	69 (56.43)
D ₆	48 (43.57)	75 (60.11)	60 (50.77)	61 (51.48)
D ₇	43 (40.68)	58 (49.46)	53 (46.43)	51 (45.53)
Z₂				
D ₁	76 (60.67)	76 (60.67)	76 (60.67)	76 (60.67)
D ₂	69 (55.86)	71 (57.42)	76 (60.36)	72 (57.88)
D ₃	69 (56.17)	68 (55.26)	65 (53.74)	67 (55.05)
D ₄	61 (51.36)	62 (51.96)	61 (51.09)	61 (51.47)
D ₅	52 (45.86)	61 (51.06)	59 (49.90)	57 (48.94)
D ₆	39 (38.64)	61 (51.07)	54 (47.01)	51 (45.57)
D ₇	29 (32.58)	57 (48.74)	49 (42.13)	44 (41.15)
Z₃				
D ₁	67 (54.94)	67 (54.94)	67 (54.94)	67 (54.94)
D ₂	50 (45.00)	51 (45.29)	54 (47.01)	51 (45.77)
D ₃	53 (46.43)	52 (46.15)	50 (45.00)	52 (45.86)
D ₄	49 (44.14)	54 (47.01)	51 (45.29)	51 (45.48)
D ₅	39 (38.63)	52 (46.15)	46 (42.71)	46 (42.49)
D ₆	33 (35.06)	48 (43.85)	38 (37.76)	40 (38.89)
D ₇	28 (31.86)	44 (41.26)	35 (35.96)	35 (36.36)
Z₄				
D ₁	94 (75.87)	94 (75.87)	94 (75.87)	94 (75.87)
D ₂	85 (67.50)	75 (61.17)	86 (68.50)	82 (65.72)
D ₃	83 (65.32)	87 (68.47)	83 (65.32)	84 (66.37)
D ₄	73 (58.39)	88 (69.39)	83 (65.32)	81 (64.37)
D ₅	63 (52.25)	83 (65.32)	85 (67.21)	77 (61.60)
D ₆	55 (47.88)	78 (61.72)	65 (53.78)	66 (54.46)
D ₇	40 (39.20)	73 (58.39)	58 (49.36)	57 (48.99)
Z₅				
D ₁	99 (85.79)	99 (85.79)	99 (85.79)	99 (85.79)
D ₂	95 (80.64)	100 (89.71)	90 (71.57)	95 (80.64)
D ₃	93 (74.32)	91 (72.57)	86 (68.50)	90 (71.80)
D ₄	81 (64.17)	91 (72.57)	91 (72.57)	88 (69.77)
D ₅	63 (52.25)	83 (65.32)	73 (58.39)	73 (58.66)
D ₆	48 (43.57)	70 (56.86)	61 (51.36)	60 (50.60)
D ₇	33 (34.74)	75 (60.00)	53 (46.43)	53 (46.06)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	63 (52.25)	63 (52.25)	63 (52.25)	63 (52.25)
D ₂	50 (45.00)	53 (46.73)	57 (48.74)	53 (46.82)
D ₃	49 (44.14)	48 (43.85)	48 (43.85)	48 (43.85)
D ₄	43 (40.69)	50 (45.00)	48 (43.85)	47 (43.18)
D ₅	37 (37.16)	47 (43.28)	42 (40.40)	42 (40.28)
D ₆	29 (32.58)	45 (42.13)	38 (37.76)	37 (37.49)
D ₇	23 (28.32)	44 (41.26)	33 (35.06)	33 (34.88)
Z₇				
D ₁	76 (60.84)	76 (60.84)	76 (60.84)	76 (60.84)
D ₂	67 (55.09)	69 (56.27)	73 (58.79)	70 (56.72)
D ₃	68 (55.26)	72 (58.08)	66 (54.34)	69 (55.89)
D ₄	61 (51.10)	73 (58.39)	67 (54.64)	67 (54.71)
D ₅	47 (42.99)	67 (54.64)	60 (50.80)	58 (49.48)
D ₆	40 (39.23)	64 (53.16)	53 (46.72)	52 (46.37)
D ₇	35 (36.07)	63 (52.54)	47 (43.28)	48 (43.96)
T-MEAN	59 (50.86)	69 (57.34)	65 (54.38)	64 (54.19)

(Figures in parentheses indicate transformed values)

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	3.25	3.25	3.25	1.88	1.23	1.23	-
CD (5%)	6.44	6.44	6.44	3.72	2.43*	2.43	NS
CD (1%)	8.48**	8.48**	8.48**	4.91**	3.21	3.21**	NS

Correlation matrix

	Germination	Temperature	Duration	Zones
Germination	1.000	-0.167**	-0.596**	-0.119*
Temperature	-0.167	1.000	0.000NS	0.000NS
Duration	-0.596	0.000	1.000	0.000NS
Zones	-0.119	0.000	0.000	1.000

$$R^2 = 0.40^{**}$$

Regression equation : $Y = 86.923 - 0.245 (\text{Temperature}) - 5.475 (\text{Duration}) - 1.095 (\text{Zones})$

Fig.27. Influence of temperature on Carbohydrates % during storage of *Azadirachta indica* seeds irrespective of zones

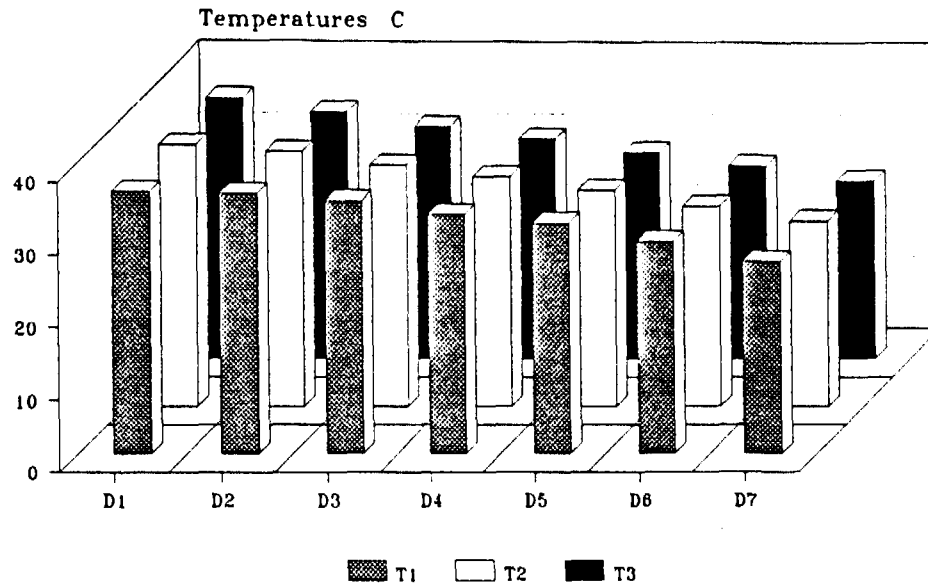
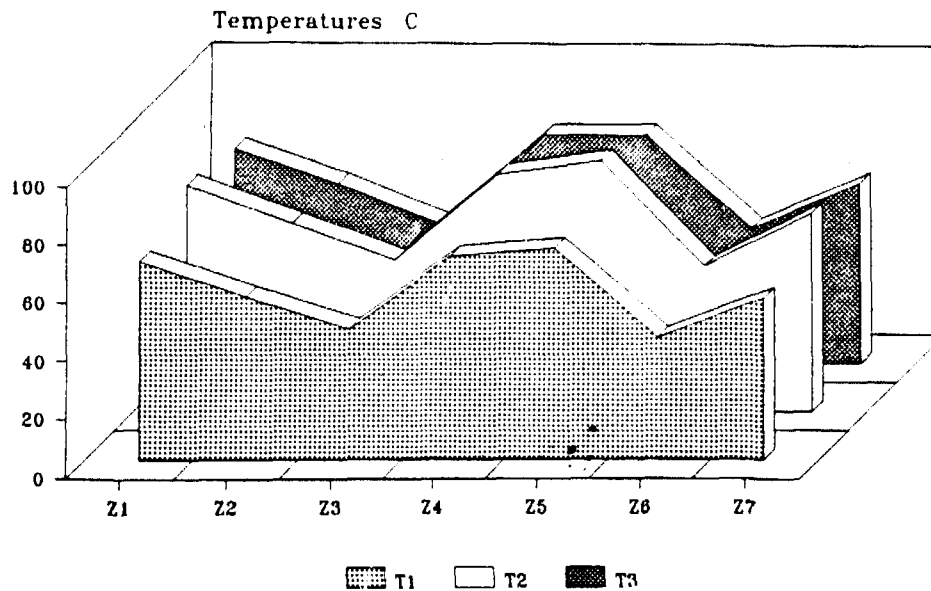


Fig.28. Influence of seed zones on germination % at different temperatures during storage of *Derris indica* seeds



irrespective of durations and zones. However, D2, D3 and D4 were on par with each other.

The studies of interaction of Z and T indicated that among the storage temperature evaluated T2 was maximum in all the zones; while the minimum was in T1. The mean maximum and minimum ranged between 69 and 59 % in T2 and T1 respectively. The mean germination for zones ranged between 80 and 46% respectively in Z5 and Z6.

The interaction of temperature with duration registered maximum mean germination in respect of T2 (69%) and minimum was recorded at T1 (59%); irrespective of the included duration of storage. Similarly the maximum and minimum germination irrespective of storage temperature was registered at D1 and D7 with 80 and 46% respectively.

Interestingly, in Pungam, the germination was negatively associated with temperature and duration of storage with r^2 value of 0.40. However, zones have been noted to influence the germination significantly.

4.11.2.2. Root length [cm] [Table 26]

Highly significant result was obtained due to root length with zones, temperature, duration and the interaction of zone with temperature. The interaction of zone with durations of storage and temperature with duration was not significant.

The reduction in root length over the period of storage was not significant, however the D1 registered the longest root. Irrespective of the zones, reduction in temperature increased the root length in most cases. In Z2, the mean root length at T3 increased to 21.2 cm from 15.3 cm at T1 irrespective of the durations. Similar results were obtained for Z3 also. However in rest of the zones there was no significant increase or decrease in root length over the other temperatures except in one or two durations of storage or it was marginal. The mean root length irrespective of zones and

Table 26 Influence of seed zones on root length (cm) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	23.0	23.0	23.0	23.0
D ₂	23.0	11.6	16.8	17.1
D ₃	19.5	15.7	17.4	17.5
D ₄	16.8	15.5	15.5	15.9
D ₅	14.7	13.9	13.7	14.1
D ₆	14.9	15.8	13.2	14.6
D ₇	13.8	15.2	17.0	15.3
Z₂				
D ₁	25.1	25.1	25.1	25.1
D ₂	10.8	12.9	20.5	14.7
D ₃	14.9	17.8	20.6	17.7
D ₄	14.9	17.4	22.2	18.2
D ₅	14.3	18.4	20.2	17.6
D ₆	13.9	16.8	20.5	17.1
D ₇	13.4	16.6	19.6	16.5
Z₃				
D ₁	21.6	21.6	21.6	21.6
D ₂	14.8	16.0	18.6	16.5
D ₃	16.8	17.5	15.6	16.6
D ₄	14.3	19.4	18.7	17.5
D ₅	13.8	18.1	17.3	16.4
D ₆	12.1	16.8	18.4	15.8
D ₇	12.9	17.5	18.7	16.4
Z₄				
D ₁	20.7	20.7	20.7	20.7
D ₂	14.6	21.0	13.8	16.4
D ₃	14.3	15.6	15.6	15.2
D ₄	13.9	17.1	17.3	16.1
D ₅	12.2	16.0	17.8	15.3
D ₆	11.8	15.3	16.7	14.6
D ₇	11.6	14.4	15.9	14.0
Z₅				
D ₁	17.9	17.9	17.9	17.9
D ₂	13.0	16.8	17.1	15.6
D ₃	12.7	16.3	15.7	14.9
D ₄	14.9	15.9	16.5	15.8
D ₅	14.1	15.2	16.5	15.3
D ₆	12.4	15.7	16.9	15.0
D ₇	10.9	13.9	14.4	13.1

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	20.0	20.0	20.0	20.0
D ₂	19.8	17.0	17.6	18.1
D ₃	19.5	16.6	17.1	17.7
D ₄	16.9	18.7	18.1	17.9
D ₅	15.6	18.5	18.7	17.6
D ₆	14.9	15.8	18.1	16.3
D ₇	12.0	16.0	17.3	15.1
Z₇				
D ₁	23.1	23.1	23.1	23.1
D ₂	17.4	22.3	18.1	19.3
D ₃	18.5	22.0	19.7	20.1
D ₄	16.7	19.2	20.3	18.7
D ₅	16.2	18.4	19.6	18.1
D ₆	16.1	18.0	19.1	17.7
D ₇	13.3	16.2	17.5	15.7
T-MEAN	15.8	17.5	18.2	17.2

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SED	2.51	2.51	2.51	-	0.9	-	-
CD (5%)	5.00	5.00	5.00	NS	1.9	NS	NS
CD (1%)	6.60**	6.60**	6.60**	NS	2.5**	NS	NS

Correlation matrix

	Root length	Temperature	Duration	Zones
Root length	1.000	-0.282**	-0.444**	0.087NS
Temperature	-0.282	1.000	0.000NS	0.000NS
Duration	-0.444	0.000	1.000	0.000NS
Zones	0.067	0.000	0.000	1.000

$$R^2 = 0.28^{**}$$

$$\text{Regression equation} = Y = 19.713 - 0.08 (\text{TEMP}) - 0.789 (\text{Duration}) + 0.119 (\text{Zones})$$

durations of storage ranged between 15.8 cm in T1 and 18.2 cm as minimum and maximum.

The interaction between zone and temperature indicated that decrease in temperature increased the root length of the seedlings and the mean ranged between 15.8 (T1) and 18.2 cm (T3). Among the zones, the mean root length was the longest in Z7 (18.9 cm) and shortest in Z5 (15.4 cm). However, Z3 was on par with Z2, Z6 and Z7.

There was negative association with temperature and duration in respect of root length with the r^2 value of 0.28.

4.11.2.3. Shoot length [cm] [Table 27]

Highly significant results were obtained for zones, temperatures and durations of storage in respect of shoot length. In all the cases, interaction effect was not significant.

The results indicated that there was significant variation in respect of shoot length between different storage period temperatures and zones only. The mean shoot length among the different zones was maximum in Z7 (32.4 cm) and minimum in Z1 (21.3 cm). Among the durations, D1 registered the longest shoot value with 33.7 cm and the lowest was at D7 (19.3 cm). Similarly the mean shoot length was more in T3 (26.5 cm) and low in T1 (22.6 cm).

Interestingly, T2 in D2 caused production of longest shoot (28.0 cm) than the rest. Similarly Z2 in T2, registered the longest shoot with 27.2 cm.

Negative association accounted with temperature and durations for shoot length. There was significant variation among the zones and Z7 registered longest shoot, irrespective of the durations and temperatures where $r^2 = 0.45$.

Table 27 Influence of seed zones on shoot length (cm) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	29.5	29.5	29.5	29.5
D ₂	22.6	21.0	25.3	22.9
D ₃	22.1	21.5	24.9	22.8
D ₄	17.6	21.1	19.1	19.3
D ₅	16.3	20.3	21.8	19.5
D ₆	16.1	18.0	20.3	18.1
D ₇	15.4	17.1	19.4	17.3
Z₂				
D ₁	33.2	33.2	33.2	33.2
D ₂	18.9	34.5	24.4	25.9
D ₃	17.7	29.5	22.7	23.3
D ₄	26.0	22.0	22.3	23.4
D ₅	20.5	25.4	26.1	24.0
D ₆	16.3	23.4	24.4	21.4
D ₇	15.2	22.6	24.1	20.6
Z₃				
D ₁	37.5	37.5	37.5	37.5
D ₂	29.0	33.3	21.4	27.9
D ₃	25.1	29.9	33.8	29.6
D ₄	23.3	29.3	31.5	28.0
D ₅	21.4	23.5	25.0	23.3
D ₆	20.0	17.9	21.0	19.6
D ₇	18.4	21.4	19.6	19.8
Z₄				
D ₁	29.7	29.7	29.7	29.7
D ₂	21.8	29.5	30.4	27.2
D ₃	20.2	26.9	25.1	24.1
D ₄	18.0	24.5	26.5	23.0
D ₅	15.6	22.8	23.9	20.8
D ₆	14.9	20.4	22.9	19.4
D ₇	14.4	17.4	21.0	17.6
Z₅				
D ₁	30.5	30.5	30.5	30.5
D ₂	19.3	24.3	25.3	22.9
D ₃	18.0	23.7	21.6	21.1
D ₄	17.8	23.8	24.9	22.1
D ₅	16.9	22.8	22.9	20.9
D ₆	17.1	20.9	22.5	20.2
D ₇	13.7	20.0	19.4	17.7

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	31.9	31.9	31.9	31.9
D ₂	23.4	25.3	26.1	24.9
D ₃	23.0	18.7	27.4	23.0
D ₄	21.3	23.3	25.5	23.4
D ₅	20.4	23.0	25.3	22.9
D ₆	18.6	19.2	23.3	20.4
D ₇	18.0	19.1	21.5	19.5
Z₇				
D ₁	43.9	43.9	43.9	43.9
D ₂	41.0	28.3	42.5	37.3
D ₃	35.5	28.1	35.9	33.2
D ₄	32.6	35.1	37.2	35.0
D ₅	24.6	31.8	32.2	29.5
D ₆	22.7	28.4	24.7	25.3
D ₇	20.0	23.0	25.2	22.7
T-MEAN	22.6	25.5	26.5	24.8

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	4.68	4.68	4.68	-	-	-	-
CD (5%)	9.25	9.25	9.25	NS	NS	NS	NS
CD (1%)	12.22**	12.22**	12.22**	NS	NS	NS	NS

Correlation matrix

	Shoot length	Temperature	Duration	Zones
Shootlength	1.000	-0.225**	-0.574**	0.267
Temperature	-0.225	1.000	0.000NS	0.000
Duration	-0.574	0.000	1.000	0.000
Zones	0.267	0.000	0.000	1.000

$$R^2 = 0.45^{**}$$

$$\text{Regression equation: } Y = 28.304 - 0.131(\text{Temp}) - 2.085(\text{Duration}) + 0.97(\text{Zones})$$

4.11.2.4. Dry matter production [g] [Table 28]

For zones, temperatures, durations the interaction of ZxD and TxD there was highly significant differences and the rest was not significant (ie zone with temperature and their interaction).

Among the zones, Z7 registered the highest value in D1, D2 and D3 and later Z1 registered the highest dry matter production upto D7 and at D4 both Z7 and Z1 had the same value (11.4 g). The maximum and minimum ranged between Z7 (13.8 g) and Z3 (10.6 g) at D1; Z7 (13.8 g) and Z5 (10.1 g) at D2; Z7 (12.4 g) and Z4 (9.6 g) at D3; Z1, Z7 (11.4 g) and Z4 (8.6 g) at D4; Z1 (10.7 g) and Z4 (8.2 g) at D5; Z1 (9.9 g) and Z4 (7.7 g) at D6 and Z1 (9.1 g) and Z4 (7.3 g) at D7, irrespective of the imposed temperatures during storage

The interaction between zone and duration revealed that increase in the durations of storage clearly resulted in the reduction of dry matter production. The mean value was 11.8 g at D1, irrespective of zones and temperatures which was maximum while the minimum was at D7 with 8.1 (g). Among the zones, Z7, registered the highest value (11.4 g) and Z5 registered the lowest (9.2 g).

Temperature duration interaction showed that decrease in temperature resulted in the increased dry matter production. However, T2 and T3 were on par with each other in most cases except at D4 and D6.

Correlation matrix indicated that there was negative association with temperature and duration of storage for the dry matter production.

4.11.2.5. Vigour Index [Table 29]

Vigour index was significantly different due to the influence of temperature and different duration of storage in chosen variable zones. It was highly significant for all the levels, significant for the interaction between ZxT and non-significant for the three way interaction.

Table 28 Influence of seed zones on dry matter production (g) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	12.3	12.3	12.3	12.3
D ₂	12.4	12.4	12.5	12.4
D ₃	11.3	12.1	12.0	11.8
D ₄	10.5	11.6	12.1	11.4
D ₅	9.4	10.9	11.7	10.7
D ₆	8.9	9.9	10.9	9.9
D ₇	7.9	9.3	10.2	9.1
Z₂				
D ₁	11.3	11.3	11.3	11.3
D ₂	10.4	11.4	11.4	11.1
D ₃	9.7	10.9	11.1	10.6
D ₄	8.9	9.9	10.7	9.8
D ₅	8.1	9.7	10.1	9.3
D ₆	7.9	9.4	9.5	8.9
D ₇	7.0	8.3	8.7	8.0
Z₃				
D ₁	10.6	10.6	10.6	10.6
D ₂	10.6	10.5	10.4	10.5
D ₃	9.5	10.7	10.9	10.4
D ₄	8.3	9.1	9.8	9.1
D ₅	8.3	8.7	9.4	8.8
D ₆	7.4	8.5	8.9	8.3
D ₇	6.6	8.1	8.4	7.7
Z₄				
D ₁	10.9	10.9	10.9	10.9
D ₂	9.6	10.4	10.6	10.2
D ₃	9.1	9.7	9.9	9.6
D ₄	7.9	8.7	9.3	8.6
D ₅	7.5	8.5	8.6	8.2
D ₆	7.0	7.7	8.5	7.7
D ₇	6.4	7.6	7.9	7.3
Z₅				
D ₁	11.4	11.4	11.4	11.4
D ₂	10.0	10.1	10.1	10.1
D ₃	8.9	9.9	10.3	9.7
D ₄	8.3	9.4	9.8	9.2
D ₅	7.8	8.3	8.7	8.3
D ₆	7.5	7.9	8.4	7.9
D ₇	6.9	7.7	8.1	7.6

Cont.

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	12.6	12.6	12.6	12.6
D ₂	11.5	11.7	11.8	11.7
D ₃	10.9	11.1	11.1	11.0
D ₄	9.4	10.7	10.9	10.3
D ₅	8.8	9.2	9.2	9.1
D ₆	8.4	8.9	9.1	8.8
D ₇	7.7	8.2	8.6	8.2
Z₇				
D ₁	13.8	13.8	13.8	13.8
D ₂	13.1	13.4	13.2	13.2
D ₃	12.2	12.4	12.7	12.4
D ₄	10.9	11.5	11.8	11.4
D ₅	9.7	10.3	11.1	10.4
D ₆	8.9	10.2	10.4	9.8
D ₇	8.4	8.9	9.2	8.8
T-MEAN	9.4	10.1	10.4	10.0

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.4	0.4	0.4	0.2	-	0.2	-
CD (5%)	0.9	0.9	0.9	0.5	NS	0.3	NS
CD (1%)	1.1**	1.1**	1.1**	0.6**	NS	0.4**	NS

Correlation matrix

	DMP	Temperature	Duration	Zones
DMP	1.000	-0.243**	-0.754**	0.066 NS
Temperature	-0.243	1.000	0.000 NS	0.000 NS
Duration	-0.754	0.000	1.000	0.000 NS
Zones	0.066	0.000	0.000	1.000

$$R^2 = 0.63^{**}$$

Regression equation: $Y = 11.968 - 0.033 (\text{Temp.}) - 0.638 (\text{Duration}) + 0.056 (\text{Zones})$

Table 29 Influence of seed zones on vigour index at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	1064	1064	1064	1064
D ₂	1024	1035	1095	1051
D ₃	934	1010	966	970
D ₄	763	958	980	900
D ₅	564	846	816	742
D ₆	421	746	654	607
D ₇	333	539	535	469
Z₂				
D ₁	859	859	859	859
D ₂	713	809	861	794
D ₃	669	735	722	709
D ₄	543	615	648	602
D ₅	418	587	591	532
D ₆	308	569	508	462
D ₇	202	470	392	354
Z₃				
D ₁	694	704	704	700
D ₂	533	533	557	541
D ₃	499	557	545	534
D ₄	404	487	524	472
D ₅	323	453	455	410
D ₆	245	408	334	329
D ₇	186	353	291	277
Z₄				
D ₁	1025	1025	1025	1025
D ₂	812	777	911	833
D ₃	751	839	817	802
D ₄	574	762	784	706
D ₅	468	700	731	633
D ₆	384	597	554	512
D ₇	254	551	454	419
Z₅				
D ₁	1129	1129	1129	1129
D ₂	951	1015	909	958
D ₃	827	901	885	871
D ₄	673	918	892	827
D ₅	487	685	631	601
D ₆	356	555	513	474
D ₇	224	578	426	409

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	788	788	788	788
D ₂	560	620	667	616
D ₃	529	533	533	531
D ₄	400	535	523	486
D ₅	322	432	387	380
D ₆	244	401	342	329
D ₇	173	357	284	271
Z₇				
D ₁	1047	1047	1047	1047
D ₂	874	927	965	922
D ₃	823	893	838	851
D ₄	660	834	785	759
D ₅	452	685	667	601
D ₆	356	666	551	524
D ₇	292	561	433	423
T-MEAN	574	707	685	655

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	54	54	54	31	20	20	-
CD (5%)	107	107	107	62	40*	40	NS
CD (1%)	141**	141**	141**	81**	53NS	53**	NS

Correlation matrix

	Vigourindex	Temperature	Duration	Zones
Vigourindex	1.000	0.209**	-0.760**	0.076NS
Temperature	0.209	1.000	0.000NS	0.000NS
Duration	-0.760	0.000	1.000	0.000NS
Zones	-0.076	0.000	0.000	1.000

$$R^2 = 0.63^{**}$$

Regression equation: $Y = 1006.415 - 4.121(\text{Temp}) - 93.239(\text{Duration}) - 9.285(\text{Zones})$

• The control D1, registered the highest vigour index, irrespective of zones; while D7 registered the lowest. Over the periods of storage, the vigour index (VI) reduced gradually in respect of the zones. At D1 the highest Vigour Index was registered by Z5 (1129) and the lowest was at Z3 (700). The maximum and minimum at D2 ranged between 1051 (Z1) and 541 (Z3); at D3, 970 (Z1) and 531 (Z6); at D4 900 (Z1) and 472 (Z3); at D5 742 (Z1) and 380 (Z5); at D6 607 (Z1) and 329 (Z5) and at D7 it was between 469 (Z1) and 271 (Z5). Over the period of storage, excepting at D1, in all the durations, Z1 registered the highest mean VI. The mean VI in different temperatures ranged only between D1 and D7.

The mean VI, was the highest in T2 at all different levels of storage excepting at D4 where it was in T3.

The interaction of ZxD revealed that the mean VI ranged between Z1 and Z3 with VI value of 829 and 466 respectively. Over the periods of storage, irrespective of the zones, the VI declined gradually and the mean VI reached a low of 733 at D7 from 944 at D1.

The interaction of temperature with duration resulted in the increased VI with decrease in temperature. However, beyond T2 it again maintained the declining trend. The mean VI ranged between 574 (T1) and 707 (T2) as minimum and maximum.

VI was negatively correlated with temperature and duration and the r^2 value was 0.63.

4.11.2.6. Oil content % [Table 30; Fig. 29]

Highly significant results were obtained for all the treatment excepting the three way interaction (ZxTxD).

Among the duration, D1, the control registered the highest per cent of oil with 39.9% in Z5 and the lowest was in Z7 with 27.2 per cent. In Z1, the mean maximum and minimum ranged between 37.5% (D1) and 24.7% (D7). In all the zones the maximum

Table 30 Influence of seed zones on oil content (%) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	37.5 (37.76)	37.5 (37.76)	37.5 (37.76)	37.5 (37.76)
D ₂	35.6 (36.63)	34.8 (36.15)	35.5 (36.57)	35.3 (36.45)
D ₃	31.2 (33.96)	33.8 (35.55)	34.3 (35.85)	33.1 (35.12)
D ₄	29.3 (32.74)	30.8 (33.71)	31.5 (34.14)	30.5 (33.53)
D ₅	25.6 (30.40)	26.4 (30.88)	26.8 (31.18)	26.3 (30.82)
D ₆	24.1 (29.43)	25.2 (30.13)	25.9 (30.59)	25.1 (30.05)
D ₇	24.1 (29.40)	24.6 (29.73)	25.3 (30.20)	24.7 (29.78)
Z₂				
D ₁	31.8 (34.32)	31.8 (34.32)	31.8 (34.32)	31.8 (34.32)
D ₂	27.5 (31.63)	27.5 (31.63)	27.5 (31.63)	27.5 (31.63)
D ₃	26.0 (30.69)	26.6 (31.05)	26.7 (31.11)	26.5 (30.95)
D ₄	25.2 (30.13)	26.1 (30.72)	26.8 (31.18)	26.0 (30.68)
D ₅	23.4 (28.93)	24.7 (29.80)	26.1 (30.72)	24.7 (29.82)
D ₆	21.9 (27.85)	24.3 (29.53)	24.9 (29.93)	23.7 (29.11)
D ₇	22.0 (27.97)	22.7 (28.45)	23.7 (29.13)	22.8 (28.52)
Z₃				
D ₁	31.7 (34.24)	31.7 (34.24)	31.7 (34.24)	31.7 (34.24)
D ₂	32.8 (34.91)	33.2 (35.18)	30.6 (33.55)	32.2 (34.55)
D ₃	29.5 (32.90)	32.3 (34.63)	29.6 (32.92)	30.5 (33.48)
D ₄	27.1 (31.37)	27.7 (31.76)	27.5 (31.63)	27.4 (31.58)
D ₅	24.9 (29.93)	25.2 (30.13)	26.1 (30.72)	25.4 (30.26)
D ₆	23.8 (29.20)	24.6 (29.73)	23.6 (29.06)	24.0 (29.33)
D ₇	23.1 (28.73)	24.3 (29.53)	24.0 (29.33)	23.8 (29.20)
Z₄				
D ₁	28.4 (32.20)	28.4 (32.20)	28.4 (32.20)	28.4 (32.20)
D ₂	27.0 (31.31)	27.7 (31.76)	26.9 (31.24)	27.2 (31.43)
D ₃	24.8 (29.87)	26.3 (30.82)	26.6 (31.05)	25.9 (30.58)
D ₄	23.2 (28.79)	23.8 (29.20)	24.9 (29.93)	24.0 (29.31)
D ₅	21.5 (27.59)	23.1 (28.73)	24.3 (29.53)	23.0 (28.62)
D ₆	20.0 (26.56)	22.1 (28.04)	22.3 (28.17)	21.5 (27.59)
D ₇	19.4 (26.10)	21.1 (27.34)	21.8 (27.83)	20.8 (27.09)
Z₅				
D ₁	39.9 (39.17)	39.9 (39.17)	39.9 (39.17)	39.9 (39.17)
D ₂	37.3 (37.64)	37.9 (38.00)	38.0 (38.06)	37.7 (37.90)
D ₃	34.5 (35.97)	36.9 (37.41)	36.8 (37.35)	36.1 (36.91)
D ₄	31.0 (33.82)	31.7 (34.26)	32.5 (34.79)	31.8 (34.29)
D ₅	28.2 (32.08)	29.0 (32.58)	30.0 (33.20)	29.1 (32.62)
D ₆	26.9 (31.24)	27.1 (31.37)	26.7 (31.11)	26.9 (31.24)
D ₇	25.7 (30.46)	26.2 (30.79)	26.6 (31.05)	26.2 (30.76)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	27.7 (31.73)	27.7 (31.73)	27.7 (31.73)	27.7 (31.73)
D ₂	24.6 (29.72)	25.7 (30.44)	26.7 (31.10)	25.7 (30.42)
D ₃	23.0 (28.63)	28.6 (32.33)	27.4 (31.54)	26.3 (30.83)
D ₄	22.3 (28.14)	26.9 (31.24)	28.8 (32.45)	26.0 (30.61)
D ₅	20.2 (26.71)	24.9 (29.93)	26.0 (30.66)	23.7 (29.10)
D ₆	18.9 (25.77)	21.1 (27.34)	23.1 (28.72)	21.0 (27.28)
D ₇	18.7 (25.62)	19.9 (26.49)	21.0 (27.27)	19.9 (26.46)
Z₇				
D ₁	27.2 (31.43)	27.2 (31.43)	27.2 (31.43)	27.2 (31.43)
D ₂	25.3 (30.16)	25.4 (30.26)	25.6 (30.43)	25.4 (30.29)
D ₃	23.8 (29.20)	25.6 (30.39)	25.1 (30.07)	24.8 (29.89)
D ₄	21.8 (27.83)	24.4 (29.60)	24.0 (29.32)	23.4 (28.92)
D ₅	19.5 (26.20)	23.1 (28.73)	23.0 (28.69)	21.9 (27.87)
D ₆	19.1 (25.91)	21.9 (27.96)	22.4 (28.25)	21.1 (27.35)
D ₇	18.8 (25.70)	21.1 (27.34)	21.6 (27.69)	20.5 (26.91)
T-MEAN	26.1 (30.58)	27.4 (31.46)	27.6 (31.63)	27.0 (31.22)

(Figures in Parenthesis indicate transformed values)

	Z	T	D	ZxT	ZxT	TxD	ZxTxD
SEd	0.96	0.96	0.96	0.55	0.36	0.36	-
CD (5%)	1.89	1.89	1.89	1.09	0.71	0.71	NS
CD (1%)	2.50**	2.50**	2.50**	1.44**	0.94**	0.94**	NS

Correlation matrix

	Oil %	Temperature	Duration	Zones
Oil %	1.000	-0.136*	-0.663**	-0.282**
Temperature	-0.136	1.000	0.000 NS	0.000 NS
Duration	-0.663	0.000	1.000	0.000 NS
Zones	-0.282	0.000	0.000	1.000

$$R^2 = 0.54^{**}$$

Regression equation: $Y = 35.17 - 0.054 (\text{Temp.}) - 1.64 (\text{Duration}) - 0.699 (\text{Zones})$

and minimum was between only D1 and D7 irrespective of temperatures. The decline in oil % was gradual in all the zones and there was 12.8% reduction in Z1, 9.0% in Z2, 7.9% in Z3, 7.6% in Z4, 13.7% in Z5, 7.8% in Z6, and 6.7% in Z7, over the periods of storage. However the temperatures couldn't influence the oil percentage significantly over the immediate level of temperatures in all the levels of storage periods.

The interaction of zone with durations of storage resulted in the reduction in oil% over the periods of storage. In Z1 the mean oil content was 30.3% and at Z7 it was 23.5% resulting in over all reduction of 6.8% during storage. However, the mean value of different durations, irrespective of zones resulted in 9.4% decline in oil content and it varied between 32.0% (D1) and 22.6% (D7).

The temperature interaction with zone revealed that decrease in temperature arrested the decline in oil content. At T1, irrespective of zones and duration the mean oil content was 26.1% and it was 27.6% at T3. With different temperature levels, the mean oil per cent in different zones, irrespective of durations and temperature resulted in 6.8% decline and it varied between 30.3% (D1) and 23.5 (D7).

The TxD interaction clearly indicated the above trends and the temperature levels gave significantly different results; the maximum and minimum ranged between T3 (27.6%) and T1 (26.1%).

The oil content was having negatively high significant correlation with temperature and duration. However, with the zones it varied significantly, having r^2 value of 0.54.

4.11.2.7. Free Fatty acid % [Table 31; Fig. 30]

The effect of different durations, period and temperatures on different zones was significantly different and influenced the free fatty acid levels in pungam. However, the three way interaction was not significant.

Table 31 Influence of seed zones on free fatty acids (%) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	6.85	6.85	6.85	6.85
D ₂	7.49	7.02	7.22	7.24
D ₃	8.35	7.39	7.39	7.71
D ₄	9.27	7.92	7.55	8.24
D ₅	11.07	9.28	8.27	9.54
D ₆	12.47	10.78	9.78	11.01
D ₇	12.97	12.38	10.78	12.04
Z₂				
D ₁	7.56	7.56	7.56	7.56
D ₂	8.28	7.53	7.39	7.73
D ₃	9.85	8.28	8.28	8.80
D ₄	10.24	9.28	8.78	9.43
D ₅	11.97	10.24	9.77	10.66
D ₆	13.37	11.78	10.28	11.71
D ₇	13.37	12.48	10.98	12.28
Z₃				
D ₁	5.94	5.94	5.94	5.94
D ₂	9.27	8.28	7.78	8.44
D ₃	9.85	9.26	8.28	9.13
D ₄	11.44	10.26	9.26	10.32
D ₅	12.87	11.30	10.26	11.48
D ₆	14.27	12.48	10.78	12.51
D ₇	14.43	12.24	11.38	12.68
Z₄				
D ₁	5.48	5.48	5.48	5.48
D ₂	6.65	7.40	7.55	7.20
D ₃	7.53	6.57	6.05	6.72
D ₄	8.14	7.53	6.57	7.41
D ₅	9.27	8.28	7.57	8.37
D ₆	10.46	9.28	9.37	9.70
D ₇	11.37	10.46	9.87	10.57
Z₅				
D ₁	4.68	4.68	4.68	4.68
D ₂	5.34	4.97	4.95	5.09
D ₃	6.26	5.78	5.45	5.83
D ₄	7.41	6.53	5.93	6.63
D ₅	8.28	7.55	7.18	7.67
D ₆	9.37	8.28	7.58	8.41
D ₇	10.87	8.78	8.93	9.53

Contd.

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	7.00	7.00	7.00	7.00
D ₂	7.56	6.57	5.95	6.69
D ₃	8.27	7.56	6.58	7.47
D ₄	8.78	7.55	7.57	7.97
D ₅	9.83	8.78	7.42	8.68
D ₆	10.97	9.26	8.77	9.67
D ₇	12.97	10.27	9.28	10.84
Z₇				
D ₁	7.15	7.15	7.15	7.15
D ₂	8.75	7.56	6.55	7.62
D ₃	9.85	8.28	7.56	8.56
D ₄	10.87	9.28	8.43	9.53
D ₅	11.87	9.70	9.28	10.28
D ₆	12.98	10.78	10.28	11.35
D ₇	14.27	12.45	11.28	12.67
T-MEAN	9.66	8.61	8.06	8.78

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	0.52	0.52	0.52	0.30	0.20	0.20	-
CD (5%)	1.02	1.02	1.02	0.59	0.39	0.39	NS
CD (1%)	1.35**	1.35**	1.35**	0.78**	0.51**	0.51**	NS

Correlation matrix

	FFA	Temperature	Duration	Zones
FFA	1.000	0.295**	0.764**	-0.130*
Temperature	0.295	1.000	0.000NS	0.000NS
Duration	0.764	0.000	1.000	0.000NS
Zones	-0.130	0.000	0.000	1.000

$$R^2 = 0.69^{**}$$

Regression equation: $Y = 6.335 + 0.053 (\text{Temp}) + 0.862 (\text{Duration}) - 0.147 (\text{Zones})$

Fig.29. Influence of seed zones on oil % at different temperatures, during storage of *Derris indica* seeds

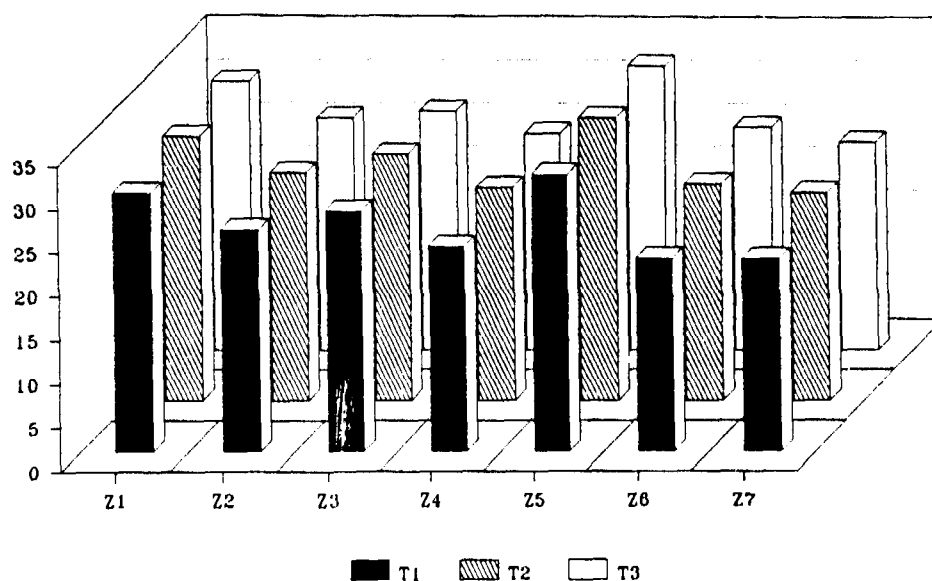
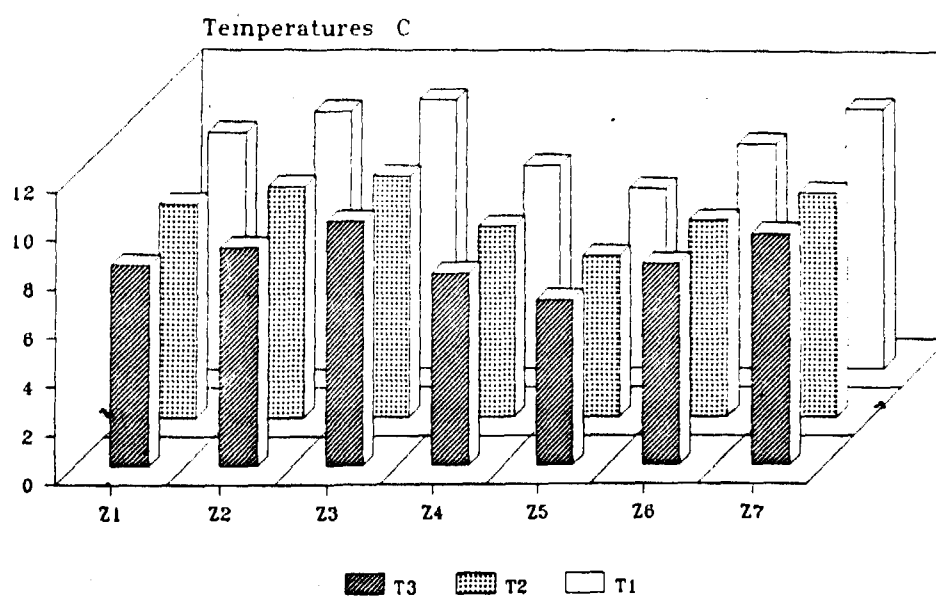


Fig.30. Influence of seed zones on Free Fatty acid (%) at different temperatures, during storage of *Derris indica* seeds



Immediately after the harvest the Z5 had the lowest level of free fatty acid with 4.68% (D1) and Z2 had the highest FFA (7.56%) at D1. Invariably in all the zones and included temperature the durations of storage significantly increased the FFA level and the mean FFA % increase was 5.19% in Z1, irrespective of temperature levels. It was 4.72% in Z2, 6.74% in Z3, 5.09% in Z4, 4.85% in Z5, 3.84% in Z6 and 5.52% in Z7. Among the temperatures, T3 appeared to arrest the further raise in FFA% in all the zones excepting in Z7 when it was T2. There was almost 1-2% drop of FFA% in T3.

The zone and duration interaction indicated the increase in FFA due to increased duration. The mean FFA% ranged between 6.38% (D1) and 11.51% (D7). The increase was gradual upto D7 right from D1. Among the zones, at different durations, Z3, gave the highest value of FFA% (10.07%) and the lowest being Z5 (6.83%).

From the interaction effect of duration with temperature it was clear that T3 registered the lower value for FFA, irrespective of zones and durations of storage. The mean FFA at T1 was 9.66% and T3 registered 8.06 per cent. At different temperature also D7 gave the highest value for FFA.

The zone and temperature interaction revealed that Z3 at all levels of temperatures registered the highest value and the lowest being Z5. The mean FFA% at T1 was 9.66 and the lowest being 8.06 at T3 irrespective of zones and durations. There was positive correlation between FFA content and temperature and duration. The r^2 value was 0.69.

4.11.2.8. Protein [Table 32; Fig. 31]

Highly significant results were obtained for all the treatments for protein content with different zones. The interaction effect was significant for duration of storage with different zones and the rest was not significant.

At D1, among the zones, the mean protein % was high in Z1 and low at Z7. The mean protein %, in Z1, irrespective of the temperatures ranged between 25.9% (D1)

Table 32 Influence of seed zones on protein content (%) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	25.9	25.9	25.9	25.9
D ₂	24.8	25.4	25.4	25.2
D ₃	24.1	23.8	24.6	24.2
D ₄	22.7	23.9	23.8	23.5
D ₅	21.8	22.7	23.0	22.5
D ₆	23.2	21.5	22.6	22.4
D ₇	18.8	19.8	20.9	19.8
Z₂				
D ₁	24.4	24.4	24.4	24.4
D ₂	22.5	22.2	23.4	22.7
D ₃	21.3	22.2	21.4	21.6
D ₄	20.7	21.4	22.1	21.4
D ₅	19.7	21.0	21.5	20.7
D ₆	19.2	20.1	21.0	20.1
D ₇	17.7	18.6	19.7	18.7
Z₃				
D ₁	25.4	25.4	25.4	25.4
D ₂	24.5	24.9	25.1	24.8
D ₃	23.3	24.0	24.8	24.1
D ₄	22.3	23.0	23.5	22.9
D ₅	20.7	22.2	22.9	21.9
D ₆	18.3	20.3	21.6	20.1
D ₇	17.8	18.9	20.4	19.0
Z₄				
D ₁	25.4	25.4	25.4	25.4
D ₂	23.9	24.9	25.2	24.7
D ₃	22.7	23.7	24.3	23.6
D ₄	21.7	22.6	23.3	22.5
D ₅	20.2	22.0	22.3	24.5
D ₆	19.9	20.6	21.7	20.8
D ₇	17.2	18.1	19.3	18.2
Z₅				
D ₁	25.3	25.3	25.3	25.3
D ₂	24.2	24.9	25.4	24.8
D ₃	23.8	24.2	23.8	24.0
D ₄	24.1	24.0	24.3	24.2
D ₅	22.9	23.6	24.0	23.5
D ₆	20.1	20.9	21.8	21.0
D ₇	20.2	20.7	20.8	20.6

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	22.7	22.7	22.7	22.7
D ₂	22.0	22.8	23.2	22.7
D ₃	20.7	22.1	22.2	21.7
D ₄	20.2	20.8	22.8	21.3
D ₅	19.4	20.2	21.0	20.2
D ₆	17.4	19.7	20.0	19.0
D ₇	17.3	18.3	19.2	18.3
Z₇				
D ₁	21.0	21.0	21.0	21.0
D ₂	19.7	20.8	20.3	20.3
D ₃	18.9	19.3	20.1	19.4
D ₄	18.2	19.2	19.3	18.9
D ₅	17.2	18.0	19.7	18.3
D ₆	16.9	17.3	18.0	17.4
D ₇	16.2	16.9	17.2	16.7
T-MEAN	21.2	21.9	22.4	21.8

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	1.0	1.0	1.0	0.6	-	-	-
CD (5%)	2.0	2.0	2.0	1.1*	NS	NS	NS
CD (1%)	2.6**	2.6**	2.6**	1.5NS	NS	NS	NS

Correlation matrix

	Protein%	Temperature	Duration	Zones
Protein%	1.000	-0.190**	-0.698**	-0.386**
Temperature	-0.190	1.000	0.000NS	0.000NS
Duration	-0.698	0.000	1.000	0.000NS
Zones	-0.386	0.00	0.000	1.000

$$R^2 = 0.67^{**}$$

$$\text{Regression equation : } Y = 26.804 - 0.039 (\text{Temp}) - 0.895 (\text{Duration}) - 0.495 (\text{Zones})$$

and 19.8% (D7). It was between 24.4% (D1) and 18.7% (D7) in Z2; 25.4% (D1) and 19.0% (D7); in Z3, 25.4% (D1) and 18.2% (D7) in Z4, 25.3% (D1) and 20.6 (D7) in Z5; 22.7% (D1) and 18.3% (D7) in Z6 and 21.0 (D1) and 16.7 (D7) in Z7 respectively.

The protein % decline was in the order of 6.1 % in Z1, 5.7% in Z2, 6.4% in Z3, 7.2% in Z4, 4.7% in Z5, 4.4% in Z6, and 4.3% in Z7 over the periods of storage. The interaction in zone with duration of storage resulted in decline in the percentage of protein over the period of storage. The mean protein % irrespective of zones and durations was the highest in D1 with 24.3% and lowest was at D7 with 18.7 per cent. The over all reduction was about 5.6 per cent. The mean maximum for different zones ranged between 25.9% and 21.0 in Z1 and Z7 at D1, Z1 and Z6 at D2, Z1 and Z2 at D3, Z5 and Z6 at D4, Z5 and Z7 at D5, Z1 and Z7 at D6 and Z5 and Z4 at D7.

There was significantly negative correlation of protein with temperature and duration of storage and the results significantly varied between the zones, with r^2 value of 0.67.

4.11.2.9. Carbohydrates % [CHO] [Table 33; Fig. 32]

The interaction between effect of temperature and duration of storage was highly significant for seeds collected from different zones. The interaction of duration with zone was significant and was highly significant with different durations.

From the results, it became evident in that among the different zones collected seeds, Z5, was having the highest percentage CHO immediately after the collection. There was steady decrease in CHO levels although the storage period and it was at a faster rate after D4. The mean CHO% declined, irrespective of the temperature, was 10.77% in Z1; 8.98% in Z2; 8.07% in Z3; 8.28% in Z4; 7.69% in Z5; 8.49% in Z6 and 8.95% in Z7. The total mean, irrespective of the durations and zones, the temperature decrease clearly arrested the decline in CHO levels in all the zones and T3 maintained superiority over the other two levels of temperatures.

Table 33 Influence of seed zones on carbohydrates (%) at different temperatures during storage of Derris indica seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₁				
D ₁	37.70	37.70	37.70	37.70
D ₂	36.31	36.82	36.88	36.67
D ₃	34.37	35.79	36.61	35.59
D ₄	31.79	33.02	34.93	33.25
D ₅	29.62	30.15	32.57	30.78
D ₆	27.59	28.49	29.95	28.68
D ₇	25.94	26.82	28.04	26.93
Z₂				
D ₁	36.39	36.39	36.39	36.39
D ₂	34.73	35.41	35.51	35.22
D ₃	33.76	35.01	35.70	34.82
D ₄	33.09	33.85	34.94	33.96
D ₅	29.94	31.32	32.73	31.33
D ₆	28.37	29.30	30.54	29.40
D ₇	26.42	27.45	28.36	27.41
Z₃				
D ₁	33.85	33.85	33.85	33.85
D ₂	32.87	33.09	33.51	33.16
D ₃	30.86	32.00	32.95	31.94
D ₄	30.49	31.24	32.13	31.28
D ₅	27.19	27.98	28.85	28.01
D ₆	25.92	27.12	27.77	26.94
D ₇	24.32	25.89	27.12	25.78
Z₄				
D ₁	35.18	35.18	35.18	35.18
D ₂	34.78	35.29	35.85	35.31
D ₃	33.65	34.48	35.46	34.53
D ₄	32.59	33.59	33.86	33.35
D ₅	30.15	31.34	32.97	31.49
D ₆	27.46	29.02	29.82	28.77
D ₇	25.78	27.07	27.84	26.90
Z₅				
D ₁	38.82	38.82	38.82	38.82
D ₂	39.05	38.65	38.74	38.81
D ₃	36.62	38.12	38.34	37.69
D ₄	35.76	36.78	37.29	36.61
D ₅	33.86	34.94	35.94	34.91
D ₆	33.07	34.06	34.74	33.96
D ₇	29.60	30.84	32.95	31.13

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
Z₆				
D ₁	36.97	36.97	36.97	36.97
D ₂	35.35	35.29	35.90	35.51
D ₃	33.67	35.18	35.10	34.65
D ₄	32.29	33.72	34.75	33.59
D ₅	30.23	30.77	32.97	31.32
D ₆	29.40	30.42	31.17	30.33
D ₇	26.94	28.17	30.19	28.43
Z₇				
D ₁	34.85	34.85	34.85	34.85
D ₂	32.48	33.59	33.85	33.31
D ₃	29.82	31.12	33.29	31.41
D ₄	29.09	29.94	31.08	30.04
D ₅	26.99	28.30	29.45	28.25
D ₆	26.08	27.22	28.59	27.29
D ₇	24.78	25.99	26.92	25.90
T-MEAN	31.57	32.42	33.26	32.42

	Z	T	D	ZxD	ZxT	TxD	ZxTxD
SEd	1.17	1.17	1.17	0.67	-	0.44	-
CD (5%)	2.30	2.30	2.30	1.33*	NS	0.87	NS
CD (1%)	3.04**	3.04**	3.04**	1.76NS	NS	1.15**	NS

Correlation matrix

	CHO	Temperature	Duration	Zones
CHO	1.000	-0.180**	-0.795**	-0.027NS
Temperature	-0.180	1.000	0.000NS	0.000NS
Duration	-0.795	0.000	1.000	0.000NS
Zones	-0.027	0.000	0.000	1.000

$$R^2 = 0.67^{**}$$

Regression equation : $Y = 37.571 - 0.055 (\text{Temp})$
 $- 1.498 (\text{Duration}) - 0.052 (\text{Zones})$

Fig.31. Influence of seed zones on Protein % at different temperatures, during storage of *Derris indica* seeds

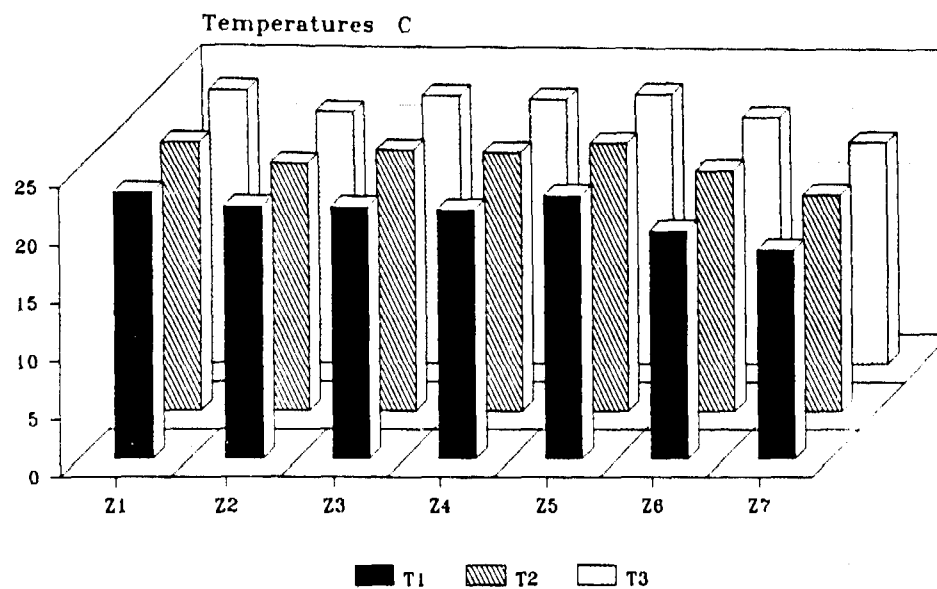
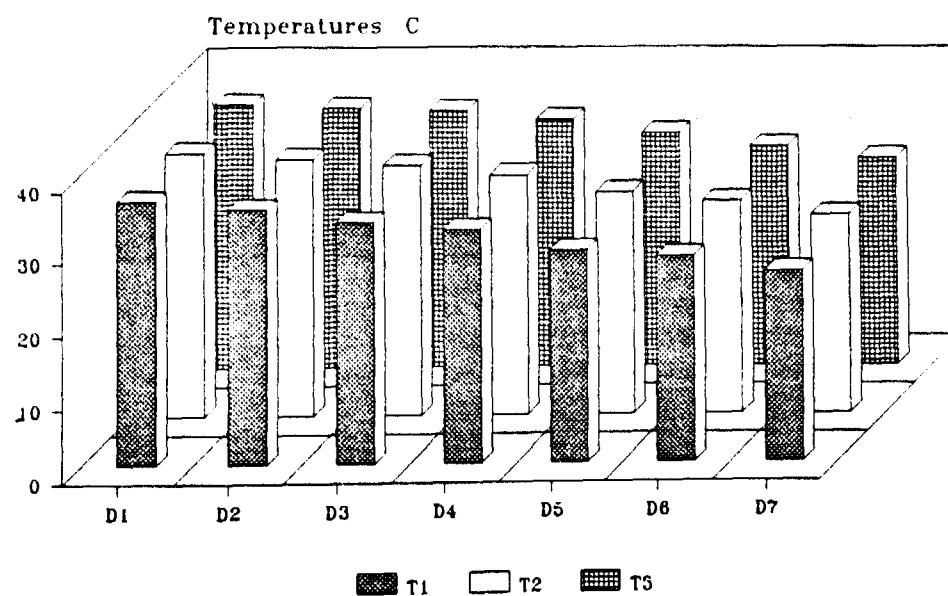


Fig.32. Influence of temperature on total Carbohydrate % during storage of *Derris indica* seeds irrespective of zones



The interaction between zone and duration resulted in significant variation among the zones during the period of storage. The same trend of decline was not maintained throughout the storage period among the zones. At D1 the highest CHO% was in Z5 and it was the same zone maintained highest level throughout the period of storage. However, the minimum level varied clearly among the zones. The mean CHO% declined from as high as 36.25% at D1 to 27.50% at D7.

The duration, temperature interaction indicated that there was not critical variation existed between different T levels at D1 and D2 and it varied there after.

From the correlation matrix it was understood that CHO was having negative association with temperature and duration levels. The r^2 value was 0.67.

4.11.3. Seed storage studies in *Ailanthus* [*Ailanthus excelsa* Roxb.].

4.11.3.1. Germination % [Table 34; Fig. 33]

The effect of temperature and durations on germination % of *Ailanthus* seeds collected from various locations was highly significant and their interaction also gave highly significant results.

In L1, at various durations of storage there was steady decline in germination per cent from D1 to D7. Initial germination was high in L1 and it was low in L6, with mean germination % of 71 and 61 respectively. Among the various temperatures tried T3 arrested the faster decline in germination over the other. At D7, the germination % variation between T1 and T3 in L1, L2, L3, L4, L5, L6 and L7 was 5, 10, 9, 4, 5, 8 and 10% respectively. The mean germination % varied between D1 and D7 in L1, L2, L3, L4, L5, L6 and L7 was 58, 57, 49, 54, 55, 46 and 53% respectively, indicating that the per cent decline in germination was the highest in L1.

The interaction of duration with location indicated that though there was about 10% different in germination % at D1, it was on par with the most of the locations excepting in L6 when the mean germination was 15 per cent.

Table 34 Influence of location on germination (%) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	71 (57.42)	71 (57.42)	71 (57.42)	71 (57.42)
D ₂	63 (52.24)	64 (52.84)	65 (53.73)	64 (52.93)
D ₃	54 (47.29)	57 (48.74)	55 (47.87)	55 (47.97)
D ₄	31 (33.83)	46 (42.70)	44 (41.55)	40 (39.36)
D ₅	26 (30.33)	34 (35.66)	29 (32.58)	30 (32.86)
D ₆	17 (23.95)	24 (29.26)	19 (25.83)	20 (26.35)
D ₇	9 (17.43)	15 (22.78)	14 (21.53)	13 (20.58)
L₂				
D ₁	69 (56.17)	69 (56.17)	69 (56.17)	69 (56.17)
D ₂	65 (53.43)	66 (54.03)	68 (55.24)	66 (54.23)
D ₃	56 (48.45)	58 (49.61)	59 (50.19)	58 (49.41)
D ₄	32 (34.44)	36 (36.57)	34 (35.66)	34 (35.56)
D ₅	23 (28.65)	28 (31.93)	27 (31.30)	26 (30.63)
D ₆	14 (21.92)	21 (27.27)	23 (28.65)	19 (25.95)
D ₇	7 (15.30)	13 (21.12)	17 (24.34)	12 (20.26)
L₃				
D ₁	63 (52.25)	63 (52.25)	63 (52.25)	63 (52.25)
D ₂	55 (47.58)	59 (50.19)	59 (50.19)	58 (49.32)
D ₃	48 (43.85)	58 (49.32)	55 (47.87)	54 (47.01)
D ₄	30 (33.20)	35 (36.27)	36 (36.87)	34 (35.45)
D ₅	25 (30.00)	30 (33.20)	27 (31.27)	27 (31.49)
D ₆	11 (19.35)	26 (30.64)	26 (30.66)	21 (26.88)
D ₇	9 (17.22)	15 (22.78)	18 (25.07)	14 (21.69)
L₄				
D ₁	67 (54.64)	67 (54.64)	67 (54.64)	67 (54.64)
D ₂	61 (51.36)	62 (51.67)	60 (50.77)	61 (51.27)
D ₃	57 (48.74)	56 (48.46)	60 (50.77)	58 (49.32)
D ₄	32 (34.44)	34 (35.36)	37 (37.46)	34 (35.75)
D ₅	26 (30.33)	30 (33.21)	31 (33.83)	29 (32.46)
D ₆	15 (22.78)	24 (29.31)	24 (29.26)	21 (27.12)
D ₇	11 (19.35)	14 (21.97)	15 (22.78)	13 (21.37)
L₅				
D ₁	67 (54.64)	67 (54.64)	67 (54.64)	67 (54.64)
D ₂	60 (50.77)	66 (54.34)	64 (53.13)	63 (52.75)
D ₃	56 (48.16)	58 (49.60)	61 (51.36)	58 (49.71)
D ₄	34 (35.66)	37 (37.46)	38 (38.06)	36 (37.06)
D ₅	28 (31.93)	33 (34.76)	27 (31.30)	29 (32.66)
D ₆	19 (25.83)	23 (28.65)	25 (30.00)	22 (28.16)
D ₇	9 (17.22)	14 (21.92)	14 (21.97)	12 (20.37)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	61 (51.36)	61 (51.36)	61 (51.36)	61 (51.36)
D ₂	52 (46.15)	61 (51.36)	64 (52.84)	59 (50.11)
D ₃	45 (42.13)	53 (46.73)	53 (46.72)	50 (45.19)
D ₄	27 (31.30)	28 (31.95)	31 (33.83)	29 (32.36)
D ₅	22 (27.95)	25 (30.00)	23 (28.65)	23 (28.87)
D ₆	13 (21.01)	21 (27.27)	23 (28.32)	19 (25.53)
D ₇	11 (19.35)	15 (22.78)	19 (25.83)	15 (22.65)
L₇				
D ₁	67 (54.64)	67 (54.64)	67 (54.64)	67 (54.64)
D ₂	53 (46.43)	59 (50.19)	60 (50.77)	57 (49.13)
D ₃	45 (42.13)	54 (47.01)	53 (46.43)	50 (45.19)
D ₄	26 (30.33)	31 (33.81)	34 (35.66)	30 (33.27)
D ₅	25 (30.00)	24 (29.26)	19 (25.83)	23 (28.36)
D ₆	13 (21.12)	20 (26.54)	21 (27.22)	18 (24.96)
D ₇	7 (15.30)	19 (25.83)	17 (24.34)	14 (21.83)
T-MEAN	36 (36.11)	41 (39.29)	41 (39.36)	39 (38.25)

(Figures in Parentheses indicate transformed values)

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	2.39	2.39	2.39	1.38	0.74	2.39	-
CD (5%)	4.72	4.72	4.72	2.72	1.46*	1.46	4.72*
CD (1%)	6.23**	6.23**	6.23**	2.98**	1.60	1.60**	6.23

Correlation matrix

	X 1	X 2	X 3
X 1	1.000	-0.959**	-0.104NS
X 2	-0.959	1.000	0.000NS
X 3	-0.104	0.000	1.000

$$R^2 = 0.93^{**}$$

$$\text{Regression equation : } Y = 69.521 - 9.577 (X_2) - 0.166 (X_3)$$

From the interaction effect of location with temperatures, it was clear that the mean germination % in T2 and T3 was on par with each other which was higher than the T1. Similar results were obtained for the interaction of temperature with durations of storage.

Highly significant negative correlation existed in respect of germination with r^2 value of 0.93 between duration and temperature.

4.11.3.2. Root length [cm] [Table 35]

Highly significant results were obtained for (i) different locations, (ii) durations and (iii) temperature levels with regard to root length. The interaction of location with duration and duration with temperature was highly significant and the rest was not-significant.

Over the duration of storage the decline in root length was evident in respect of the chosen locations with different temperature levels. However, T2 and T3 at D7 were on par with each other in all the locations excepting L4. Irrespective of the location, at different levels of durations, T1 gave the shortest root length. The mean root length, irrespective of the temperature varied between 8.90 and 5.07, 7.60 and 5.73, 8.75 and 5.10, 8.30 and 4.48, 8.20 and 5.90, 7.90 and 5.68 and 8.20 and 5.23 cm in L1, L2, L3, L4, L5, L6 and L7 respectively.

The interaction of location with duration revealed that there was no significant variation in the mean root length between the locations and they were on par with each others. However there was significant variation between the durations of storage and the mean root length, irrespective of the temperatures and locations was 8.26 cm at D1 and 5.40 cm at D7 and the decline was 2.86 cm.

From the temperature and duration interaction it was evident that T1 registered the lowest value for root length than T2 and T3.

Table 35 Influence of location on root length (cm) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L ₁				
D ₁	8.90	8.90	8.90	8.90
D ₂	7.40	7.35	8.30	7.68
D ₃	7.30	6.75	7.10	7.05
D ₄	6.50	6.45	7.10	6.68
D ₅	6.40	6.50	6.60	6.50
D ₆	5.60	6.50	6.75	6.28
D ₇	4.70	6.10	6.20	5.67
L ₂				
D ₁	7.60	7.60	7.60	7.60
D ₂	7.40	7.50	8.00	7.63
D ₃	6.70	6.70	6.95	6.78
D ₄	6.25	6.90	7.10	6.75
D ₅	6.20	6.55	6.70	6.48
D ₆	5.20	6.10	6.60	5.97
D ₇	4.80	6.20	6.20	5.73
L ₃				
D ₁	8.75	8.75	8.75	8.75
D ₂	8.00	7.70	8.00	7.90
D ₃	7.00	7.20	7.50	7.23
D ₄	6.75	6.45	6.80	6.67
D ₅	5.65	6.00	6.50	6.05
D ₆	5.30	6.70	6.90	6.30
D ₇	4.30	5.40	5.60	5.10
L ₄				
D ₁	8.30	8.30	8.30	8.30
D ₂	8.00	7.80	8.30	8.03
D ₃	7.10	7.10	7.70	7.30
D ₄	6.10	6.30	6.90	6.43
D ₅	5.55	6.00	6.60	6.05
D ₆	4.55	5.55	5.70	5.27
D ₇	3.55	4.50	5.40	4.48
L ₅				
D ₁	8.20	8.20	8.20	8.20
D ₂	7.80	8.00	8.90	8.23
D ₃	6.90	7.20	7.60	7.23
D ₄	6.40	6.90	7.40	6.90
D ₅	5.90	6.10	6.30	6.10
D ₆	4.80	5.40	5.60	5.27
D ₇	4.50	6.60	6.60	5.90

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L ₆				
D ₁	7.90	7.90	7.90	7.90
D ₂	7.55	7.60	8.00	7.72
D ₃	6.60	6.80	7.20	6.87
D ₄	6.10	6.45	6.20	6.25
D ₅	6.30	6.70	7.00	6.67
D ₆	5.55	5.90	6.10	5.85
D ₇	4.05	6.50	6.50	5.60
L ₇				
D ₁	8.20	8.20	8.20	8.20
D ₂	7.10	7.50	8.20	7.60
D ₃	7.20	7.60	7.00	7.27
D ₄	6.90	7.00	7.15	7.02
D ₅	5.70	6.00	6.60	6.10
D ₆	5.20	5.60	6.00	5.60
D ₇	3.50	6.00	6.20	5.23
T-MEAN	6.37	6.82	7.10	6.76

	L	T	D	LxD	LxT	LxD	LxTxD
SEd	0.38	0.38	0.38	0.22	-	0.14	-
CD (5%)	0.75	0.75	0.75	0.43	NS	0.23	NS
CD (1%)	1.00**	1.00**	1.00**	0.57**	NS	0.37**	NS

Correlation matrix

	Root length	Temp	Duration	Location
Root length	1.000	-0.261**	-0.842**	-0.049NS
Temperature	-0.261	1.000	0.000NS	0.000NS
Duration	-0.842	0.000	1.000	0.000NS
Location	-0.049	0.000	0.000	1.000

$$R^2 = 0.78^{**}$$

$$\text{Regression equation: } Y = 5.520001 - 0.024(\text{Temp}) - 0.482(\text{Duration}) - 0.028(\text{Location})$$

There was negative association for the root length with temperature and duration and was highly significant with r^2 value of 0.78.

4.11.3.3. Shoot length [cm] [Table 36]

The effect of temperature and duration with different location seeds gave highly significant results for shoot length and their interaction was also significant.

In different locations the reduction in shoot length was evident from the results at all the temperatures, over the duration of storage. There was no significant variation between the temperature levels over the duration of storage for shoot length in L1, L3, however, it was significant between T1 and T3 at D6 in L2 and L4, D4 and D6 in L5, D3 to D7 in L6 and D4 and D7 in L7. The mean shoot length, irrespective of temperatures, over the durations varied between 8.10 and 4.13, 7.80 and 3.80, 7.70 and 4.10; 7.00 and 3.97, 7.50 and 3.73, 8.00 and 4.17 and 8.10 and 4.00 cm in L1, L2, L3, L4, L5, L6 and L7 respectively.

Location and duration interaction indicated that the mean shoot length irrespective of durations varied between 6.28 (D1) and 5.75 cm (D6). In L1 the mean shoot length reduction over the period of storage was 3.97 cm and it was 4.00, 3.6, 3.03, 3.77, 3.83 and 4.1 cm in L2, L3, L4, L5, L6 and L7 respectively. The mean shoot length irrespective of location was varying between 7.74 (D1) cm and 3.79 cm (D7).

The temperature and duration interaction revealed that there was significant variation in shoot length at different temperature levels and T3 was the highest at all levels of durations. The mean root length varied between 5.64 (T1) and 6.25 cm (T3) irrespective of the included durations.

Location and temperature interaction indicated that the mean shoot length between different locations ranged between 6.28 cm and 5.75 cm in L1 and L6 respectively. At T1 and T2 the maximum root length was in L1; while the minimum was in L6. At T3 the maximum and minimum ranged between L1 and L7.

Table 36 Influence of location on shoot length (cm) at different temperatures during storage of Ailanthus excelsa seeds.

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	8.10	8.10	8.10	8.10
D ₂	7.65	7.70	7.90	7.75
D ₃	7.45	7.60	7.90	7.65
D ₄	6.00	6.20	6.45	6.22
D ₅	4.80	5.50	5.60	5.30
D ₆	4.70	5.00	4.70	4.80
D ₇	4.00	4.10	4.30	4.13
L₂				
D ₁	7.80	7.80	7.80	7.80
D ₂	7.85	7.50	7.60	7.65
D ₃	7.40	7.60	7.30	7.43
D ₄	6.25	6.60	6.10	6.32
D ₅	4.60	5.70	5.80	5.37
D ₆	4.30	4.60	5.40	4.77
D ₇	3.70	3.80	3.90	3.80
L₃				
D ₁	7.70	7.70	7.70	7.70
D ₂	7.20	7.40	7.55	7.38
D ₃	6.90	7.20	7.50	7.20
D ₄	5.60	6.00	6.30	5.97
D ₅	5.10	5.40	5.60	5.37
D ₆	4.60	5.20	5.40	5.07
D ₇	4.00	4.10	4.20	4.10
L₄				
D ₁	7.00	7.00	7.00	7.00
D ₂	7.55	7.65	7.80	7.67
D ₃	6.60	7.00	7.30	6.97
D ₄	6.10	6.20	6.40	6.23
D ₅	5.00	5.10	5.30	5.13
D ₆	4.10	5.40	5.60	5.03
D ₇	3.55	4.05	4.30	3.97
L₅				
D ₁	7.50	7.50	7.50	7.50
D ₂	7.10	7.30	7.50	7.30
D ₃	6.50	6.70	7.05	6.75
D ₄	5.05	5.20	6.30	5.52
D ₅	4.30	5.00	5.30	4.87
D ₆	3.90	5.70	5.10	4.90
D ₇	3.40	3.70	4.10	3.73

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	8.00	8.00	8.00	8.00
D ₂	7.10	7.30	7.50	7.30
D ₃	5.55	6.30	7.00	6.28
D ₄	5.10	5.40	6.20	15.57
D ₅	3.55	4.25	5.20	4.33
D ₆	3.30	5.35	5.20	4.62
D ₇	3.30	4.40	4.80	4.17
L₇				
D ₁	8.10	8.10	8.10	8.10
D ₂	7.40	7.60	7.75	7.58
D ₃	6.20	6.80	7.10	6.70
D ₄	5.10	5.30	6.30	5.57
D ₅	3.85	4.30	4.70	4.28
D ₆	3.50	5.10	4.30	4.30
D ₇	3.20	4.45	4.35	4.00
T-MEAN	5.64	6.06	6.25	5.98

	L	T	D	LxD	LxT	TxD	LxTxD
SED	0.37	0.37	0.37	0.19	0.13	0.13	-
CD (5%)	0.66	0.66	0.66	0.38	0.25	0.25	NS
CD (1%)	0.88**	0.88**	0.88**	0.51**	0.33**	0.33**	NS

Correlation matrix

	Shoot length	Temperature	Duration	Location
Shoot length	1.000	-0.172**	-0.915**	-0.127*
Temperature	-0.172	1.000	0.000 NS	0.000 NS
Duration	-0.915	0.000	1.000	0.000 NS
Location	-0.127	0.000	0.000	1.000

$$R^2 = 0.88^{**}$$

Regression equation: $Y = 8.537 - 0.02 (\text{Temperature})$
 $- 0.671 (\text{Duration}) - 0.093 (\text{Location})$

There was negative correlation between shoot length and temperature, duration of storage where the r^2 value was 0.88.

4.11.3.4. Dry matter production [g] [Table 37]

Highly significant results for the dry matter production were obtained with the different temperature and duration levels for the seeds gathered from different location except the location and temperature were each and three way interactions.

The highest value for dry matter production was obtained in L1 and the lowest was in L7. Irrespective of the locations, due to the decline in temperature, there was significant increase in dry matter production. The per cent reduction in mean dry matter production was 62.9, 59.0, 59.0, 57.2, 58.0, 54.1 and 53.4% in L1, L2, L3, L4, L5, L6 and L7 respectively over the periods of storage, irrespective of the temperatures. The dry matter production was ranging between 0.213 and 0.079, 0.188 and 0.077, 0.183 and 0.075, 0.173 and 0.074, 0.186 and 0.078, 0.172 and 0.079 and 0.161 and 0.075 g in L1, L2, L3, L4, L5, L6 and L7 respectively.

The interaction between location and duration revealed that the reduction in mean dry matter production was maintained in a steady trend throughout the storage period for all the locations and among the locations. L1 was the highest with 0.143 g as mean dry matter production and the lowest was in L7 with 0.129 g. Untill D4, L1 was maximum and there after the reduction was faster, and at D5 perhaps the L1 was the lowest with mean dry matter production.

The temperature and duration interaction gave significant variation among the temperature levels involved over the period of storage. The dry matter production at T1 was the lowest in all the durations; however, T2 and T3 was on par with each other. The mean dry matter production among different temperature levels ranged between 0.129 and 0.138 g with T1 and T3 respectively.

Table 37 Influence of location on dry matter production (g)
at different temperatures during storage of
Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	0.213	0.213	0.213	0.213
D ₂	0.184	0.176	0.182	0.180
D ₃	0.170	0.173	0.183	0.175
D ₄	0.132	0.152	0.157	0.147
D ₅	0.107	0.112	0.115	0.111
D ₆	0.090	0.093	0.093	0.092
D ₇	0.074	0.080	0.083	0.079
L₂				
D ₁	0.188	0.188	0.188	0.188
D ₂	0.167	0.172	0.174	0.171
D ₃	0.163	0.163	0.169	0.165
D ₄	0.132	0.137	0.144	0.138
D ₅	0.113	0.115	0.121	0.116
D ₆	0.094	0.098	0.102	0.098
D ₇	0.074	0.077	0.081	0.077
L₃				
D ₁	0.183	0.183	0.183	0.183
D ₂	0.175	0.175	0.177	0.176
D ₃	0.158	0.167	0.161	0.162
D ₄	0.130	0.139	0.142	0.137
D ₅	0.110	0.115	0.119	0.115
D ₆	0.087	0.095	0.100	0.094
D ₇	0.070	0.074	0.081	0.075
L₄				
D ₁	0.173	0.173	0.173	0.173
D ₂	0.161	0.168	0.173	0.167
D ₃	0.145	0.166	0.165	0.159
D ₄	0.128	0.136	0.137	0.134
D ₅	0.108	0.123	0.124	0.119
D ₆	0.094	0.093	0.103	0.097
D ₇	0.072	0.073	0.077	0.074
L₅				
D ₁	0.186	0.186	0.186	0.186
D ₂	0.174	0.176	0.177	0.176
D ₃	0.133	0.163	0.164	0.153
D ₄	0.123	0.143	0.147	0.138
D ₅	0.108	0.118	0.122	0.116
D ₆	0.084	0.091	0.100	0.092
D ₇	0.072	0.079	0.081	0.078

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	0.172	0.172	0.172	0.172
D ₂	0.168	0.174	0.175	0.172
D ₃	0.139	0.154	0.167	0.153
D ₄	0.120	0.141	0.142	0.135
D ₅	0.108	0.124	0.126	0.120
D ₆	0.085	0.092	0.096	0.091
D ₇	0.077	0.079	0.081	0.079
L₇				
D ₁	0.161	0.161	0.161	0.161
D ₂	0.168	0.174	0.176	0.173
D ₃	0.147	0.149	0.150	0.149
D ₄	0.123	0.140	0.143	0.135
D ₅	0.107	0.119	0.123	0.116
D ₆	0.090	0.093	0.098	0.094
D ₇	0.073	0.075	0.077	0.075
T-MEAN	0.129	0.135	0.138	0.134

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.006	0.006	0.006	0.002	-	0.004	-
CD (5%)	0.013	0.013	0.013	0.005	NS	0.008	NS
CD (1%)	0.017**	0.017**	0.017**	0.007**	NS	0.010**	NS

Correlation matrix

	DMP	Temperature	Duration	Location
DMP	1.000	-0.03 NS	-0.959**	-0.094 NS
Temperature	-0.103	1.000	0.00 NS	0.000 NS
Duration	-0.959	0.000	1.000	0.000 NS
Location	-0.094	0.000	0.000	1.000

$$R^2 = 0.94^{**}$$

Regression equation : $Y = 0.003 \text{ (Temperature)} - 0.019 \text{ (Duration)}$
 $- 0.002 \text{ (Location)}$

There was significant negative correlation for the dry matter with the duration of storage and the r^2 value was 0.94.

4.11.3.5. Vigour Index [Table 38]

The effect of temperature and duration of storage on various location seeds was highly significant and the interaction of location with temperature and the three way interaction was not significant.

The VI was maximum in L1 at D1 and the lowest was in L6. However, over the period of storage the maximum and minimum was not having the definite trend and finally at D7 the VI just 1, irrespective of the temperature or location. However, there was significant difference between the temperature levels of T1 and T3 at many locations.

From the interaction of location with duration it was evident that the maximum mean VI was in L1 (7) and lowest was in L6 and L7 together (5). The mean VI over the durations ranged between 12 and 1 at D1 and D7 respectively.

The temperature and duration interaction indicated that with decrease in temperature the VI was increased and ranged between 5 and 7 with T1 and T3.

There was negative correlation between VI and duration of storage and however the negative association of temperature was not significant.

4.11.3.6. Oil content % [Table 39; Fig. 34]

There was highly significant variation among the treatments of temperature, duration on different location seeds for oil content. The interaction of location with duration and temperature with duration was highly significant and the rest was not significant.

At D1, the maximum oil content was recorded in L1 and L4. Over the period of storage irrespective of the temperature levels the oil content declined but at T3 decrease

Table 38 Influence of location on vigour index at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L ₁				
D ₁	15	15	15	15
D ₂	11	11	12	12
D ₃	9	10	10	10
D ₄	4	7	7	6
D ₅	3	4	3	3
D ₆	2	2	2	2
D ₇	1	1	1	1
L ₂				
D ₁	13	13	13	13
D ₂	10	11	12	11
D ₃	9	9	10	10
D ₄	4	5	5	5
D ₅	3	3	3	3
D ₆	1	2	2	2
D ₇	1	1	1	1
L ₃				
D ₁	11	11	11	11
D ₂	10	10	10	10
D ₃	8	9	10	9
D ₄	4	5	5	5
D ₅	3	3	3	3
D ₆	1	2	3	2
D ₇	1	1	1	1
L ₄				
D ₁	12	12	12	12
D ₂	10	10	11	10
D ₃	8	10	10	9
D ₄	4	5	5	5
D ₅	3	4	4	3
D ₆	1	2	3	2
D ₇	1	1	1	1
L ₅				
D ₁	12	12	12	12
D ₂	10	12	11	11
D ₃	7	9	10	9
D ₄	4	5	6	5
D ₅	3	4	3	3
D ₆	2	2	3	2
D ₇	1	1	1	1

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	10	10	10	10
D ₂	9	11	11	10
D ₃	6	8	9	8
D ₄	3	4	4	4
D ₅	2	3	3	3
D ₆	1	2	2	2
D ₇	1	1	2	1
L₇				
D ₁	11	11	11	11
D ₂	9	10	11	10
D ₃	7	8	8	7
D ₄	3	4	5	4
D ₅	3	3	2	3
D ₆	1	2	2	2
D ₇	1	1	1	1

T-MEAN	5.47	6.23	6.40	6.03

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.52	0.52	0.52	0.30	-	0.20	-
CD (5%)	1.02	1.02	1.02	0.59	NS	0.39	NS
CD (1%)	1.35**	1.35**	1.35**	0.78**	NS	0.51**	NS

Correlation matrix

	VI	Tempeature	Duration	Location
VI	1.000	-0.094NS	-0.954**	-0.102 NS
Tempeature	-0.94	1.000	0.000 NS	0.000 NS
Duration	-0.954	0.000	1.000	0.000 NS
Location	-0.102	0.000	0.000	1.000

$$R^2 = 0.93^{**}$$

Regression equation : $Y = 13.194 - 0.032 (\text{Temperature})$
 $- 2.011(\text{Duration}) - 0.216 (\text{Location})$

Fig.33. Influence of location on germination %
at different temperatures, during storage of
Ailanthus excelsa seeds

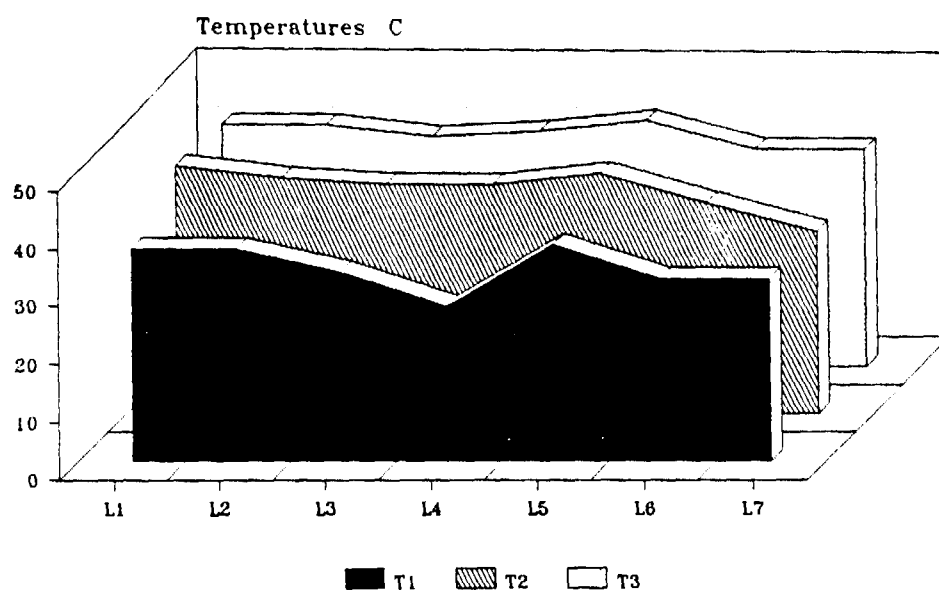


Fig.34. Influence of temperature on oil (%)
during storage of *Ailanthus excelsa* seeds
irrespective of locations

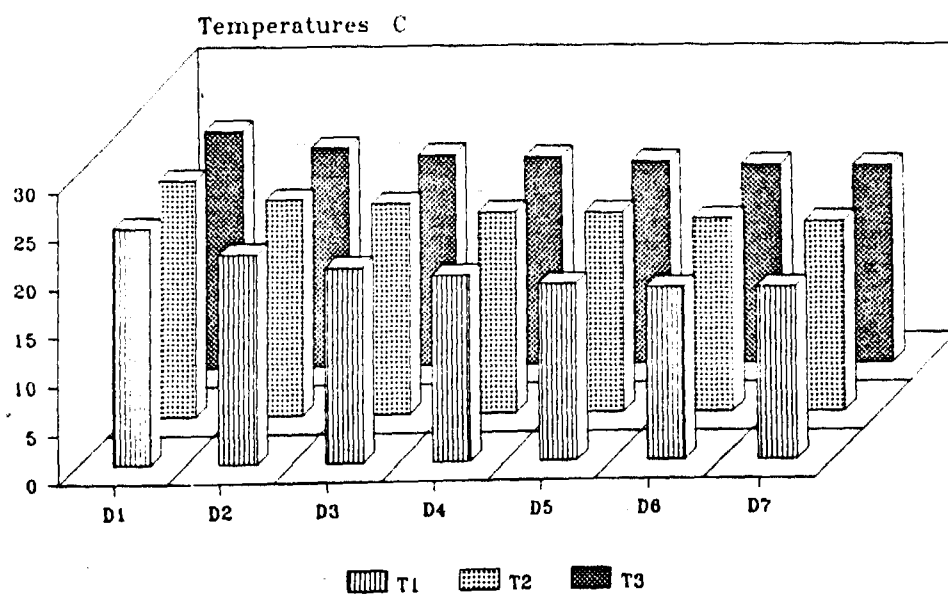


Table 39 Influence of location on oil content (%) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	25.4	25.4	25.4	25.4
D ₂	19.4	21.3	23.3	21.3
D ₃	18.3	20.8	20.8	20.0
D ₄	17.6	18.7	19.5	18.6
D ₅	17.1	18.3	18.6	18.0
D ₆	16.7	18.2	18.3	17.7
D ₇	16.2	17.6	17.3	17.0
L₂				
D ₁	23.7	23.7	23.7	23.7
D ₂	21.6	22.3	22.6	22.2
D ₃	19.6	21.6	21.5	20.9
D ₄	18.3	20.9	21.5	20.2
D ₅	18.3	20.3	20.9	19.8
D ₆	17.6	19.9	20.5	19.3
D ₇	17.6	18.5	20.0	18.7
L₃				
D ₁	24.2	24.2	24.2	24.2
D ₂	23.1	23.9	23.3	23.4
D ₃	20.3	22.3	22.6	21.7
D ₄	19.9	21.6	23.0	21.5
D ₅	18.9	21.2	21.9	20.7
D ₆	18.1	20.0	21.1	19.7
D ₇	17.7	19.8	22.0	19.8
L₄				
D ₁	25.4	25.4	25.4	25.4
D ₂	21.3	21.5	21.9	21.6
D ₃	20.8	21.5	20.3	20.9
D ₄	19.2	20.5	20.9	20.2
D ₅	17.9	20.4	20.8	19.7
D ₆	17.0	19.9	19.5	18.8
D ₇	17.2	19.9	20.1	19.1
L₅				
D ₁	23.4	23.4	23.4	23.4
D ₂	21.5	21.9	20.9	21.4
D ₃	19.1	20.7	21.7	20.5
D ₄	18.6	20.4	21.4	20.1
D ₅	17.1	19.9	20.4	19.1
D ₆	17.0	18.9	19.7	18.5
D ₇	17.3	18.4	19.4	18.4

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	23.5	23.5	23.5	23.5
D ₂	23.6	23.6	23.3	23.5
D ₃	22.2	23.1	23.0	22.8
D ₄	21.4	22.3	22.7	22.1
D ₅	19.9	23.2	22.1	21.7
D ₆	19.4	21.6	22.2	21.1
D ₇	18.9	20.9	21.6	20.5
L₇				
D ₁	25.3	25.3	25.3	25.3
D ₂	21.5	21.6	22.9	22.0
D ₃	21.4	22.4	22.6	22.1
D ₄	20.4	21.5	21.5	21.1
D ₅	18.9	21.5	22.6	21.0
D ₆	19.4	21.7	23.0	21.4
D ₇	20.7	22.7	23.2	22.2
T-MEAN	20.0	21.4	21.8	21.0

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.838	0.838	0.838	0.5	-	0.3	-
CD (5%)	1.656	1.656	1.656	1.0	NS	0.6	NS
CD (1%)	2.187**	2.187**	2.187**	1.3**	NS	0.8**	NS

Correlation matrix

	Oil %	Temperature	Duration	Location
Oil%	1.000	-0.335**	-0.677**	0.276**
Temperature	-0.335	1.000	0.000 NS	0.000 NS
Duration	-0.677	0.000	1.000	0.000 NS
Location	0.276	0.000	0.000	1.000

$$R^2 = 0.65^{**}$$

Regression equation: $Y = 22.628 - 0.062 (\text{Temp}) - 0.777 (\text{Duration}) + 0.317 (\text{Location})$

in oil content was at a slower rate in all the locations. The mean oil per cent over the period of storage ranged between 25.4 and 17.0, 23.7 and 18.7, 24.2 and 19.8, 25.4 and 19.1, 23.4 and 18.4, 23.5 and 20.5 and 25.3 and 22.2% in L1, L2, L3, L4, L5, L6 and L7 respectively. However the highest per cent of decline was only in L1 and it amounted to 8.4 per cent.

From the location and duration interaction it was found that in L1 the decrease in oil % took upper hand right from the D2, where from lowest % of oil was recorded only in L1. However, the declining trend in oil % was not uniform through out the storage period and it varied widely between different locations. The mean oil content was 22.2% in L6 and L7 each and it was 19.7 % in L1. Over the period of storage, the mean oil content dropped to as low as 19.4 % at D7 from 24.4 % (D1).

Highly significant results was obtained between the different levels of temperature throughout the period of storage and was evident from the temperature and duration interaction. The mean oil content ranged between 20.0 and 21.8 % in T1 and T3 respectively.

There was highly significant negative correlation which existed for oil content with temperature and duration levels with r^2 value of 0.65.

4.11.3.7. Free Fatty Acid % [Table 40; Fig. 35]

Highly significant variation existed for the results obtained with different temperature, duration studied on different location seeds for free fatty acid levels and their interactions. However, the three way interaction was not significant.

There was the highest level of FFA % in L5 at D1. Over the storage at T1 there was phenomenal increase in FFA % levels in all the locations and it was low at T3. The mean FFA %, irrespective of the temperatures ranged between 6.3 and 8.9, 6.1 and 10.0, 6.9 and 10.7, 7.3 and 9.7, 7.7 and 10.3, 7.3 and 10.2, and 7.2 and 10.8 % in L1, L2, L3, L4, L5, L6 and L7 respectively.

Table 40 Influence of location on free fatty acid (%) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L ₁				
D ₁	6.3	6.3	6.3	6.3
D ₂	7.8	7.7	6.5	7.3
D ₃	8.1	6.8	7.0	7.3
D ₄	8.7	7.1	7.1	7.6
D ₅	9.1	7.3	7.0	7.8
D ₆	9.7	7.9	7.5	8.4
D ₇	10.4	8.3	7.9	8.9
L ₂				
D ₁	6.1	6.1	6.1	6.1
D ₂	7.4	7.3	6.9	7.2
D ₃	8.7	7.7	7.3	7.9
D ₄	9.0	8.0	8.0	8.3
D ₅	9.7	8.3	8.1	8.7
D ₆	10.4	8.7	8.3	9.1
D ₇	11.4	9.5	9.0	10.0
L ₃				
D ₁	6.9	6.9	6.9	6.9
D ₂	8.2	7.4	7.1	7.6
D ₃	8.9	8.1	7.7	8.2
D ₄	9.7	8.3	7.7	8.6
D ₅	10.4	9.1	8.3	9.3
D ₆	10.9	10.0	9.0	10.0
D ₇	12.4	10.2	9.5	10.7
L ₄				
D ₁	7.3	7.3	7.3	7.3
D ₂	7.4	7.2	7.3	7.3
D ₃	8.0	7.5	7.3	7.6
D ₄	8.3	8.1	7.5	8.0
D ₅	9.1	8.7	8.1	8.6
D ₆	10.6	9.3	8.4	9.2
D ₇	11.0	9.6	8.4	9.7
L ₅				
D ₁	7.7	7.7	7.7	7.7
D ₂	8.0	7.5	7.3	7.6
D ₃	8.5	7.7	7.3	7.8
D ₄	8.9	8.1	7.9	8.3
D ₅	9.4	8.5	8.2	8.7
D ₆	10.7	9.3	8.3	9.4
D ₇	11.1	10.1	9.7	10.3

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	7.3	7.3	7.3	7.3
D ₂	7.7	7.0	6.9	7.2
D ₃	8.1	7.5	7.2	7.6
D ₄	9.4	8.5	7.9	8.6
D ₅	10.2	9.1	8.4	9.2
D ₆	10.9	9.9	9.3	10.0
D ₇	11.7	9.9	9.1	10.2
L₇				
D ₁	7.2	7.2	7.2	7.2
D ₂	7.7	7.5	7.2	7.5
D ₃	8.2	7.7	7.5	7.8
D ₄	9.4	8.3	7.7	8.5
D ₅	10.4	9.3	8.7	9.5
D ₆	11.3	10.3	9.0	10.2
D ₇	12.2	10.4	9.7	10.8
T-MEAN	9.1	8.2	7.8	8.4

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.272	0.272	0.272	0.2	0.1	0.1	-
CD (5%)	0.538	0.538	0.538	0.3	0.2	0.2	NS
CD (1%)	0.710**	0.710**	0.710**	0.4**	0.3**	0.3**	NS

Correlation matrix

	X 1	X 2	X 3	X 4
X 1	1.000	0.411**	0.781**	0.212**
X 2	0.411	1.000	0.000 NS	0.000 NS
X 3	0.781	0.000	1.000	0.000 NS
X 4	0.212	0.000	0.000	1.000

$$R^2 = 0.82^{**}$$

$$\text{Regression equation } Y = 5.901 + 0.044(x_2) + 0.52(x_3) + 0.141(x_4)$$

The interaction of location with duration of storage indicated that there was minimum FFA content where increased in L4 (2.4%) and the maximum was in L2 (3.9%). The mean FFA content over the period of storage increased to 10.1 % (D7) from 7.0 % (D1).

The temperature and duration interaction clearly indicated that decrease in temperature definitely arrested the FFA % over the period of storage. The mean FFA % of the different temperature ranged between 9.1% (T1) and 7.8 % (T3) irrespective of the durations.

From the location and temperature interaction it was found that there was clear variation in the storability of seeds between different location and it was evident from the result that the FFA % irrespective of the temperature ranged between 7.7 (L1) and 8.8 (L7).

There was highly significant positive correlation for the FFA content with temperature and durations of storage with r^2 value of 0.82.

4.11.3.8. Protein content % [Table 41; Fig. 36]

The effect of temperature and duration of storage in different location seeds gave highly significant results. The interaction of location with duration and temperature with duration was highly significant.

Initial protein content was high in L3 with 40.9 % at D1. There was declining trend in protein content over the period of storage, irrespective of the temperature levels studied. The mean protein decline was 9.3, 7.4, 10.3, 8.7, 8.4, 5.1 and 8.0 % in L1, L2, L3, L4, L5, L6 and L7 respectively.

From the location and duration interaction it was evident that there was no uniform reduction over the different D levels and it varied between the different locations. The mean protein content over the storage was 34.6 % in L1 and it was 32.5,

Table 41 Influence of location on protein content (%) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	39.2 (38.76)	39.2 (38.76)	39.2 (38.76)	39.2 (38.76)
D ₂	37.4 (37.70)	37.3 (37.64)	38.3 (38.23)	37.7 (37.86)
D ₃	34.1 (35.73)	35.0 (36.27)	35.7 (36.69)	34.9 (36.23)
D ₄	34.0 (35.67)	34.7 (36.09)	36.2 (36.99)	35.0 (36.25)
D ₅	32.7 (34.88)	33.8 (35.55)	34.8 (36.18)	33.8 (35.54)
D ₆	31.0 (33.83)	31.5 (34.14)	31.9 (34.39)	31.5 (34.12)
D ₇	29.3 (32.77)	30.1 (33.27)	30.3 (33.40)	29.9 (33.15)
L₂				
D ₁	36.1 (36.93)	36.0 (36.87)	36.1 (36.93)	36.1 (36.91)
D ₂	35.4 (36.51)	35.8 (36.72)	37.4 (37.70)	36.2 (36.98)
D ₃	33.2 (35.17)	34.5 (35.96)	36.3 (37.05)	34.7 (36.06)
D ₄	31.2 (33.93)	32.7 (34.86)	33.5 (35.35)	32.5 (34.71)
D ₅	28.6 (32.33)	30.0 (33.21)	31.0 (33.83)	29.9 (33.12)
D ₆	27.6 (31.69)	28.8 (32.45)	31.6 (34.20)	29.3 (32.78)
D ₇	26.4 (30.92)	29.7 (33.02)	30.0 (33.21)	28.7 (32.38)
L₃				
D ₁	40.9 (39.76)	40.9 (39.76)	40.9 (39.76)	40.9 (39.76)
D ₂	37.5 (37.76)	37.3 (37.64)	37.3 (37.64)	37.4 (37.68)
D ₃	36.0 (36.87)	36.0 (36.87)	36.6 (37.23)	36.2 (36.99)
D ₄	33.8 (35.57)	35.1 (36.33)	35.9 (36.81)	35.0 (36.24)
D ₅	30.1 (33.27)	35.2 (36.36)	35.9 (36.81)	33.7 (35.48)
D ₆	28.3 (32.14)	35.7 (36.69)	36.3 (37.05)	33.4 (35.29)
D ₇	28.2 (32.07)	31.3 (34.02)	32.4 (34.70)	30.6 (33.59)
L₄				
D ₁	39.1 (38.70)	39.1 (38.70)	39.1 (38.70)	39.1 (38.70)
D ₂	36.5 (37.16)	37.4 (37.70)	38.1 (38.12)	37.3 (37.66)
D ₃	36.4 (37.11)	34.4 (35.90)	37.2 (37.58)	36.0 (36.86)
D ₄	33.7 (35.49)	34.9 (36.21)	35.8 (36.75)	34.8 (36.15)
D ₅	31.5 (34.14)	33.9 (35.61)	34.8 (36.15)	33.4 (35.30)
D ₆	29.4 (32.83)	33.1 (35.12)	34.5 (35.97)	32.3 (34.64)
D ₇	28.6 (32.32)	31.5 (34.14)	31.1 (33.89)	30.4 (33.45)
L₅				
D ₁	35.9 (36.81)	35.9 (36.81)	35.9 (36.81)	35.9 (36.81)
D ₂	34.2 (35.79)	35.1 (36.33)	35.9 (36.81)	35.1 (36.31)
D ₃	31.9 (34.38)	33.9 (35.61)	35.7 (36.69)	33.8 (35.56)
D ₄	30.4 (33.45)	32.0 (34.45)	33.9 (35.61)	32.1 (34.50)
D ₅	27.3 (31.50)	30.5 (33.52)	32.8 (34.94)	30.2 (33.32)
D ₆	26.3 (30.85)	28.5 (32.27)	29.9 (33.15)	28.2 (32.09)
D ₇	26.0 (30.62)	27.3 (31.50)	29.2 (32.71)	27.5 (31.61)

Contd..

Contd..

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	33.4 (35.30)	33.4 (35.30)	33.4 (35.30)	33.4 (35.30)
D ₂	33.3 (35.24)	34.9 (36.21)	36.4 (37.11)	34.9 (36.19)
D ₃	31.8 (34.33)	32.8 (34.94)	35.5 (36.57)	33.4 (35.28)
D ₄	29.4 (32.83)	31.4 (34.07)	32.7 (34.87)	31.2 (33.92)
D ₅	28.8 (32.46)	30.3 (33.40)	31.6 (34.20)	30.2 (33.35)
D ₆	28.0 (31.95)	29.2 (32.71)	29.9 (33.15)	29.0 (32.60)
D ₇	27.0 (31.31)	28.2 (32.08)	29.5 (32.93)	28.3 (32.10)
L₇				
D ₁	36.0 (36.87)	36.0 (36.87)	36.0 (36.87)	36.0 (36.87)
D ₂	35.1 (36.33)	36.0 (36.87)	36.9 (37.41)	36.0 (36.87)
D ₃	33.8 (35.55)	34.7 (36.09)	35.8 (36.75)	34.8 (36.13)
D ₄	30.4 (33.43)	31.4 (34.08)	34.0 (35.67)	31.9 (34.39)
D ₅	28.9 (32.52)	30.7 (33.65)	32.1 (34.51)	30.6 (33.56)
D ₆	27.5 (31.66)	29.1 (32.64)	30.9 (33.77)	29.2 (32.69)
D ₇	26.6 (31.0)	28.1 (32.01)	29.3 (32.77)	28.0 (31.94)
T-MEAN	32.0 (34.41)	33.4 (35.25)	34.4 (35.89)	33.3 (35.18)

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.8	0.8	0.8	0.45	-	0.29	-
CD (5%)	1.5	1.5	1.5	0.89	NS	0.58	NS
CD (1%)	2.0**	2.0**	2.0**	1.17**	NS	0.77**	NS

Correlation matrix

	X 1	X 2	X 3	X 4
X 1	1.000	-0.271**	-0.785**	-0.241**
X 2	-0.271	1.000	0.000NS	0.000NS
X 3	-0.785	0.000	1.000	0.000NS
X 4	-0.241	0.000	0.000	1.000

$$R^2 = 0.75^{**}$$

Regression equation : $Y = 39.865 - 0.078(X 2) - 1.411(X 3) - 0.432(X 4)$

Fig.35. Influence of location on Free Fatty Acid (%) at different temperatures during storage of *Ailanthus excelsa* seeds

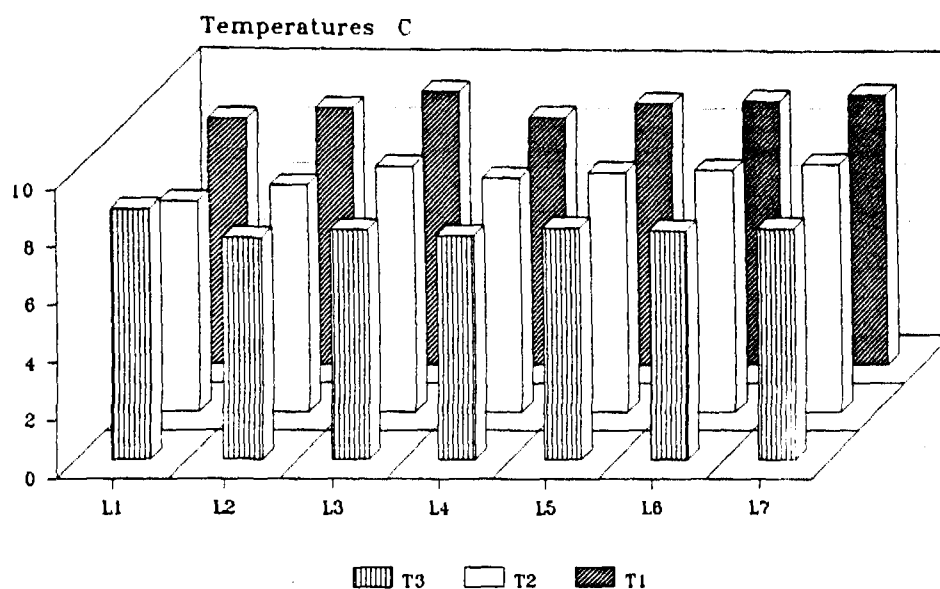
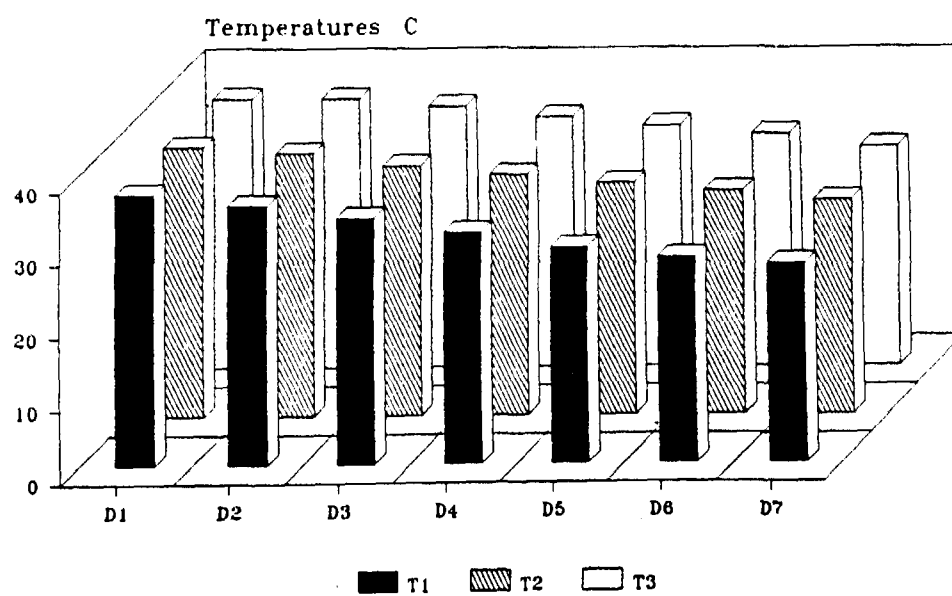


Fig.36. Influence of temperature on Protein (%) during storage of *Ailanthus excelsa* seeds irrespective of locations



35.3, 34.8, 31.8, 31.5 and 32.3 per cent in L2, L3, L4, L5, L6 and L7 respectively. It was ranging between 31.5 (L6) and 35.3 % (L3).

The temperature and duration interaction indicated that the reduction in oil content was slow in T3, in all the durations, irrespective of the locations. There was steady drop in mean protein percentage right from D1 and reached the lower level of 29.1% at D7. Among the different temperatures tried, the mean protein % varied between 32.0 and 34.4 in T1 and T3 respectively.

There was highly significant negative correlation existed between the protein content and duration and temperature with r^2 value of 0.75.

4.11.3.9. Carbohydrate content [%] [Table 42 ; Fig.37]

The carbohydrate content was significantly varied due to the locations, temperature and the duration of storage. The significant result was obtained for their interaction effect except location and temperature interaction.

Irrespective of the storage temperature and duration, the mean value ranged between 21.4% (L2) and 16.82% (L4). The maximum and minimum

4.12. QUALITY VARIATION IN OFF-SEASON COLLECTED SEEDS OF NEEM :

[*Azadirachta indica*] [Table 43; Fig. 38]

The results for the off-season collected seeds was significant only for the oil content and free fatty acid content and not other parameters.

4.12.1. Oil content %

The oil content for the off-season collected seeds was 25.9% and it was 4.8% lesser than the normal season collected seeds. It amounted for approximately 16% reduction in the oil content.

Table 42 Influence of location carbohydrate content (%) at different temperatures during storage of Ailanthus excelsa seeds

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₁				
D ₁	24.05	24.55	24.55	24.38
D ₂	22.80	23.00	22.70	22.83
D ₃	20.80	21.40	21.30	21.17
D ₄	20.20	20.90	21.65	20.92
D ₅	20.90	20.80	21.20	20.70
D ₆	19.00	19.90	20.60	19.83
D ₇	17.30	19.20	19.90	18.80
L₂				
D ₁	24.40	24.40	24.40	24.40
D ₂	23.70	23.90	24.50	24.03
D ₃	22.55	23.40	23.80	23.25
D ₄	21.35	22.20	22.70	22.08
D ₅	18.90	19.90	20.70	19.83
D ₆	18.10	18.10	19.30	18.50
D ₇	16.80	17.80	18.80	17.80
L₃				
D ₁	23.70	23.70	23.70	23.70
D ₂	22.40	22.90	23.60	22.97
D ₃	20.80	21.00	21.50	21.10
D ₄	19.40	20.50	20.90	20.27
D ₅	19.10	19.70	20.35	19.72
D ₆	18.30	19.30	19.80	19.13
D ₇	17.60	17.70	18.50	17.93
L₄				
D ₁	18.90	18.90	18.90	18.90
D ₂	18.40	18.80	20.00	19.07
D ₃	16.00	16.80	17.20	16.67
D ₄	15.70	16.90	17.90	16.83
D ₅	15.50	16.80	17.30	16.53
D ₆	14.50	15.00	15.30	14.93
D ₇	13.80	14.90	15.80	14.83
L₅				
D ₁	20.00	20.00	20.00	20.00
D ₂	18.70	18.70	19.20	18.87
D ₃	17.40	18.00	18.80	18.07
D ₄	15.30	16.10	16.80	16.07
D ₅	14.90	16.00	17.00	15.97
D ₆	14.10	15.40	16.20	15.23
D ₇	13.50	14.30	14.50	14.10

Contd.

Contd...

Duration (D)	T ₁	T ₂	T ₃	D-Mean
L₆				
D ₁	22.00	22.00	22.00	22.00
D ₂	20.20	20.70	21.40	20.77
D ₃	19.50	20.10	20.20	19.93
D ₄	18.00	18.60	19.20	18.60
D ₅	16.65	17.40	18.50	17.52
D ₆	16.25	17.40	18.00	17.22
D ₇	14.55	15.10	17.00	15.55
L₇				
D ₁	23.75	23.75	23.75	23.75
D ₂	22.70	22.80	23.40	22.97
D ₃	21.70	22.40	23.20	22.43
D ₄	20.00	20.60	20.70	20.43
D ₅	17.80	18.90	20.00	18.90
D ₆	16.80	17.80	19.30	17.97
D ₇	15.80	16.90	17.90	16.87
T-MEAN	18.85	19.50	20.08	19.48

	L	T	D	LxD	LxT	TxD	LxTxD
SEd	0.61	0.61	0.61	0.35	-	0.23	-
CD (5%)	1.21	1.21	1.21	0.69	NS	0.456	NS
CD (1%)	1.59**	1.59**	1.59**	0.92**	NS	0.60**	NS

Correlation matrix

	CHO %	Duration	Temperature
CHO %	1.000	-0.697**	-0.174**
Duration	-0.697	1.000	0.000 NS
Temperature	-0.174	0.000	1.000

$$R^2 = 0.52^{**}$$

$$\text{Regression equation : } Y = 22.875 - 0.993 (\text{Duration}) - 0.04 (\text{Temperature})$$

Table 43 Influence of seed collection season on germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Azadirachta indica

Variables	Control	Off-season	Mean	CD 5 %	CD 1 %
Germination (%)	94	92	93	NS	NS
Root length (cm)	11.6	11.6	11.6	NS	NS
Shoot length (cm)	8.8	9.3	9.0	NS	NS
Dry matter					
production (g)	5.5	5.3	5.4	NS	NS
Vigour index	335	515	469	502	NS
Oil (%)	30.8	28.9	28.4	2.1	2.9**
Free fatty acid (%)	5.0	3.9	4.4	0.3	0.4**
Protein (%)	17.0	16.8	16.9	NS	NS
CHO (%)	35.1	34.8	35.0	NS	NS

Fig.37. Influence of temperature on Carbohydrate (%) during storage of *Ailanthus excelsa* seeds irrespective of locations

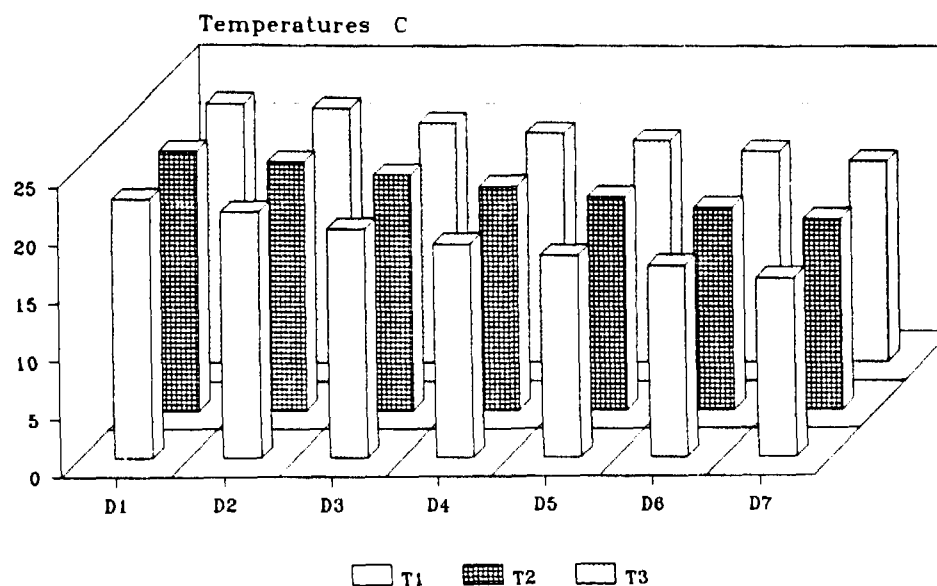
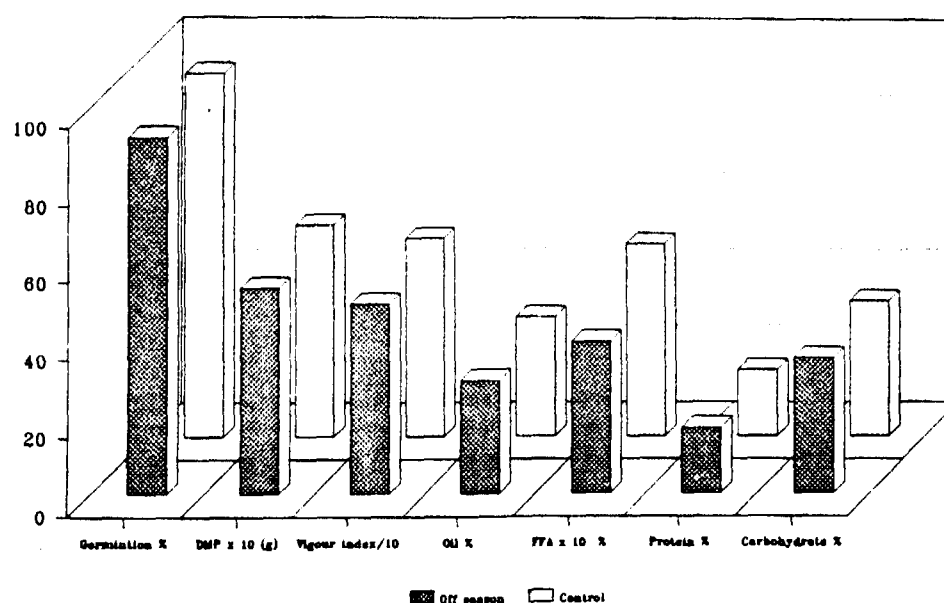


Fig.38. Influence of season of collection on germination DMP, vigour index, oil, FFA, protein and carbohydrate content % in *Azadirachta indica* seeds



4.12.2. Free fatty acid content %

In the off-season collected seeds the free fatty acid content recorded was 3.9 % where as it was 5.0% in the normal season collected ones. There was 1.1% reduction in free fatty acid in the off-season collected seeds.

4.13. AZIMUTH INFLUENCE ON FLOWER AND FRUIT SETTING IN NEEM AND PUNGAM

4.13.1. *Azadirachta indica* [Table 44]

Number of primary branches, secondary branches, tertiary branches, number of inflorescence/sq.m and number of flowers/panicle, number of flowers/sq.m, number of fruits that reached to maturity all were highest on the south orientation followed by the western direction.

However the fruit set percentage was maximum only on the western side than the other directions. The lowest value for all the parameters observed were obtained for the east orientation.

4.13.2. *Derris indica* [Table 45]

The number of primary branches, secondary branches, tertiary branches, number of inflorescence/sq.m, number of flowers/panicle, and percentage of fruit set was maximum only in the south orientation and followed by the west orientation.

The lowest value for all the parameters taken was in east direction.

4.13.3. Azimuth influence on seed Germination, Root length, Shoot length, Dry matter production, Vigour Index, Oil %, Free fatty acid %, Protein % and CHO %, in *Azadirachta indica* [Table 46; Fig.39]

Significant different result was obtained for germination, root length, vigour index, free fatty acid %, protein % and carbohydrate % only.

Table 44. No. of primary, secondary, tertiary branches and inflorescence per sq.m. number of flowers per inflorescence and percentage of fruit set as influenced by the direction on the trees (Azimuth) in Azadirachta indica

Parameters	East	West	North	South
No. of primary branches	1	2	1	2
No. of secondary branches	10	12	12	12
No. of tertiary branches	21	24	22	26
No. of inflorescence branches	225	230	220	230
No. of flowers per panical	65	85	76	88
No. of flower per sq.m	14,625	19,550	16,720	20,240
No. of fruits reached maturity per sq.m	2,250	3,450	2,640	4,140
Fruit setting %	15.4	17.6	15.8	20.5

Table 45. Number of primary, secondary, tertiary branches and inflorescence per sq.m. number of flowers per inflorescence and percentage of fruit set as influenced by the direction on the trees (Azimuth) in Derris indica

Parameters	East	West	North	South	Mean
No. of primary branches	1	1	1	3	1.3
No. of secondary branches	12	14	12	16	13.5
No. of tertiary branches	26	26	25	28	26.5
No. of inflorescence per sq.m	250	260	250	270	257.5
No. of flowers per panical	40	46	35	48	42.3
No. of flower per sq.m	10,000	11,960	8,750	12,960	10,917.5
No. of fruits reached to maturity per sq.m	1500	2080	1500	2160	1810
Fruit setting %	15	17.4	17.14	16.6	16.5

4.13.3.1. Germination [%]

The highest germination was obtained from D4 (South oriented) and the lowest was from D3 (North oriented). The maximum and minimum ranged between 96 and 86% with the variation of 10 per cent.

4.13.3.2. Root length [cm]

The longer root was in D2 (West oriented) and the shorter being at D3 (North).

4.13.3.3. Vigour Index

The vigour index was maximum at D2 and minimum at D3 with 404 and 332 respectively.

4.13.3.4. Free fatty acid [%]

The free fatty acid content was maximum on the North oriented seeds and minimum in D4 (South).

4.13.3.5. Protein content [%]

The maximum and minimum protein ranged between 17.4 and 16.2 % in D2 and D1 respectively.

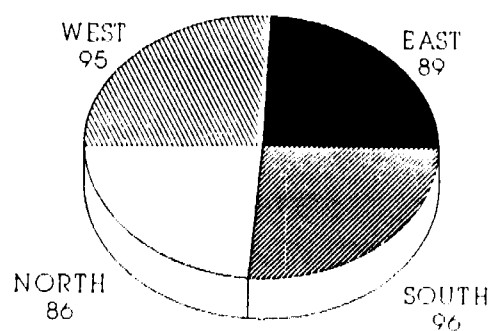
4.13.3.6. Carbohydrates [%]

The highest CHO content was recorded in D2 (36.8%) and the lowest being in D3 (34.1%) with variation of 2.7 per cent.

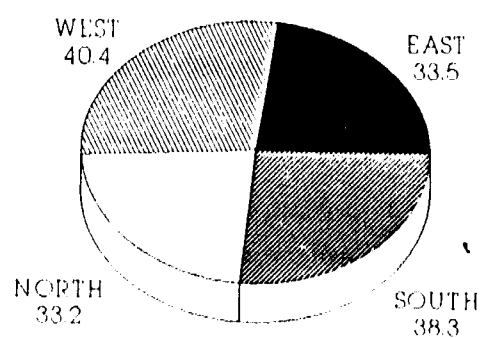
Table 46 Azimuth influence on seed germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%) and carbohydrate (%) in Azadirachta indica

Variables	East	West	North	South	Mean	CD 5 %	CD 1 %
Germination (%)	89	95	86	96	92	4	6**
Root length (cm)	10.0	11.1	10.0	10.7	10.4	0.8*	1.2 NS
Shoot length (cm)	8.1	9.0	8.7	9.4	8.8	NS	NS
Dry matter production (g)	4.0	4.2	3.8	4.0	4.0	NS	NS
Vigour index	335	404	332	383	364	59*	82 NS
Oil (%)	27.6	31.2	27.3	30.2	29.1	NS	NS
Free fatty acid (%)	4.8	4.8	5.3	4.5	4.8	0.4*	0.6 NS
Protein (%)	16.2	17.4	16.5	17.0	16.8	0.9*	1.2 NS
Carbohydrate (%)	34.8	36.8	34.1	35.5	35.3	1.3	1.8**

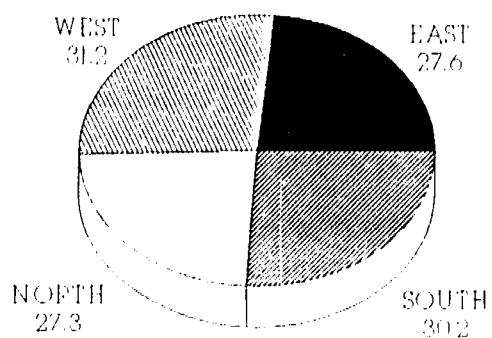
Fig.39. Azimuth influence on seed germination %
vigour index, oil, free fatty acid, protein and
carbohydrate content % in *Azadirachta indica*



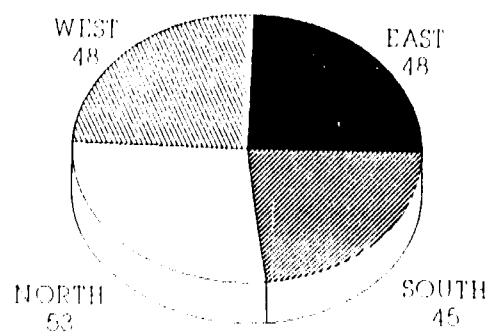
Germination (%)



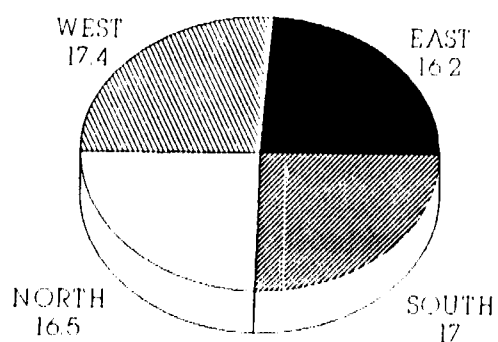
Vigour Index



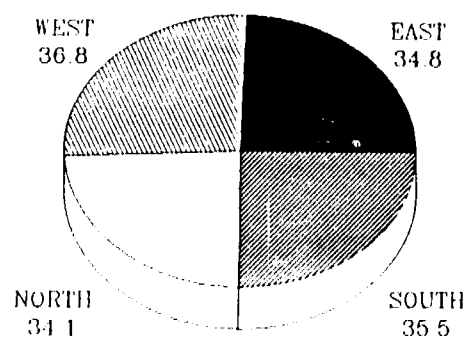
Oil (%)



Free fatty acid (%) x 10⁻¹



Protein (%)



Carbohydrate (%)

4.14. EFFECT OF DECOATING ON SEED STORABILITY IN *Azadirachta indica*

[Table 47]

Effect of decoating was significant for moisture content, root length, shoot length, dry matter production, vigour index, free fatty acids and total carbohydrates. The duration of storage also significantly influencing all the parameters.

4.14.1. Moisture content [%]

The reduction in moisture content over the normal seeds over the period of storage was 2.3, 2.3 and 3.4 % at D0, D1 and D2 respectively. The mean moisture content at control was 15.8 % and 14.0 % in decoated seeds irrespective of the storage period.

4.14.2. Germination [%]

The highest germination of 97 % for decoating was brought down to 25% after 3 months of storage (D3) and it was 93 and 30% at D0 and D3 respectively for control seeds. The significant reduction in germination in decoated seeds was only after D2 stage.

4.14.3. Root length [cm]

The root length was low in control (C1) irrespective of the duration of storage.

4.14.4. Shoot length [cm]

The influence of decoating on shoot length was seen much upto D2 over the control and mean shoot length was 7.5 cm in C2 and 6.7 cm in C1 irrespective of the duration.

4.14.5. Dry matter production [g]

The mean dry matter production over the period of storage indicated that the decoated seeds perform well in storage only to a limited period and the mean dry matter production was 4.5 g in C2 and 4.0 g in C1.

4.14.6. Vigour index

The mean vigour index value of C2 over the period of storage showed superiority over the C1 and it was 308.

4.14.7. Oil content [%]

The oil did not vary by decoating at D0 but it varied towards the end of the storage period and it ranged between 30.5 and 28.0 % at D0 and 23.9 and 22.8% in D3.

4.14.8. Free fatty acid [%]

The free fatty acid content was significantly varied between the C1 and C2 only at D2, where C2 registered 8.5 per cent. The mean free fatty acid content over a period of storage ranged between 5.3 and 8.5 per cent.

4.14.9. Protein content [%]

No significant variation existed between the C1 and C2 at each level of storage but the duration of storage influenced the protein content and the mean value ranged between 17.0 and 15.7 per cent.

4.14.10. Carbohydrates [%]

The significant reduction in CHO in decoated seeds was evident from the studies during storage period. The variation between C1 and C2 was 6.4 % at D1 and 4.8% at D2.

Table 47 Effect of decoating on germination (%), root and shoot length (cm), dry matter production (g), vigour index, oil (%), free fatty acid (%), protein (%), and carbohydrate content (%) during storage of *Azadirachta indica* seeds.

Duration of storage	Control	Decoating	Mean	CD 5 %	CD 1%
Moisture content (%)					
D0	19.6	17.3	18.4	T 2.2	3.0**
D1	16.2	13.9	15.0	D 2.2	3.0**
D2	15.3	11.9	13.6	TxD 2.2*	3.0 NS
D3	12.0	12.9	12.5		
Mean	15.8	14.0	14.9		
Germination (%)					
D0	93	97	95	T NS	NS
D1	81	79	80	D 4	6**
D2	53	48	51	TxD 4*	6 NS
D3	30	25	27		
Mean	64	62	62		
Root length (cm)					
D0	13.1	14.5	13.8	T 1.2	1.7**
D1	10.0	13.4	11.7	D 1.2	1.7**
D2	9.1	10.4	9.8	TxD 1.2*	1.7
D3	7.3	7.8	7.6		
Mean	9.9	11.5	10.7		
Shoot length (cm)					
D0	8.9	9.4	9.1	T 0.6	0.8**
D1	7.8	8.4	8.1	D 0.6	0.8**
D2	5.5	7.3	6.4	TxD 0.6	0.8**
D3	4.7	4.8	4.7		
Mean	6.7	7.5	7.1		
Dry matter production (g)					
D0	5.4	5.8	5.6	T 0.9*	1.2 NS
D1	3.8	4.4	4.1	D 0.9	1.2**
D2	3.6	4.3	4.0	TxD NS	NS
D3	3.1	3.4	3.3		
Mean	4.0	4.5	4.2		
Vigour index					
D0	502	564	533	T 59*	80 NS
D1	301	373	337	D 59	80**
D2	191	207	199	TxD NS	NS
D3	92	86	89		
Mean	271	308	290		

Contd..

Contd..

	Duration of storage	Control	Decanting	Mean	(D 5 %	(D 1%
Oil (%)						
	D0	5.1	5.5	5.3	T 0.7	0.9**
	D1	7.2	7.6	7.7	D 0.7	0.9**
	D2	7.1	8.5	7.8	TxD 0.7*	0.9 NS
	D3	8.5	8.6	8.5		
	Mean	7.0	7.5	7.2		
Protein (%)						
	D0	16.9	17.0	17.0	T NS	NS
	D1	15.4	15.3	15.3	D 1.6	2.1**
	D2	15.2	14.6	14.9	TxD NS	NS
	D3	15.6	15.8	15.7		
	Mean	15.8	15.7	15.7		
Carbohydrate (%)						
	D0	33.0	36.0	34.5	T 3.6	4.9**
	D1	35.0	28.5	31.8	D 3.6	4.9**
	D2	31.2	26.4	28.8	TxD 3.6	4.9**
	D3	28.1	24.6	26.3		
	Mean	31.8	28.9	30.3		

DISCUSSION

CHAPTER V

DISCUSSION

1. Phenology of *Azadirachta indica*, *Derris indica* and *Ailanthus excelsa*

Seed is the principal means for perpetuation of most trees comprising of many woody species from one generation to the next. The life of a seed involves with complex series of biological events beginning with initiation of the flower and terminates with the germination of the mature seeds. A knowledge of the life processes comprising of initiation, development and ripening is basically required for success in harvesting and using the quality seeds. Ability to estimate seed crops accurately comes with an understanding of floral and fruit arrangement, flower-seed relationships, fertility index, and due to the way of environmental effects.

In numerous woody plants, the process of flower initiation and development to the blooming stage are of continued activity extending over many months. During this period, climatic factors (extrinsic) and internal conditions (intrinsic) interact to shape the quantity and quality of flowers and early development are known, but information is fragmentary regarding the physiological requirements for most of the sylviculturally valuable species under Tamil Nadu conditions.

A knowledge on flowering phenology is required to enable the collector to select the timing and methods of seed harvesting at the most appropriate to the species. It is very important while handling the seeds for storage or pretreatment, most of the beneficial effects can be derived from the knowledge of how seed develop in nature. It is also becoming important to understand a species phenological variation in relation to the geography. This process will assist the collector to choose the most appropriate sequence of collecting sites, so as to extend the total durations of useful collections. The effect of periodicity especially in the seed bearing of forest trees is rather irregular. Therefore, the habit of periodicity in flowering becomes important to plan for seed

collection. It is rather unfortunate that the periodicity in tropical species is well less documented.

Obviously the flower primordia initiation in neem occurred during the first week of April, immediately after the new flush period. These periods of flower initiation and maturity under normal situations coincide with one to two hot weather heavy spells. The extended period of flowering in general, ends during May and all the fruits follow the sequence of maturity and attain the full maturity during June-July, continuing with the South West monsoon period.

The flowering in *Derris indica*, is much more influenced by the edaphic and climatic factors having no set pattern of flowering or flower initiation period. However, in most cases, the first primordia initiation starts during April (20-25th) of a year and the same remained true for the tree selected for seed development and maturation study in this investigation as well. The bisexual flower initiated during April reaches the full maturity during August or September. The lengthy period of seed maturity and poor dispersal of fruits from the tree most frequently involving the maturing seeds to adverse weather condition will have definite influence upon the seed quality characteristics at harvest.

The shortest period of flowering in *Ailanthus* resulted in the uniform maturation of samara and faster dispersal coinciding with the gale winds in hot summer ensuring the dispersal to longer distances, aided by its wing. The initiation of flower primordia was in the month of February-2nd week, and the seeds took about 14 weeks to attain the full maturity. Male and bisexual flowers occur on separate trees or on the same tree.

In many pines primordium development takes place largely after vegetative growth in mid or late summer. But in Douglas-fir (*Pseudotsuga menziesii* (Mirb) Franco), flower initials develop at the start of the growing season coincident with bud bursting of the current season's female flowers (Owens and Smith, 1964). The female flower structure of sweetgum (*Liquidambar styraciflua* L.) is morphologically complete

by early summer and over winters (Flint, 1959); whereas the female initials of white Oak (*Quercus alba* L.), formed during late summer are still morphologically immature at the time of bud breaks in May (Turkel *et al.*, 1955).

In many species producing unisexual flowers, the female flowers start earlier and differentiate more rapidly ((Turkel *et al.*, 1955; Duff and Nolan 1958; Fraser 1962, 1966).

In neem, pungam and Ailanthus there was heavy flowering and associated with more flower and fruit drop. Many shrub species produce flowers in quantity almost every year, but the magnitude of flowering on most forest trees is highly variable from year to year, a phenomenon known as 'periodicity'. Light and heavy flowering in alternate years have been characteristic of many fruit and forest trees (Kramer and Kozlowski 1960).

In pungam, (*Derris indica* L.) the flowering is indeterminate and each tree at each location was flowering at different periods, without following the 'periodicity'.

Flowering in some species has an inherent rhythm that appears to be independent of site or climatic conditions, but good production years in other species are correlated with climatic conditions (Schrock 1957, Stern 1961).

II. Seed Development and Maturity study in Neem, Pungam and Ailanthus

When are seeds mature? This really poses problems in quality harvest. According to Nitsch (1965) there are four phases of growth and development in seeds which may be described as i) cell initiation and multiplication within the flower bud, ii) pollination, pollen growth and fertilization, iii) cell enlargement and cell multiplication in the seed and iv) maturation and finally senescence. Most fruits enlarged rapidly following fertilization accompanied by a variety of concomitant physiological changes. These include macro molecules particularly the carbohydrate, protein, nitrogen constituents and organic acids. Respiration reaches a peak as maturation is obtained (Nitu, 1968) and then declines as senescence begins. Moisture plays a pivotal role

throughout the changes. Other more easily observable changes include the loss or gain of a distinctive colour, a change in flavour or odour, a softening in fleshy fruits (or achievement of brittleness as in conifer seeds). Some fruits lose their chlorophyll content and photosynthetic activity as they ripen. In most seeds, complex carbohydrates, fats, oil and protein usually accumulate and fats (lipids) form the major food reserve in many tree species.

In humid tropics and tropics there is a special problem, because seasonality effects are usually subtle or absent and period and maximum seed production is uncertain. After detection of flowering in a stand from which it is desired to collect seeds, it is important to carry out periodic reconnaissance to check on the progress of fruit maturation. An efficient schedule of reconnaissance requires prior knowledge of the length of time between anthesis and fruit maturity. The flowering to fruit maturity is highly variable between the trees.

Among the Malaysian trees, the period from anthesis to fruit maturity varies from 3 weeks for *Persea javanica* to 11 months for *Diospyros maingayi* (Ng and Loh 1974).

In *Azadirachta indica* during fruit and seed development, the fruit length reaches its maximum at 11 weeks after the anthesis. Similar behaviour has been noted in respect of width and seed length. Breadth of seed, fresh and dry weight of seed reached its maximum at 12 weeks after the anthesis coinciding with the fall of moisture content, indicating its physiological maturity period with 93% germination. However the germination increased further to 97% at 12th week indicating the involved after ripening period. At this stage the fruit colour changed to yellow from light green colour, which is the physical index of seed maturity.

Ching and Ching (1962) noted that when the cones scales of *Pseudotsuga menziesii* had turned brown, seeds were matured and seedling vigour was high. Cone maturation in yellow cedar (*Chamaecyparis nootkatensis* (D.Don) Spatch) is also

signalled by a colour change from green (often with purple markings) to yellow or golden brown with dark brown markings. (Harris, 1971; Owens, 1975).

Distinct colour changes have been associated with the attainment of maturity in hard wood fruits, and have recently been revived as practical maturity indices particularly in the Southern United States. The main reason is that other indices offer no advantage over the easily observed attribute.

A colour change from green to light brown in acorns of white oak (*Quercus alba* L.) and dark red, brown in Shumard oak (*Q. shumardii* Buckl.), was found to be a very good maturity indicator (Bonner, 1976a).

Colour changes have also been recommended as ripeness indicators in other oaks (Bonner, 1974), in green ash (*Fraxinus pennsylvanica* Marsh) (Bonner, 1973), in black cherry (*Prunus scrotina* Ehrh.), and in yellow poplar (*Liriodendron tulipifera* L.) fruits Bonner, 1975, 1976b

Both Pfister (1967) and Oliver (1974) have recommended seed-showing colour as an index.

Moisture content of fruit and seed, dry matter accumulation as expressed by the fresh and dry weight of developing seeds, their sizes, the length, breadth, colour of mature fruit, germination percentage, seedling dry matter, root and hypocotyl length of seedlings were the best criteria in fixing the maturity status as suggested by Oliver (1974) and Rierveld (1978).

The grand fibre cone dry weight and cone length were reported to be significantly correlated with seed production (Ching, 1960).

Physiological maturity (PM), was defined as the occurrence of maximum dry seed weight. Teckrony *et al* (1979) defined physiological maturity as the point where the plant reaches reproductive state which is described as the occurrence of one normal pod on the main stem that had reached to its maturity.

Buszewicz and Gordon (1971) reported that cones of *Pinus merkusii* should be collected when the majority had begun to turn the colour of cone brown. A purpling of the cones of balsam fir (*Abies balsamea* (L.) Mill.) suggests attainment of maturity (Stoeckeler and Jones, 1957).

Moisture plays a critical role in maturation and changes in cone scale and seed moisture content have been noted as strong manifestations for the ripening progressed (Rediske, 1961).

Edwards (1980) listed the information on 22 species in seven genera for which moisture content and/or cone specific gravity indices have been recommended.

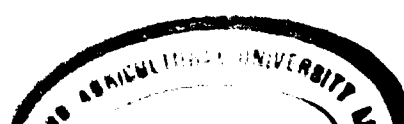
In the present study the seed chlorophyll content was 0.21 mg/g of seeds indicating the seed maturity status. At this stage the biochemical compositions such as protein, carbohydrates and oil content was maximum which resulted in the increased dry weight.

Blanche *et al.* (1980) reported increased dry weight, germinability, acorn diameter and length; while fresh weight and per cent moisture content increased initially which then declined towards maturity. These changes correlated very well with chlorophyll changes.

In seeds, complex carbohydrates, fats, oils and proteins usually accumulate and lipids form the major food reserve in many tree species. For example 25-30% of the storage material in mature noble fir (*Abies procera* Rehd.) seed is crude lipid (Rediske and Nicholson, 1965); whereas the storage proteins constituted only 6-7 per cent.

In the present study as well *Derris indica* seeds attained physiological maturity period only after 17 weeks of maturity. The fruit and seed length, fresh and dry weight of seed reached its maximum between 16 weeks and 18 weeks of maturity. The moisture content started decreasing even from the initial stage of maturity.

The loss in moisture content from the early stages even before the attainment of physiological maturity seems to be a peculiar phenomenon in pungam.



The accumulation of oil, protein and carbohydrates reached to its maximum level during 17 weeks of maturation, coinciding with the maximum germination percentage indicating the physiological maturity period.

A major difficulty in seed collection whether or not the seeds are dispersed at maturity, is that not all of the fruits mature simultaneously. Maturation date varies for cones on the same tree (Ching, 1960; Fowells, 1949, Maki, 1940) from tree to tree within the same stand (Allen, 1958), from stand to stand in the same year (Fowells, 1949) and varies from one year to the next (Allen, 1958; Fowells, 1949).

Increases in carbohydrates, nitrogenous constituents and organic acids are the major physiological changes during maturation. The respiration reaches a peak as physiological maturity is attained (Ching and Ching, 1962; Nitu 1968) and then declines as senescence begins.

Rediske (1961) concluded that *Pseudotsuga menziesii* seeds with a reducing sugar of 22 mg/g were immature; while maturity was achieved when the level had fallen to 13 mg/g.

Similar study was carried out by Renganayaki (1989) in cashew (*Anacardium occidentale*).

In the present investigation, the seed maturation in *Ailanthus excelsa* Roxb. reached the physiological maturity period at 11 weeks after anthesis coinciding with the maximum dry weight and falling moisture content per cent. Until 11th week, the accumulation of food reserves was gradual indicating the steady increase in dry weight of samara and seed.

Similar results were reported on many tree species. Nautiyal and Purohit (1985) reported sigmoid pattern for fresh and dry weight of seeds during the first 35 days after anthesis and there after a sharp rise in respect of sal (*shorea robusta*). The percentage of moisture content gradually increased from 60% to 70% during the first 31 days after anthesis and finally declined to 40% level.

Earlier work done by Ramakrishnan (1988) revealed the same sequence of maturity for fruit and seed physical characters in *Ailanthus excelsa* seeds.

In short, the seeds of neem mature when the colour of the fruit changed to slight yellow and where the fresh and dry weight reached their maximum. All these processes took about 11-12 weeks and seeds were harvestable after 12 weeks of anthesis. At this stage even birds started eating the fruits.

In *Derris indica* seeds, the maturation of seeds took long period and in that the seed physiological maturity was attained 17 weeks after anthesis. The colour of the fruit was changed to dull brown or straw coloured from green at physiological maturity stages. At this stage, the seeds produce rattling sound within the shell.

Seeds of *Ailanthus excelsa* were mature after 11 weeks and the samara colour changed to straw colour from greenish yellow. At this period, the maximum accumulation of food resources resulted in the increased dry weight of both the samara and seed.

Similar findings were reported by Gawande and Karivaratharaju (1989) in Kapok, *Delonix regia* (Sivasamy, 1987) *Acacia nilotica* (Rajasingh, 1987).

The biochemical study on seed maturation clearly gave an evidence or prelude for the increase in the dry matter production and the associated increase in germination of seeds. However, the free fatty acid level was kept at very low per cent indicating the soundness of the seed at maturity. Kaloyereas (1958) had earlier shown a relationship between increase in seed fat rancidity and loss of seed viability. In other words, the decreased rancidity resulted in increased germinability.

III. Testing Neem seed for its recalcitrancy

Seeds may be broadly divided into two categories, based on whether or not they undergo a period of maturation drying as the final pre-shedding developmental phase. The great majority of seed species do, infact terminate their development by maturation

drying, during which there is a metabolic switch from the developmental mode to that of germination (Kermode and Bewley, 1986). Most of these seed species will retain viability for remarkably long periods (Ellis and Roberts, 1980).

Recalcitrant species seeds are generally highly desiccation sensitive (Roberts, 1973) and do not undergo maturation drying. King and Roberts (1979) updated these and produced a list of about 90 species which can be classified as recalcitrant based on reports from the literature. This compilation is hampered by incomplete information, and some of the recalcitrant species reported to have been killed by drying have since proved to be orthodox seeds.

Recalcitrant seeds should be stored in moist medium to obviate dehydration injury and relatively warm conditions as these are mostly sensitive to chilling injury. (Chin and Roberts, 1980).

In neem because of the occurrence of high moisture content (37.2%) in fresh seeds (Maithani *et al.*, 1988); and manifestation of chilling damage by the seeds (Ezumah, 1986, Maithani *et al.* 1989), the species is indicated to be recalcitrant one. On the basis of moisture content for the seeds obtained from Haiti plantation Chaney and Knudsen, (1988) argued that neem is not the recalcitrant one. The tropical species belonging to moist tropical forests neem occurring in the dry tropical it is understood that neem is a short-lived orthodox seed.

In order to overcome this controversy Chin *et al.* (1984) proposed a methodology to classify the orthodox and recalcitrant species. According to him, the seeds upon slow drying are subjected to various temperature treatments, tested for their viability by conducting germination test.

In the present study the neem seed tested with the above procedure and the results obtained revealed that with reduction in temperature there was reduction in germination which differed significantly at moisture regimes. The seeds exposed to 50°C treatment for low moisture should have killed the seeds giving nil germination.

However, in contrast at 16% moisture content also it gave nearly 79-80% germination clearly indicating that the neem seeds doesn't belong to the recalcitrant group.

As Chin *et al.* (1984) argue the faulty drying and improper storage could be the reason for poor viability potential, the proposed cheap method of earthen pot placed on wet sand under shade (Ponnusamy *et al.* 1989), seems to be quite reasonable.

IV. Effect of drying on neem (*Azadirachta indica* Adr. Juss) seed quality.

In order to understand the dehydration effects on the potential germination and vigour the seeds were dried under sun in oven at 40°C and room temperature to bring down the moisture content to the reasonably low level of 16 per cent.

Under shade drying conditions it registered about 91% germination with higher vigour index. The sun drying proved to be lethal and it gave 80% germination.

Berjak and Pammenter (1984) studied the drying effect on the recalcitrant seeds of *Landolphia kirkii* which was stored in silica gel and lost 50% viability after 15 days. But when excised embryonic axes were flash dried to water content of 16% within 60 minutes essentially undiminished viability (90%) was retained. Considerable damage occurred in embryos of seeds dried over silica gel where distal hypocotyl cells were extensively damaged.

Ezumah (1986) studied the drying of effect neem under direct sunlight and shade drying and reported that sun drying didn't affect the seed germination and viability.

In contrast to the above results, in the present study the sun drying reduced the germination to the tune of 10% which cannot be left unaccounted. The possible reason could be the faster desiccation or the rate of desiccation could be a factor which indirectly affect viability. Chin and Roberts (1980) suggested that rapid drying of large seeds may be less damaging than slow drying. Neem seeds are large relative to many orthodox seeds and therefore have a small surface area/volume ratio and the rate of water loss is likely to be slower than that of smaller seeds under a given environmental conditions.

This may be the reason for the Ezumah's argument. However, in neem the presence of mucilagenous coating is impermeable to gas while fully hydrated.

Edwards and Mumford (1985) reported that the differential changes in the physical and chemical properties of the seed coats during drying could be one reason why different drying strategies have produced varying results with respect to germination capacity. More over the differences in the rate of desiccation could be a factor which indirectly affects viability (Bewley and Krochko, 1982)..

Barton (1943) found that drying sour orange seeds on blotters in the laboratory was more damaging than allowing seeds to equilibrate in open containers at 50°C.

From the present study it is evident that the seeds of neem shouldn't be dried under direct sun light which reflects in poor viability potential.

V. Effect of crow feeding in neem (*Azadirachta indica*) seed quality.

In natural conditions, the fleshy fruits are often eaten by the animals and birds. The fruits are preferred by them for their fleshy and tasty nature of parts of fruits. This process ensures the tree with the effective dissemination by this dispersal mechanism. In some other species the physiological (endogenous) and mechanical dormancy (exogenous) is broken by the process, which augment the germination process of the seeds. Under natural conditions the tree and the natural animals and birds are inter-dependent. In neem, the fleshy fruits are eaten by the crows in large numbers and are being deposited on the ground underneath the same tree (or) other trees.

When crows feed the ripened fruits they pass through the intestinal digestive system and attain improved germination and vigour potential.

In order to understand the mechanism involved in the enhancement of germination, a study was conducted and the documented results evidently revealed that (i) the crow fed seeds recorded reasonably low moisture content in it and (ii) associated

with the germination potential at a high rate in respect of the crow fed seeds. The other parameters such as the root and shoot length, vigour index were more in these seeds.

It is plausible, such an enhancement might have been due to the lesser drying injury to the seed and the way seeds are being facilitated in this extraction method. The other biochemical reason as evidently brought out from the study is indicated by the presence of lower free fatty acid content in the crow fed seeds and comparatively higher food reserve in the seeds. Upon storage as well, the seed food reserve was not depleted faster when compared to the normally extracted (fermentation method) seeds.

The action of the digestive chemical entities was reported on many other species, especially the animal systems. Seeds of *Acacia senegal* and *Ceratonia siliqua* that have passed through the digestive tracts of goats germinated readily when placed in favourable conditions, because of the action of the strong digestive chemicals. Feeding the pods to penned goats and collecting the seeds from the droppings was a convenient pretreatment for these species (Goor and Barney, 1976).

Seeds of some species are said to be regurgitated after partial rumination eg. *Gmelina arborea* (Greaves, 1981). According to Troup (1921) seeds of *Acacia nilotica* are ejected after rumination by sheep and goats but pass right through the digestive tract in respect of cattle. In either case germination was improved by the digestive action.

The action of digestive chemicals might have softened the outer shell with the resultant improved germination and vigour in the seeds, besides carrying out the extraction in perfect manner through natural means.

VI. α -amylase test for fresh and old lots of neem

The seed quality of neem in storage based on biochemical parameters, such as α -amylase was taken into consideration. The presence of α -amylase content in the seed embryo was dependent on the age of the seed lot.

Although α -amylase production by the embryo was not always associated with the growth and germination, the ability of embryos to produce α -amylase depended upon their age in mother plant (Cornford *et al.*, 1987).

In the present investigation the α -amylase production was measurable at much higher level in the freshly harvested seeds; while the old lots (6 months old) produced little or nil.

Similar study was made on the tomato seeds by Sundereswaran (1990), and evaluated the pickingwise response of seeds for α -amylase activity which was prominent as affected by seed senescence.

The seeds collected from the 'crown' possessed superior quality than the 'ground' collected ones. The seeds collected from the 'crown' though had higher seed moisture than the 'ground' collected ones, upon natural drying facilitated with improved germination, root and shoot length.

Delayed harvest in the seeds like neem will pose great problem due to the natural fermentation and also the way by which insect and fungi and other pests act on it. The main disadvantages of collection from natural fruit shedding are the risks of collecting immature, empty or unsound seeds comprising of varied levels of seed deterioration or premature germination if collection is delayed. This is also based on the uncertainty in identifying the mother trees from which seed is collected. Seeds in the first fruits to fall naturally in the season are often of poor quality (Aldhous, 1972)

Observations have indicated that many of the seeds of the more important dipterocarps lose their viability within a few days of shedding and studies on *Shorea platyclados* in Malaysia demonstrated that seed lots collected from the ground included considerably more defective seeds than the lots collected from the crown of the standing tree (Tang, 1971).

In the present study as well the seeds collected at physiological maturity period right from the crown possessed higher seed quality by having more food reserves in it and with low free fatty acid content. Seeds of neem after shedding develop the fermentation process at natural condition reduced the quality of the seed. Similar results were obtained for *Derris indica* also. In *Derris indica* the 'ground' collected seeds had more pathogenic invasion and insect damage thus reducing the seed quality can be the other reason.

VII. Seed quality in relation to Seed source variations

The established seed zones, assume significance since they are considered for seed collection. Careful evaluations, rightly bring the establishment on the basis of climatic and physiographic characters. These zones are being used as guide for seed collection. In natural forest, seed zones are of uniform ecological units, which are delineated, for the control of seed and planting material.

Seed source variation on seed quality characteristics is one of the areas discussed since more than two decades. In neem, pungam and Ailanthus great variation among the seeds collected from various zones and locations have been demonstrated.

In neem, the seeds collected from the zone 6, resulted in the higher germination and comparatively gave higher percentage of oil associated with low free fatty acid and protein and carbohydrates. However, variation in status of vigour of the seedlings was negligible. Interestingly, variation in respect of seed composition has been observed.

Taking stock of physical characters evaluated, it was clearly seen that variation exists in seed length, breadth and colour.

In pungam, the seed source variations presented great variation in respect of seed size and shape and are very well associated with the potential germinability of the seeds and vigour.

In *Ailanthus excelsa* also, the germinability varied between 73 and 62% resulting in 10% variation and variations due to parameters also perceptible.

In this context, the results obtained from teak seeds of 18 Indian source by Gupta and Pattanath (1975) showed great variation in germination capacity and after ripening requirements as well as in responses to soaking in water, nutrient solution and mesocarp treatments among the seed sources.

Pathak *et al.*, (1974) examined the seeds of *Leucaena leucocephala* from various sources in India and Australia and observed that a trend of increasing heavy seeds towards Southern latitudes in Australia only. The seed length, breadth and thickness followed a similar pattern.

Variation in germination was noted among different samples of the same species of Malaysian rattans. For example, germination of different seed lots of *Colanus manan* varied from 0.2 % to 83 per cent (Manokaran, 1978).

These variations among the seed lots collected from the present study include seeds collected from the high fertile to low fertile, high rainfall to low rainfall and varied soil type regions. This geographical variation could have acted on the developing seeds and hence resulted in the expression with poor viability potential.

In *Derris indica*, the seeds collected from Thanjavur district gave poor germination when compared to other regions. The reason could be traced due to the fact that seeds produced at high rainfall zone associated with relatively higher humidity conditions. The biochemical manifestation for causing this variation in the seed lot was more evident from the results obtained.

Chalupa and Durzan (1972) examined seed size (length and weight of embryos and endosperm, weight of seeds) and biochemical composition (soluble sugars, amino acids, soluble proteins) for expressing the variation. Although significant relationships were associated in respect of seed size and soluble sugar content to climate of the seed

source, variations in the data did not allow them to be used as reliable criteria for the identification of seed origin.

Similarly, Birot (1972) studied the variation in seed weight of Douglas fir (*Pseudotsuga menziesii*) from various pacific Northwest sources.

Similar studies were reported by many scientists in *Cedrus diodora* (Thapliyal and Gupta 1980), *Querus rubra* (McGee, 1974) and Douglas-fir (Sorensen and Miles, 1978).

In the present study the variation in the biochemical composition of oil, protein, carbohydrates, chlorophyll content and free fatty acid was observed among the chosen seed lots.

Especially, the seeds collected from the medium fertile dry and cool regions of Tamil Nadu accounted with the pronounced superior seed quality characteristic than the other seeds collected from higher rainfall and high temperature zones.

White spruce (*Picea glauca*) seeds from Ontario and the Yukon were analysed for isoenzymes, the results clearly produced the banding patterns of total proteins and isoenzymes with the specific seed origin (Battacharya, 1979).

Earlier some attempts have been made to define the limits of provenances or seed zones of a few north temperate conifers (Barner, 1978) and similar studies have been made more recently on the delineation of provenance regions of *Pinus caribaea* and *P. Oocarpa* in Honduras (Robbins and Hughes, 1983).

Provinces or regions of seed collection for *Eucalyptus Canalduiensis* have been defined in terms of the main drainage systems in Australia (Turnbull, 1973).

In order to high-light the seed variation in relation to anatomical and physiological potential of the seeds the x-ray techniques was employed in the present study. It clearly indicated the presence of double seededness, hollowness, damaged, shrivelled seeds and split cotyledons.

Radiograph was first used to determine seed quality over 70 years ago (Lundstron, 1903), cited by Kamra, 1964). The studies of Simak and Gustafsson (1953)

highlighted the x-ray technique as a diagnostic method for tree seed analysis. The x-ray contrast method uses varied contrast or radiopaque agents as developed and applied successfully to species of *Pinus* and *Picea* (Simak 1957; Kamra, 1963).

Employing this technique the seed quality of various sources or the single lot can be revealed at a faster rate. Complicated photographic equipment is not necessary and pictures can be made with polaroid film which provide clear and detailed radiographs within 30 seconds (Edwards 1973).

Seed storage studies in neem, Pungam and Ailanthus

From the storage studies, it was evident, that the seeds of neem does not fair well at low temperature over a long period of storage. However irrespective of the zones there was declining trend over the periods of storage. Marked differences in vigour and viability potential among the zones were evident.

From the present study, it was clear that neem seeds can't be stored beyond 6 months under room temperature conditions. However, reduction in the temperature drastically reduced the seed quality with respect to their viability potential.

Temperature below -5°C killed all the acorns of *Quercus robur*, while a temperature of +1°C encouraged excessive pre germination (60-75% after 3 winters; while radicles upto 25 cm long, compared with 12% and radicles < 0.5 cm long at -1°C) (Suszka and Tylkowski, 1980).

In the present study at low temperatures, with advancing storage period reduction in oil, protein, carbohydrates as biochemical manifestation was observed. However, the increased free fatty acid could have lead to the free radical formation and the death of the seeds.

In *shorea roxburghii* G.Don seeds, under ambient conditions, germination remained at 90% from 7 to 28 days which dropped sharply between that time and the next test after 56 days of the study. Under cold storage conditions (2°C), following the

initial improvement in germination to day 7, no viable seed remained after 14 days. Low temperature beyond this level killed the seeds (Panochit *et al.*, 1984).

Cocoa (*Theobroma cacao*) seeds are recalcitrant and lose their viability rapidly at moisture contents below 27% and storage temperatures below 17°C. The seeds are best stored at 30% to 35% moisture and 17° to 30°C. Under these conditions, germination above 67% was maintained for at least 70 days with proper seed preparation and packaging (Chin *et al.*, 1984).

In the present study investigation of the storability of the *Derris indica* and *Ailanthus excelsa*, it was revealed unlike in neem, the Pungam and Ailanthus seeds could store well at low temperature comparatively. At low temperature Ailanthus seed stored even beyond 6 months period.

Orthodox species which rapidly lose viability unless they are given the optimum treatments include species in the genera populus salix and Ulmus (Willan, 1985). Many of these lose viability within a few weeks under natural conditions or it stored in ambient conditions of temperature and humidity, but can be stored for months or year if maintained at low temperature.

Similar reports were made on *Ulmus american* (Barton, 1961), *Populus sieboldii* (Sato, 1949), *Populus balsomifera* and *Salix glauca* (Zasada and Densmore 1980).

For *Ailanthus excelsa* the low temperature was recommended by Ramakrishnan (1988).

Storing of neem seeds at relatively low temperature and high humidity do better (Ponnusamy *et al.*, 1989). Biochemical changes during storage was discussed by many scientists. Nautiyal and Purohit (1985) in *Shorea robusta* reported that concomittant with ageing there was an enhanced concentration of solutes in the seed leachates, rapid loss in moisture content, overall decline in the carbohydrates, proteins, acid phosphatase activity, a slight increase in the phenolic contents and the loss of seed viability.

Koostra and Harington (1969) have shown that a decline in polar lipids, chiefly owing to their oxidation, may be the immediate cause of leaky cell membranes in seeds. Thus the break down of lipids results in the production of free radicals that inactivate enzymes and proteins.

The moisture content loss upon storage may be the other reason for faster viability loss in the seeds of *Ailanthus* and *pungam* under ambient conditions. In neem though it did well under ambient storage conditions the loss in viability at low temperatures may be due to 'chilling injury' to the seeds.

The zone or location variation in the seeds was clearly observed and noted to depend upon the food resource present in the seeds before storage.

The percentage of sound seeds in a high yielding mother tree is usually higher than in one with a poor crop. Similarly a given mother tree will have a higher percentage of sound seeds in a good crop year than in a poor one. Collection from high-cropping mother trees in a seed year is likely to yield seeds with the best longevity in storage (Willan, 1985). Dematuration of large molecules, accumulation of toxic substances are some of the changes documented and known to be associated with the loss of seed viability in many cases (Roberts, 1979).

Roberts (1972) considered the depletion of essential metabolites including loss of food reserves as one of the intrinsic theories for loss of seed viability. The seeds of neem, *pungam* and *Ailanthus* exhibited variation in respect of their storage potential. The seeds of neem must be stored under ambient conditions after proper drying. Low temperature has been noted always lethal for neem.

Derris indica and *Ailanthus excelsa* seeds can be stored well even under -5°C and ambient temperature resulted in the faster viability loss. As a biochemical manifestation the viability loss irrespective of the species was found to be associated with free fatty acid level.

Influence of off-season collection in neem

Neem seed contains high amount of oil amounting to 25-35% depending on the locations or zones. High percentage of oil content resulted in the poor storability of seeds.

According to Karivaratharaju (1990) the oil seeds produced in the off-season contain lesser oil and hence keep better in the storage as well.

In the present study the seeds collected from the off-season contained lesser oil content varying to 5% level. Similarly, the free fatty acid percentage was also lesser. The off-season collected seeds besides performing well in storage, associated very well with increased germination and vigour potential.

Seasonal variation in the tree crops was reported by many scientists. Sorensen and Franklin (1977) reported the year to year variation which accounted for 25% of the variation in cotyledon number and 45% of the variation in seed weight.

Orr-Ewing (1954) reported improved germination in the seeds collected in the month of July.

Azimuth influence on seed quality

The position of the seeds on the mother tree is an important factor which determine the final quality of the seeds. The source sink relationship is not uniform all over the tree canopy which get varied with light quality and the nutrients. The branch which lie much lower may not be exposed to the sun light for the required period or the branches on the top exposed to over light will certainly result in the variation of the flowering, fruiting and quality of the seeds produced.

Extensive study was made on the agricultural crops. Renganayaki (1989) reported the azimuth influence in the seeds of *Anacardium occidentale*.

In the present study the positional variation was observed for *Azadirachta indica* and *Derris indica* seeds.

The South and West oriented seeds gave increased flowering, fruit setting germination and oil content.

Subbaiah (1983) reported the reproductivity of an entire inflorescence or a whole fruiting branch which was related to its orientation.

Influence of light on fruiting and fruit quality has been reported in apple (Jackson *et al.*, 1977).

While collecting fruits of neem and pungam the seeds must be collected from the South and West borne orientation and not from the East and North orientation.

Effect of decoating on neem seed quality.

Neem seed is a drupe contains one or two seeds inside. The outer shell is bit harder and the imbibition and gas exchange may be delayed. The effect of decoating and its effect during storage revealed that moisture drop in the decoated seed was even faster. The germination was much improved only in the initial stage. Upon storage the decoated seeds did not perform.

The seed coat may contain some inhibitors since the treatment with seed infusing chemicals *viz.*, acetone, petroleum ether improved germination (Sivasamy, 1989), which could have removed the inhibitors upon infusion. Hence, the decoating could have helped the kernels to emerge faster and thus resulted in the earlier germination and increased root and shoot length.

The testa removal has been shown to bring about an increased in oxygen uptake by fully imbibed seeds (Edwards and Mumford, unpublished report).

The rates and percentages of germination of seeds from which the integuments had been removed was increased (Edwards and Mumford, 1985).

The view that the seed coverings may regulate the oxygen supply reaching the embryo and hence germination, is supported by these findings. It has been

demonstrated that the integuments of freshly extracted seeds are impermeable to gases (Mumford and Pongumbean, 1982).

To improve or to increase the speed of germination the decoating in neem present promising trend.

SUMMARY

CHAPTER VI

SUMMARY

The trees of neem *Azadirachta indica* Adr.Juss, *Derris indica* L. and *Ailanthus excelsa* Roxb. were tagged at different locations of Tamil Nadu and the seeds collected from them were tested at the Department of Seed Technology, Tamil Nadu Agricultural University, Coimbatore-641 003. The experiments were carried out to have an insight into.

- a) Phenological behaviour
- b) Seed development and maturation
- c) Seed polymorphism in relation to seed sources
- d) Season of collection
- e) The storage and
- f) Other quality characteristics.

The results are summarised here under:

In *Azadirachta indica*, the flowering started in the month of April and matured in the month of June-July when the fruits became yellow, indicative of physical index of maturity. At this stage the fruit and seed dry weight was the maximum. Similarly, the biochemical compositions viz., oil, protein and carbohydrates were also high. For all these processes of development, it took 12 weeks from the date of anthesis. In *Derris indica* the physiological maturity stage was attained 18 weeks after anthesis where the dry weight of pod and seed was maximum. Maximum accumulation of oil, protein and carbohydrates associated with lower free fatty acid content was also noted.

In *Ailanthus excelsa* the samara matured 12 weeks after anthesis and the fruits turned to straw yellow colour, with maximum dry weight and protein, oil and carbohydrates.

Among the three species included for the seed development and maturation the moisture content in *Azadirachta indica* seeds, was maximum at harvest. The free fatty acid content in all these three species was kept at low when seeds were physiologically mature.

A test to identify the recalcitrancy in neem, was carried out. At 50% moisture content the highest germination per cent was obtained in T1 (ambient). However when temperature dipped down, the germination % dropped. But in the case of seeds kept at 5°C with 16% moisture content the seed did not lose its viability and thereby indicated that the neem seed doesnot fall in the recalcitrant group of seed. The overall reduction in germination was 10% only.

Seed drying in neem indicated that drying of neem seed under direct sunlight resulted in the over all reduction in germination % to the extent of 10 per cent. However the seeds kept at 40°C in an oven until the moisture content % reached 16% maintained its superiority. The root and shoot length, dry matter production and vigour index were low in the sun dried seeds.

The seeds collected from the droppings of crow at D0, had initial moisture content of 17.15 per cent. However, the level was reduced to 13.75% after 5 months of storage. This was associated with the higher germination %, root and shoot length, dry matter production and vigour index. Even in the depletion of food reserves, there was slower rate of reduction in the crow fed seeds than the control. The highest germination of 98% was recorded in the crow fed seeds at D0.

Activity of α -amylase in the ageing seeds, at initial stage measured 15 mm but dropped to the lower level of just 2 mm at D6 (5 months old seeds) indicated that the seeds lost their viability upon storage. When, 'crown' and 'ground' collected seeds were tested for their seed quality the results revealed that the ground collected seeds, alone had the higher moisture content % and lost their viability potential sooner than the 'crown' collected seeds.

The seed polymorphism, as a resultant of the ecological variations was the interesting observation and the seeds size including length and breadth varied widely in pungam. The 1000 seed weight was varying much, besides length and breadth when compared to other two species.

The seed source variations as revealed by using x-ray technique ('contact and 'contrast' therapy) indicated that seeds collected from L5 was having more hollowness (Anatomical potential).

Seed quality variation in relation to ecological variation was observed for seed germination, vigour and their biochemical compositions which intern reflected on the physiological potential of the seeds.

In neem, the germination variation was accountable for 10 per cent only.

Similarly the oil, free fatty acid, protein and carbohydrates varied much. In pungam, the seed source variation accounted for nearly 36% in respect of germination potential. With regard to other biochemical aspects also, higher variation was observed clearly. The oil content variation accounted for 10.53 % and the protein was varying to an extent of 24.37 per cent, among the seed sources. Among the sources tested, Z1 was having maximum quality potential.

In *Ailanthus excelsa*, the L1 seeds registered higher per cent of oil, protein and carbohydrates with low free fatty acid with the resultant increased germinability. Maximum germination of 73 % was registered in L1 with higher vigour index value of 16 per cent.

The season of collection in neem tree was influencing the quality parameters including the germination, oil content and free fatty acid levels. The 'off-season' collected seeds had the oil content to 21 per cent. However, in the off-season collected seeds quality of seed as revealed with free fatty acid content (1.1 % lesser) was superior.

During storage, among the seeds of *Azadirachta indica* placed under ambient, 50°C and -50°C temperatures for 6 months indicated faster rate of reduction in

germination, root and shoot length, vigour index and even with regard to biochemical compositions at lower temperature condition than the ambient temperatures. Among the zones, Z6 registered the highest in germination of 99% and it was rapidly brought down to 47 at the end of the storage period. The poor performance of Z2 and Z5 was traceable to the faster depletion of food reserves. However, over the period of storage, the ambient temperature registered higher germination potential with lower free fatty acid content.

In *Derris indica* and *Ailanthus excelsa* with reduction in the storage temperature germination was enhanced to a certain extent. Irrespective of the temperature and durations, the Z1 seeds maintained its germination potential through out its storage period. Similar observation was made on the *Ailanthus excelsa* seeds as well. Pungam and Ailanthus seed had negative association with the temperature for most of the evaluated seed quality parameters. Seeds of *Azadirachta indica* alone had established positive association. However, negative association was evident for the duration of storage, for all the included quality parameters.

The 'Azimuth' influence, in neem, was perceptible for branches, flowering, flower bearing and related seed quality parameters. The number of inflorescence and flowers/sq.m, fruit setting percentage, seed germination, vigour index and other biochemical constituents viz., oil, free fatty acid, protein and carbohydrates was maximum in the 'South' and 'North' oriented branches/seeds.

The effect of decoating in neem resulted in the faster depletion of the moisture content % which dropped to 12% and below over the period of storage. This reflected on the germination potential of the seeds as well. At initial stage, (D0), decoated seeds facilitated germination process, which inturn gave increased root and shoot length and hence accounted for the greater vigour index.

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PLATES

Plate 3. General view of *Derris indica* tree
branch bearing flowers



Plate 4. General view of *Derris indica* tree
branch bearing pods



Plate 1. General view of *Azadirachta indica*
tree branch bearing flowers



Plate 2. General view of *Azadirachta indica*
tree branch bearing fruits



Plate 5. A branch of *Ailanthus excelsa* tree with flower panicle 239

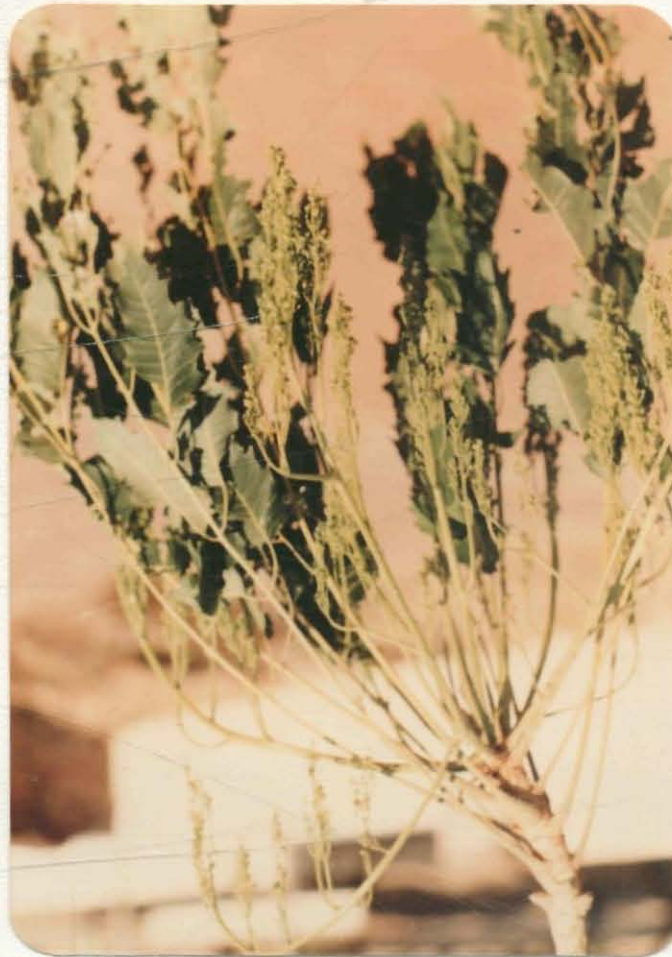


Plate 6. Fruit development and maturity stages in *Azadirachta indica*

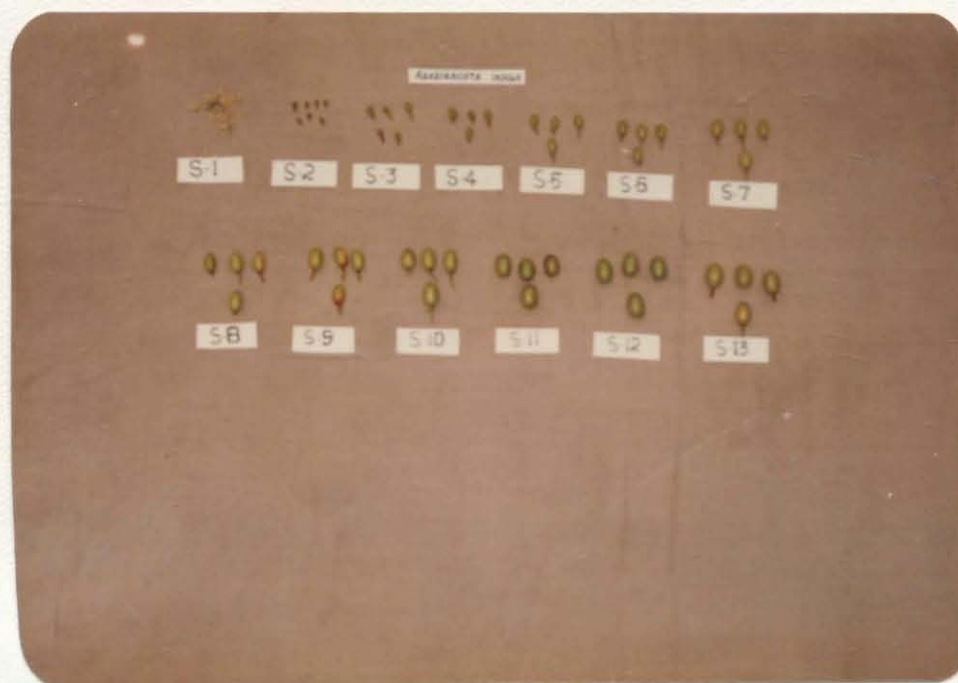


Plate 7. Physical variations in *Azadirachta indica* seeds collected from different locations

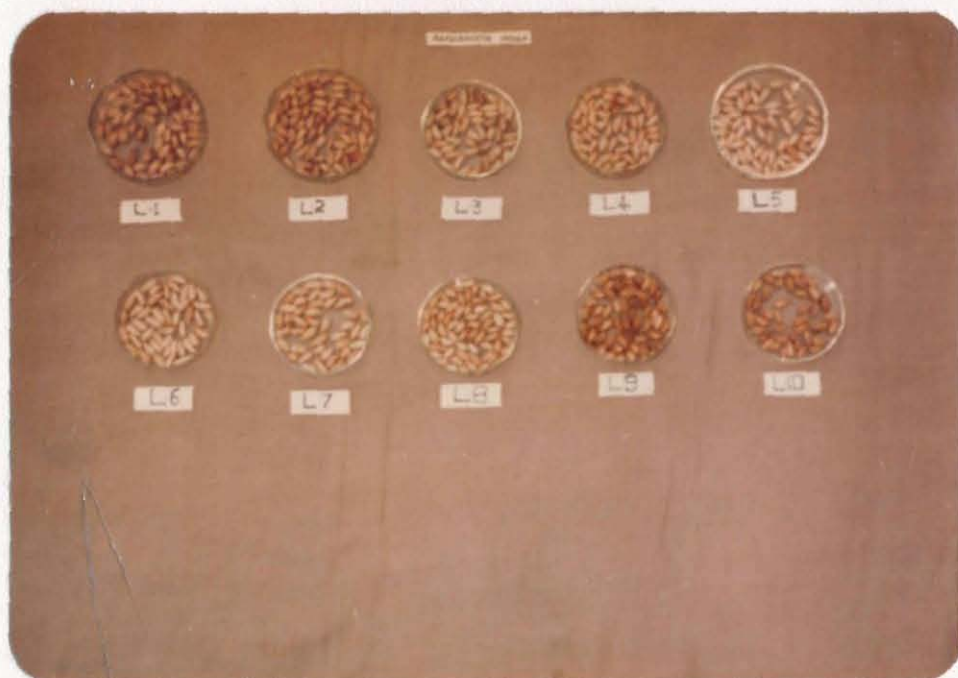


Plate 8



Plate 9. Physical variations of *Derris indica* seeds collected from different locations

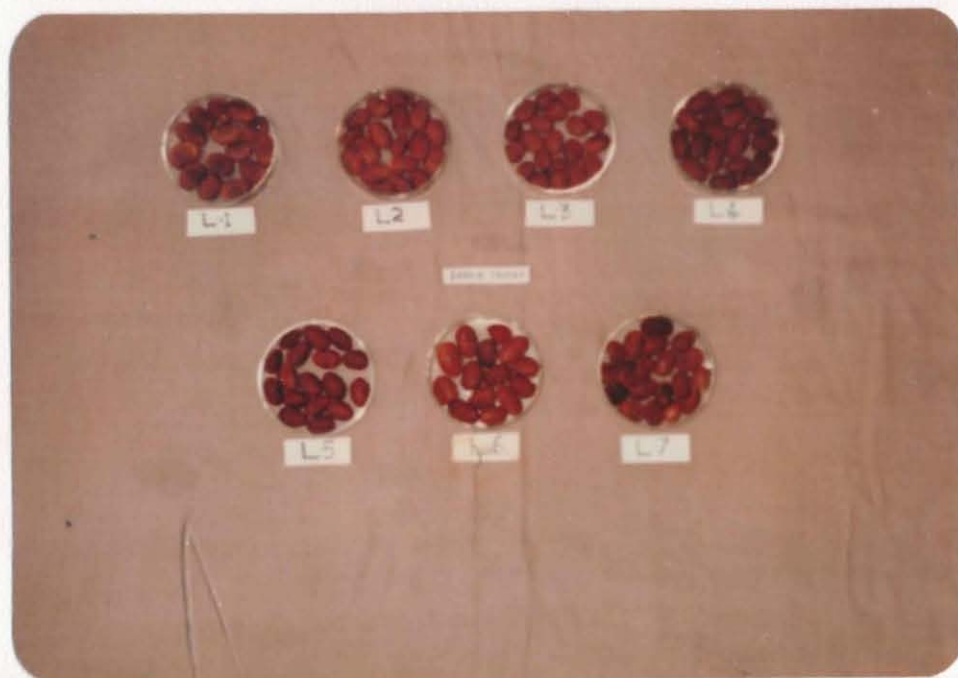


Plate 10

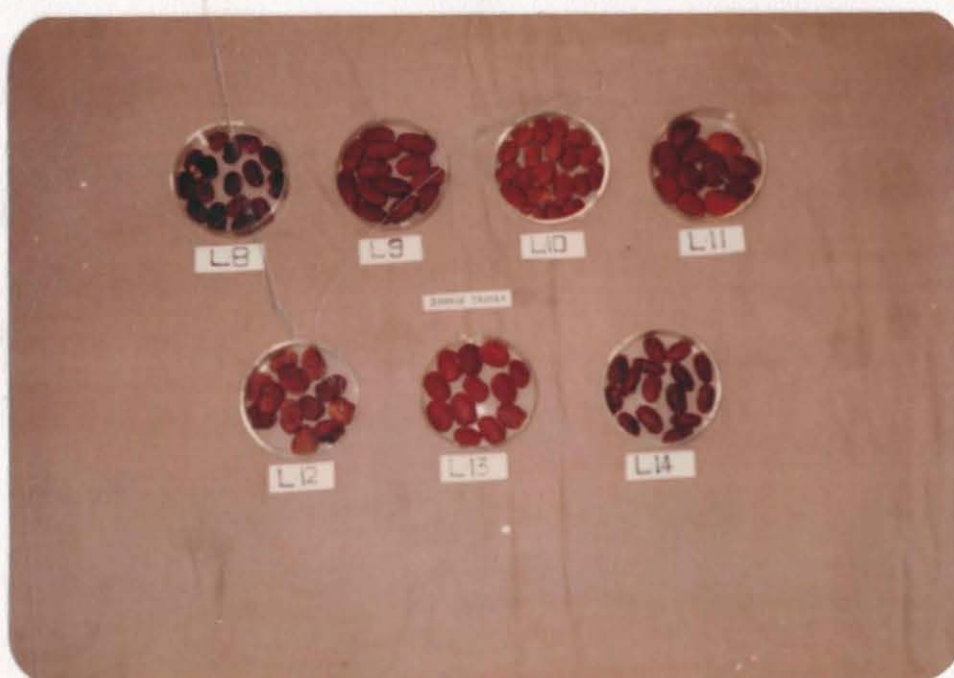


Plate 11. α -amylase activity (clear zone) during storage of *Azadirachta indica* seeds

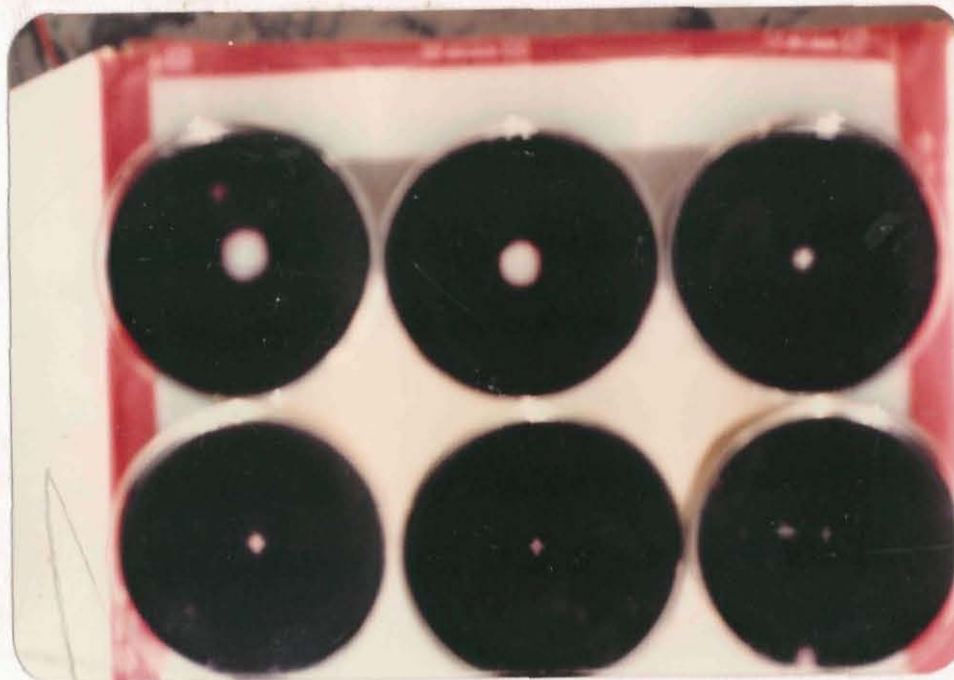


Plate 12. Azimuth influence on seed germination and seedling development in *Azadirachta indica*



ANNEXURE

ANNEXURE-I

Azadirachta indica A. Juss

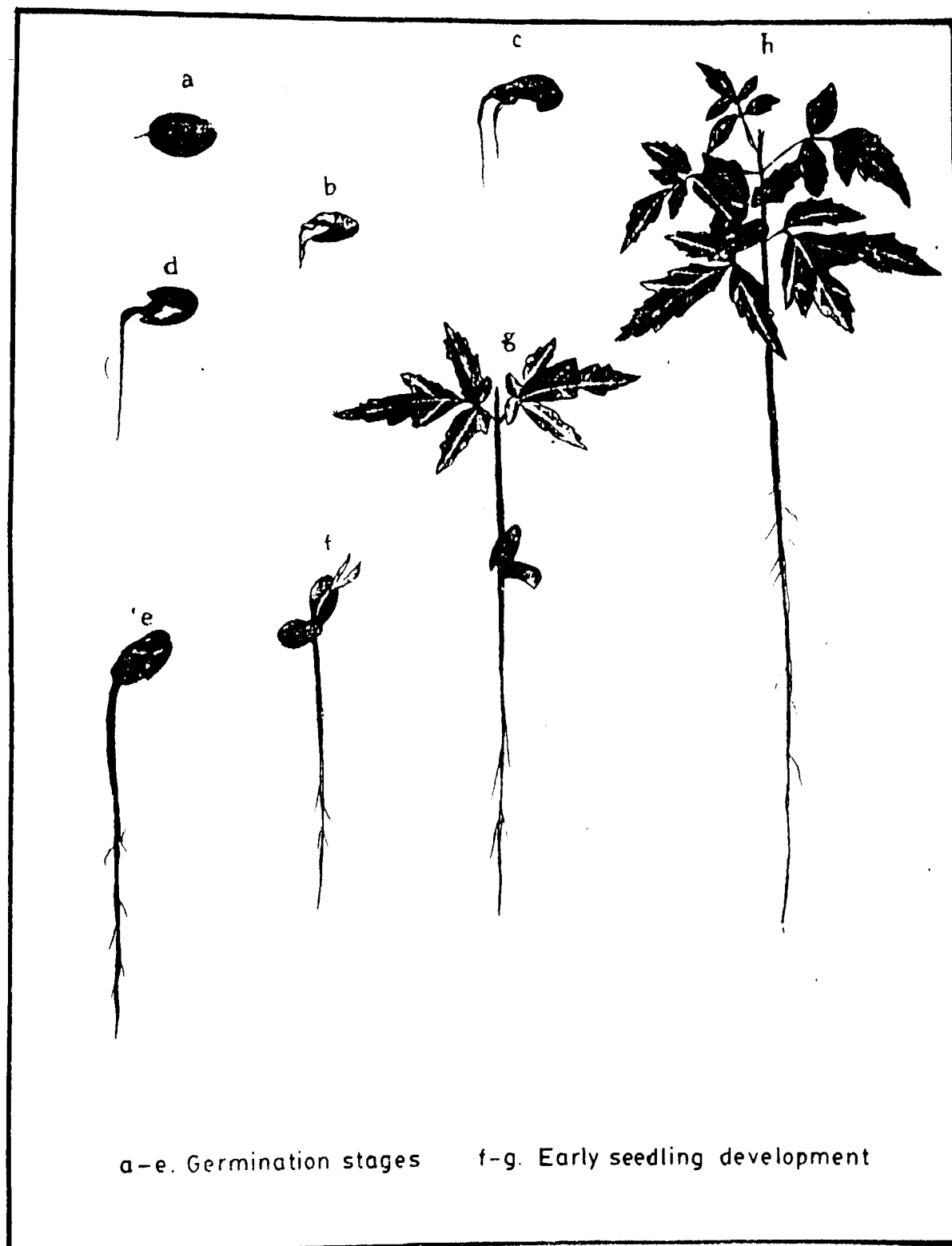
Order: *Meliaceae*

Evergreen tree and becomes deciduous in dry localities and new leaves appear in March-April. A moderate sized to large tree with a fairly dense rounded crown and glabrous imparipinnate leaves; bark moderately thick, furrowed longitudinally and obliquely, dark grey, reddish brown inside. The heart wood is red, hard, and durable and is used for house building, furniture and many other purposes, The bark, gum, leaves and flowers are all used in medicine, while the seeds yield an oil used in medicine and also for burning. Leaf and seeds contain the alkaloid called **Margosin** and **Azadirachtin** both having insecticidal property. The cake from the seed after oil extraction serves as good manure, especially in the rice field. Besides it is also fed to the cattle.

Distribution and Habitat

Gamble says that if wild anywhere in India it is probably so in the forests of the Carnatic and parts of the Deccan. It is cultivated all over India and Burma, more especially in the drier parts of the country and has evidently become wild in many localities as an escape from cultivations. It is a very useful roadside or avenue tree in dry and moderately dry climates, thriving as a rule where the normal rainfall varies from 18 to 45 inches and where the maximum shade temperature may be as much as 120°F., though it will not stand excessive cold.

It will grow on most kinds of soil, does well on black cotton soil and does not do badly even on clay. It thrives better than most other species on dry stony shallow soil with a waterless subsoil, or in places where there is a hard calcareous or clay pan not far from the surface. It will not grow well on land liable to inundation.



Flowering and fruiting

The panicles of small white flowers, smelling honey, appear from March to May and the fruit ripens from June to August. The fruit is a smooth ellipsoidal drupe 0.5 to 0.7 inch long, greenish yellow when ripe, one-celled and one-seeded or sometimes two-seeded (Fig .4)

Germination

Epigeous. The true testa of the seed is a brown papery covering inside the cartilaginous putamen of the drupe. The radicle emerges from the end of the seed and the hypocotyle arches withdrawing the cotyledons from the two coverings and in straightening, raising them above ground; the two coverings are either left in the ground or carried up over the cotyledons from which they eventually drop to the ground (Fig. 40)

***Derris indica* syn *Pongamia glabra* vent**

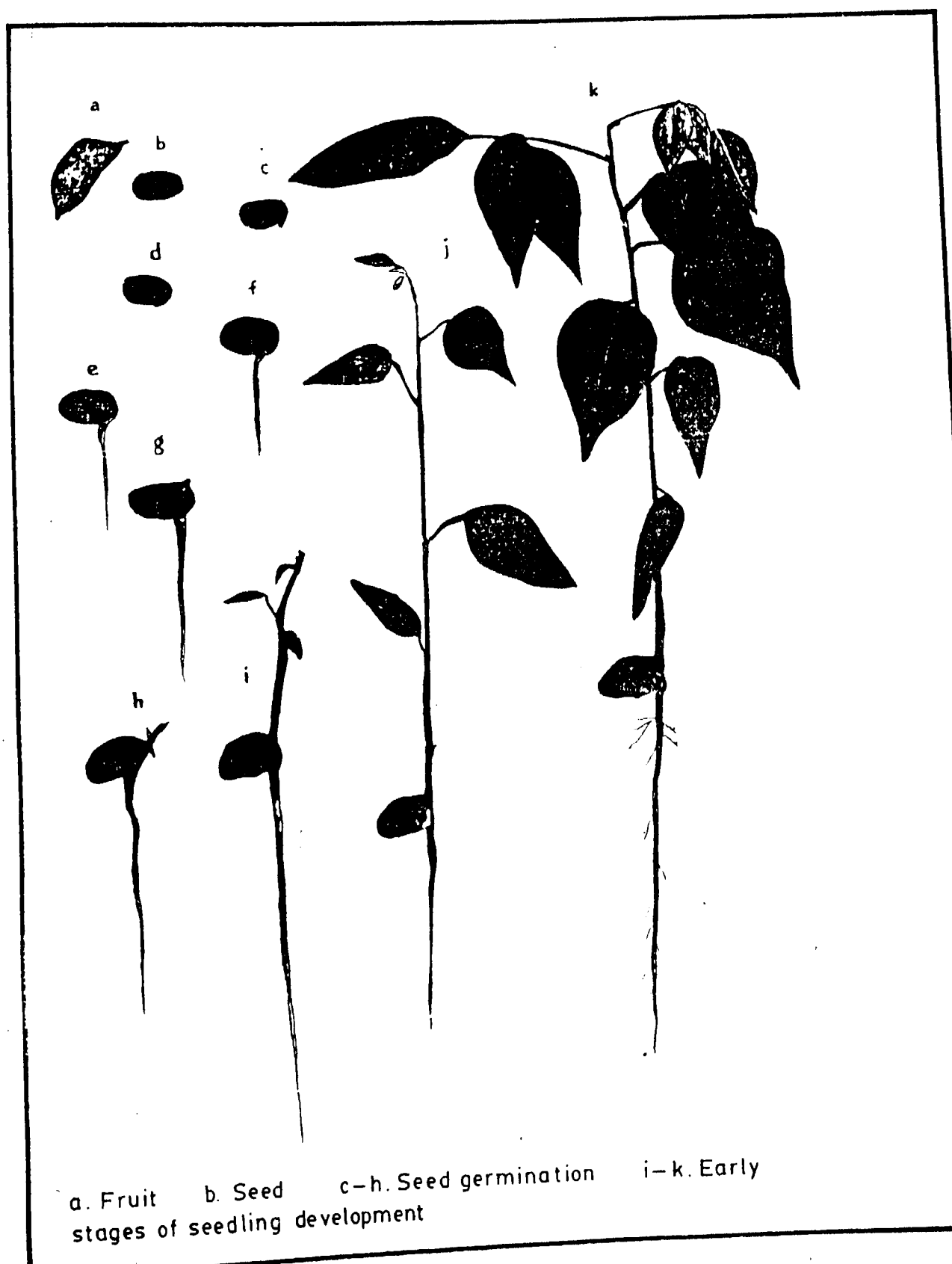
Order: Leguminaceae.

A moderate sized nearly evergreen tree with a spreading shady crown and short bole; bark fairly thin, smooth. grey, yellowish inside. The wood which is yellowish white, is not durable and is used mainly for fuel. The tree is planted for shade and ornament throughout the greater part of India. The seeds yield a thick oil used for burning and as an application for skin diseases. The oil contains an alkaloid called **Derrin** has got insecticidal property.

Distribution and Habitat

The tree is wonderfully adaptable as regards locality, although commonly found wild in the sandy beds of streams or along the sea-shore, thriving with its roots in fresh or salt water. It is grown successfully as a road-side tree in comparatively dry parts of the

Fig. 41 Stages seed germination and seedling development in Derris indica. L.



known to have been cultivated successfully the absolute maximum shade temperature varies from 100°F, the absolute minimum from under 30° to over 60°F., and the rainfall from 20 to over 100 inches.

Flowering and Fruiting

The racemes of lilac flowers appear from April to June. Racemes sometimes paniced, about 3-5 inches long, calyx truncate, standard orbicular, with inflexed auricles at the base; keel slightly incurved obtuse. Upper stamen free at the base, connate with others in a tube in the middle; anthers uniform. Ovary nearly sessile, with 2 ovules; style incurved, stigma small, terminal. Pod broadly and obliquely oblong or slightly falcate, thick but flat, 1 or 2 seeded, indehiscent, the sutures obtuse, without wings. The pods ripen from March to May in the following year. Pods are 1.5 to 2 inches long by 1 inch broad, pointed at the both ends. Seeds are approximately 0.7 to 0.8 inch by 0.5-0.7 inch compressed, elliptical or reniform, wrinkled, reddish brown, testa leathery. (Fig.5)

Germination

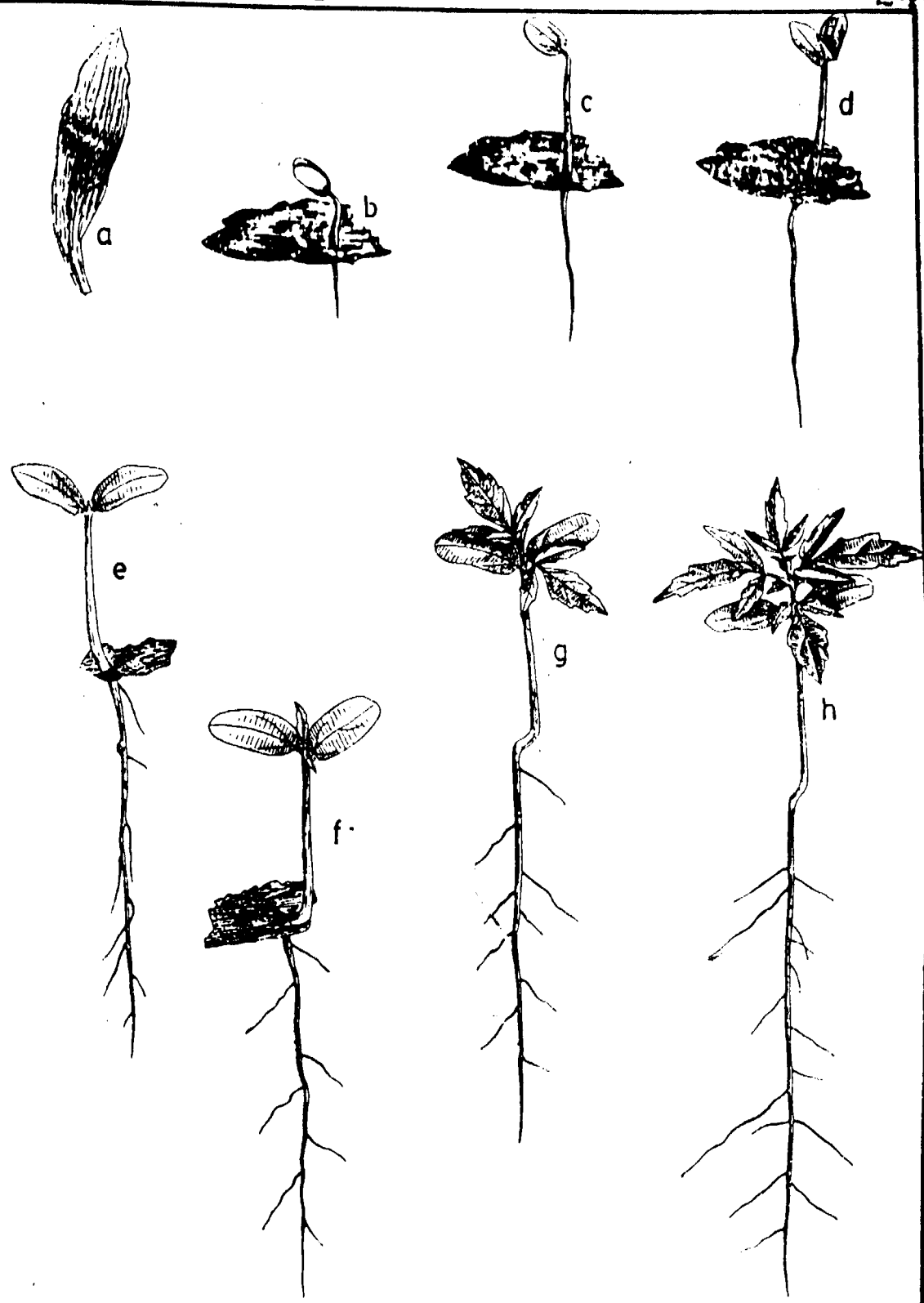
Hypogeous. The thick radicle emerges from one end of the seed and the primary root attains some length before plumule appears, the young shoot arching to extricate itself and then straightening. (Fig. 41)

Ailanthus excelsa, Roxb.

Order: Simarubaceae

Other species in the order simarubaceae are

- i) *Ailanthus malabarica*, DC;
- ii) *A. glandulosa*. Desf.



a. Samara b-e. Stages of germination
f-h. Early development of seedling

Description about the tree

A large deciduous tree, bark light grey and smooth in young trees, with large conspicuous leaf-scars, rough, granular and greyish brown in older ones. Leaves pinnaetely compound, upto 3 feet long with 8-14 pairs of leaflets. In seedlings and saplings imparipinnate leaves are the rule for the first three or four years, after which the terminal leaflet becomes reduced in size, or is represented by a mere prolongation of the rachis, and finally the typical abrupt paripinnaete leaves are formed during fourth or fifth season. The wood, which is soft and white, is used for packing-cases, and is reported to make good match splints.

Distribution and Habitat

Indigenous in the Indian peninsula and often planted in different parts of India. It is found in mixed deciduous forest and in the central provinces, also in sal forest.

Flowering and Fruiting

The panicles of small yellowish flowers appear in February-March and fruits ripen in May-June. The fruit is a red, one seeded samara, 2-3 inches long by 0.5-0.6 inch wide, prominently veined, acute at both ends and twisted at the base. The fruit being winged is adapted for dissemination by wind.

Flower description

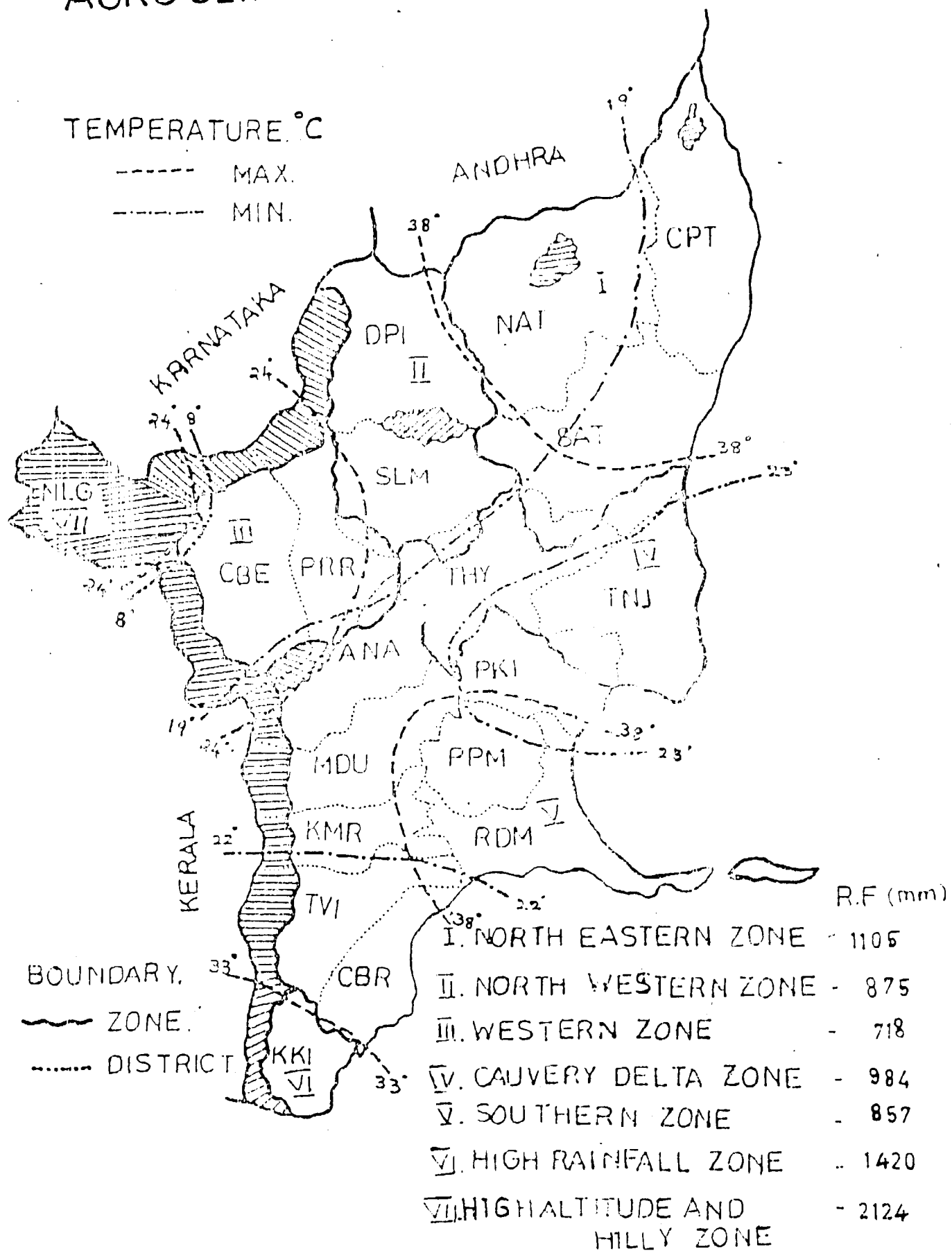
Flowers polygamous, calyx small, 5 lobed, lobes equal imbricate, petals 5 patent valvate or slightly imbricate at the sides with tips incurved, disk 10 lobed, stamens 10 in the male flowers, (10 or fewer or non in the female or hermaphrodite) inserted at the base of the disk filaments very short or filiform without scales, ovary of 2-5 carpels more or less connate (rudimentary in the male flowers) carpels compressed 1 celled, styles as many as the carpels, consolidated into 1 with plumose stigma, often more or less distinct

towards the base, ovules solitary in each cell attached to the ventral suture below the apex, fruit of 1 to 5 oblong membranous samara thickened in the centre round the single seed, seed flattened, suspended, testa membranaceous, albumen scanty, cotyledons leafy nearly orbicular, radicle short superior. (Fig.6)

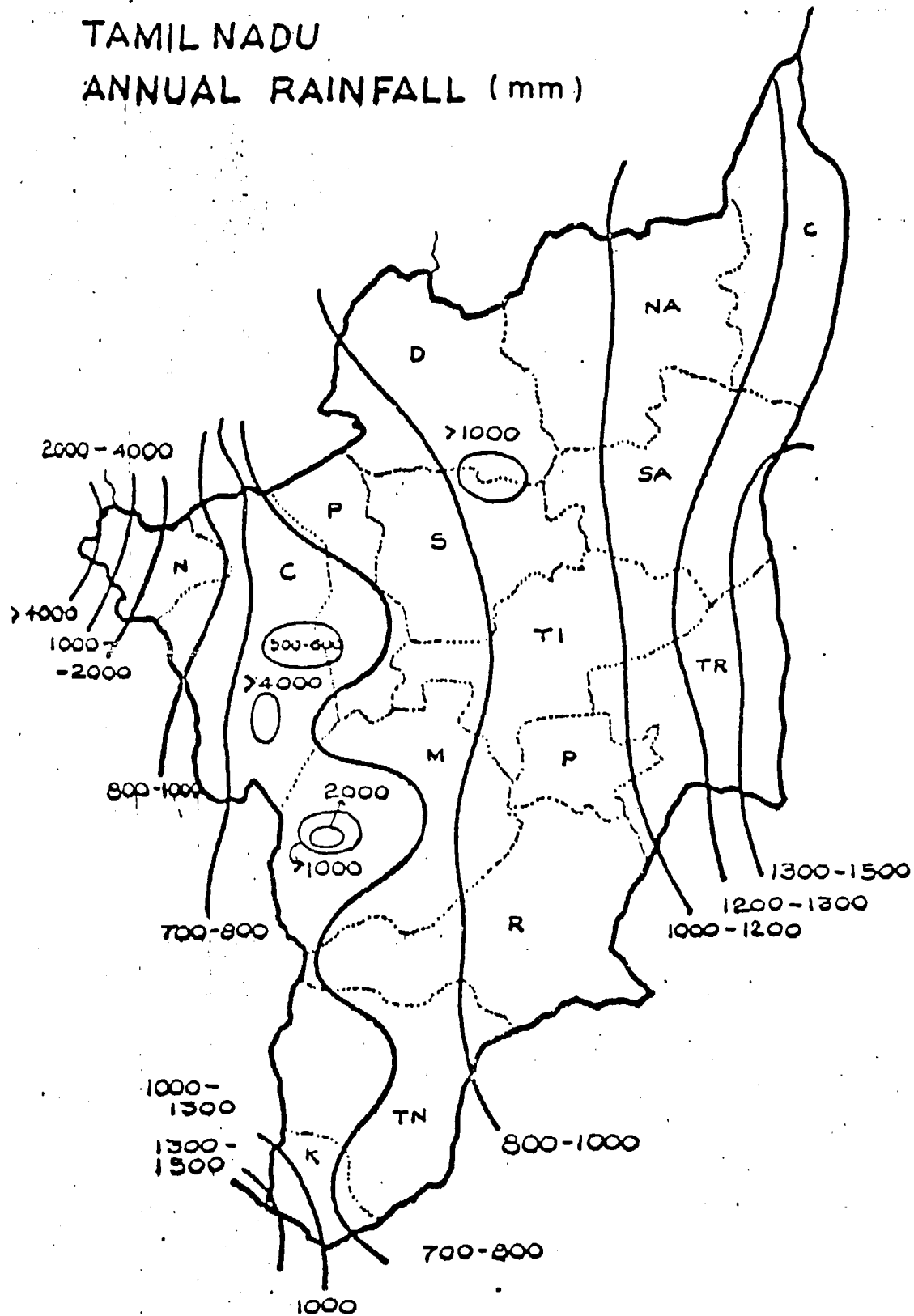
Germination of seeds (Fig. 42)

Epigeous. The radicle and plumule emerge from the cell and break through the winged covering, the cotyledons being carried up and the testa usually left inside the fruit. There is a decided kink at cotyledon base owing to the effort of the seedling to escape from the cell in which the seed is enclosed.

AGROCLIMATIC ZONES - TAMIL NADU ²⁰¹

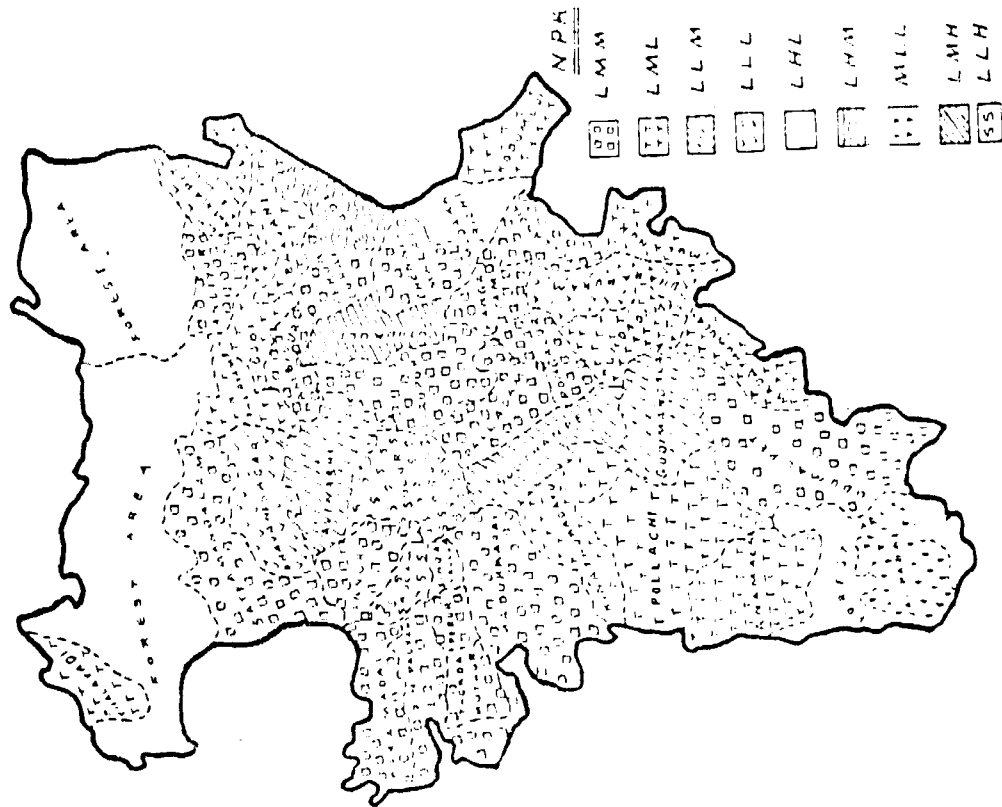


TAMIL NADU
ANNUAL RAINFALL (mm)

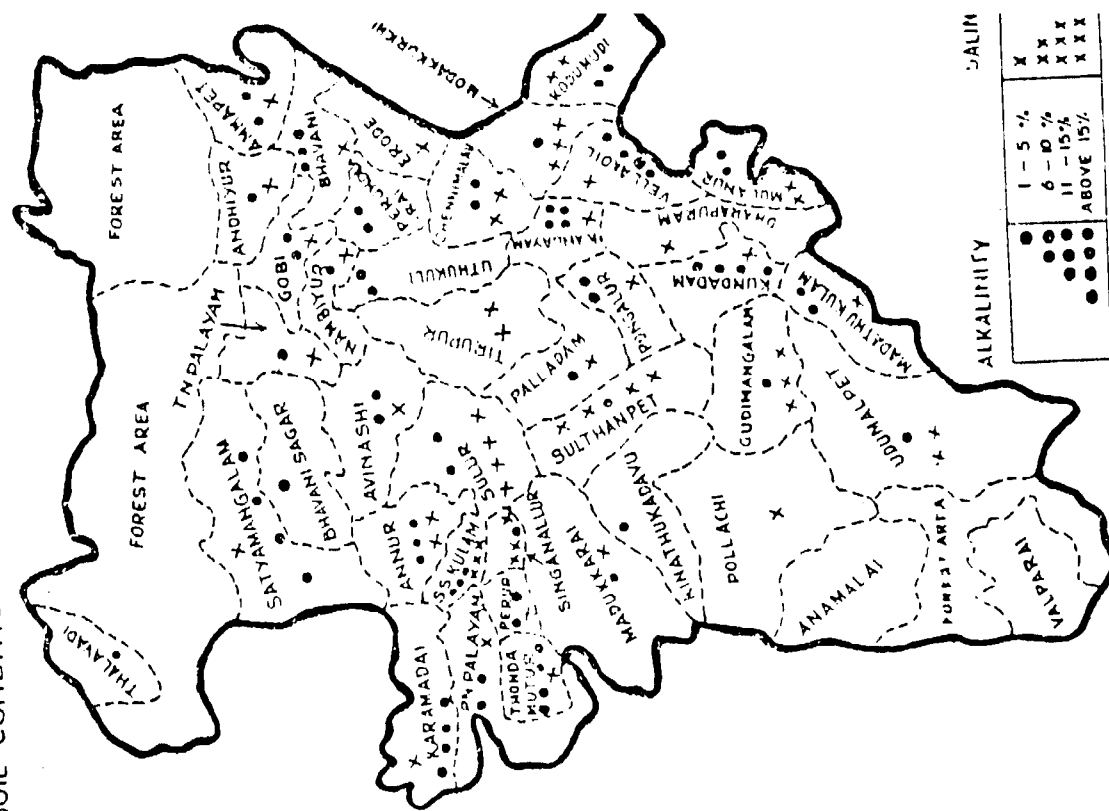


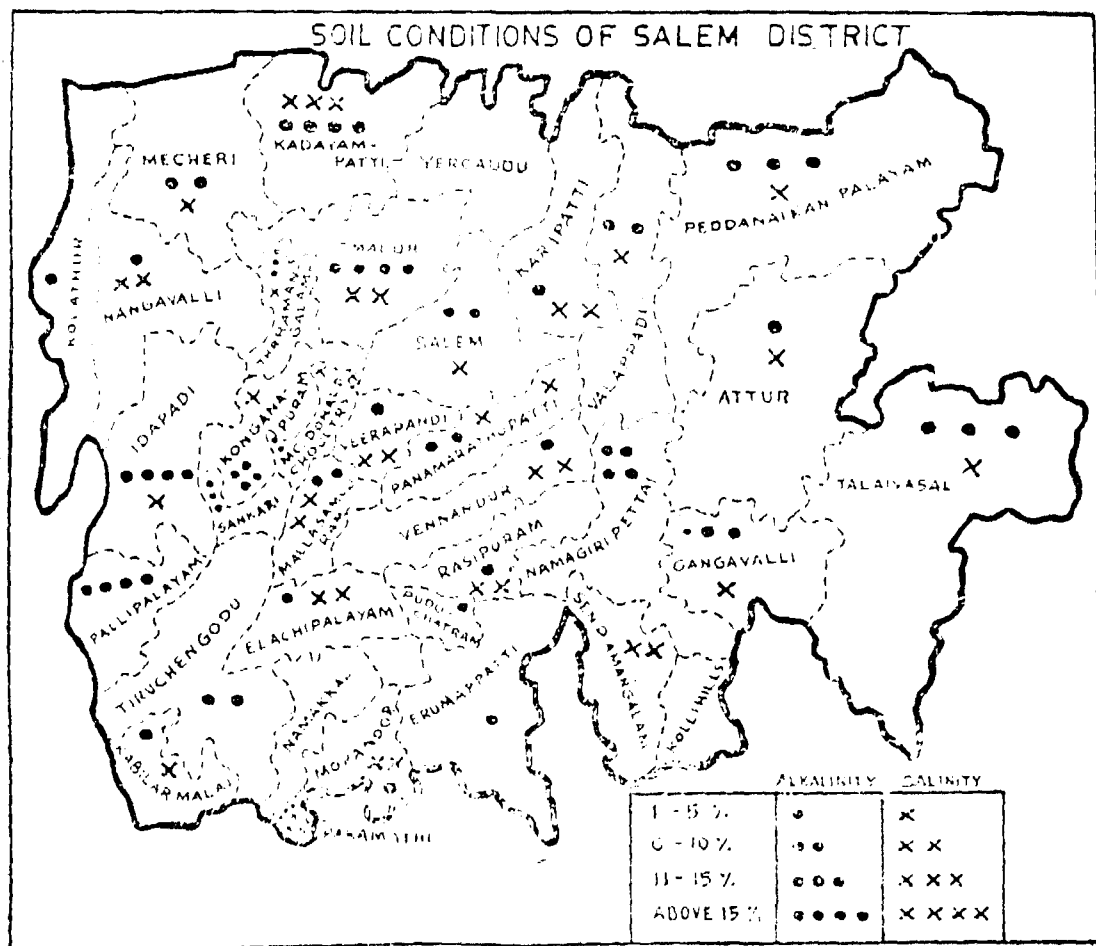
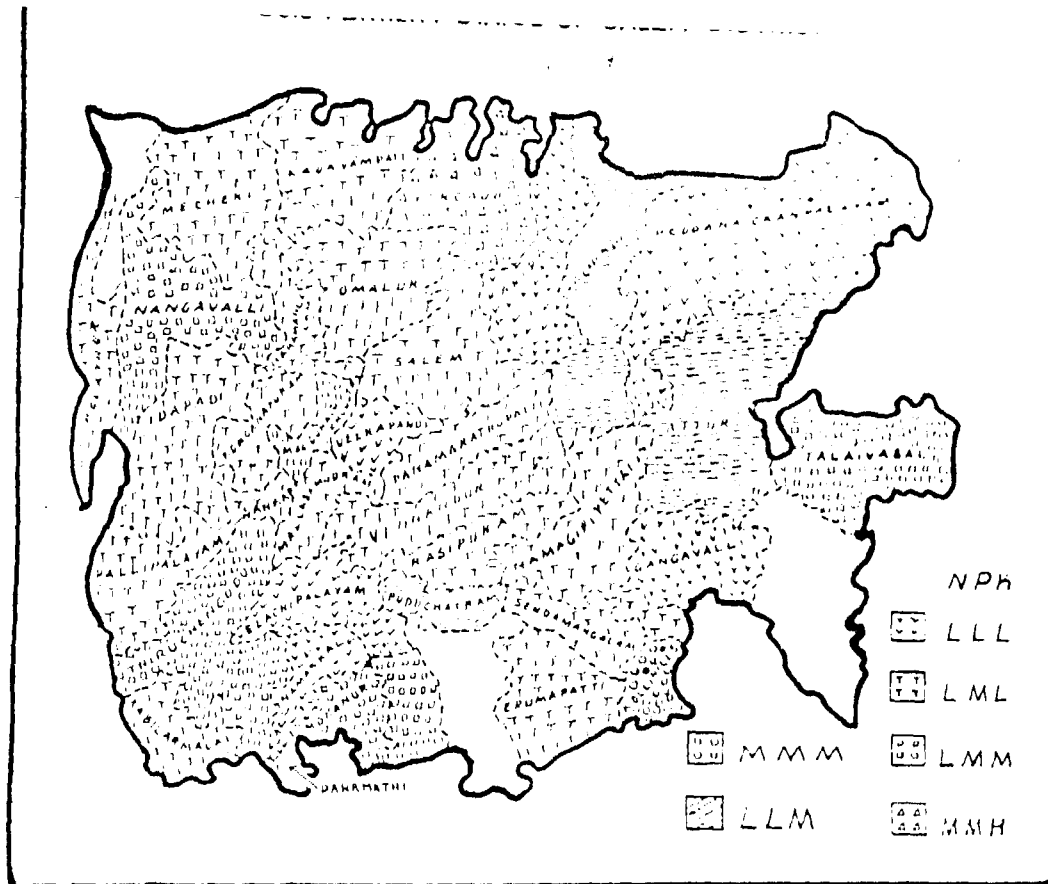
C

SOIL FERTILITY STATUS OF COIMBATORE DISTRICT

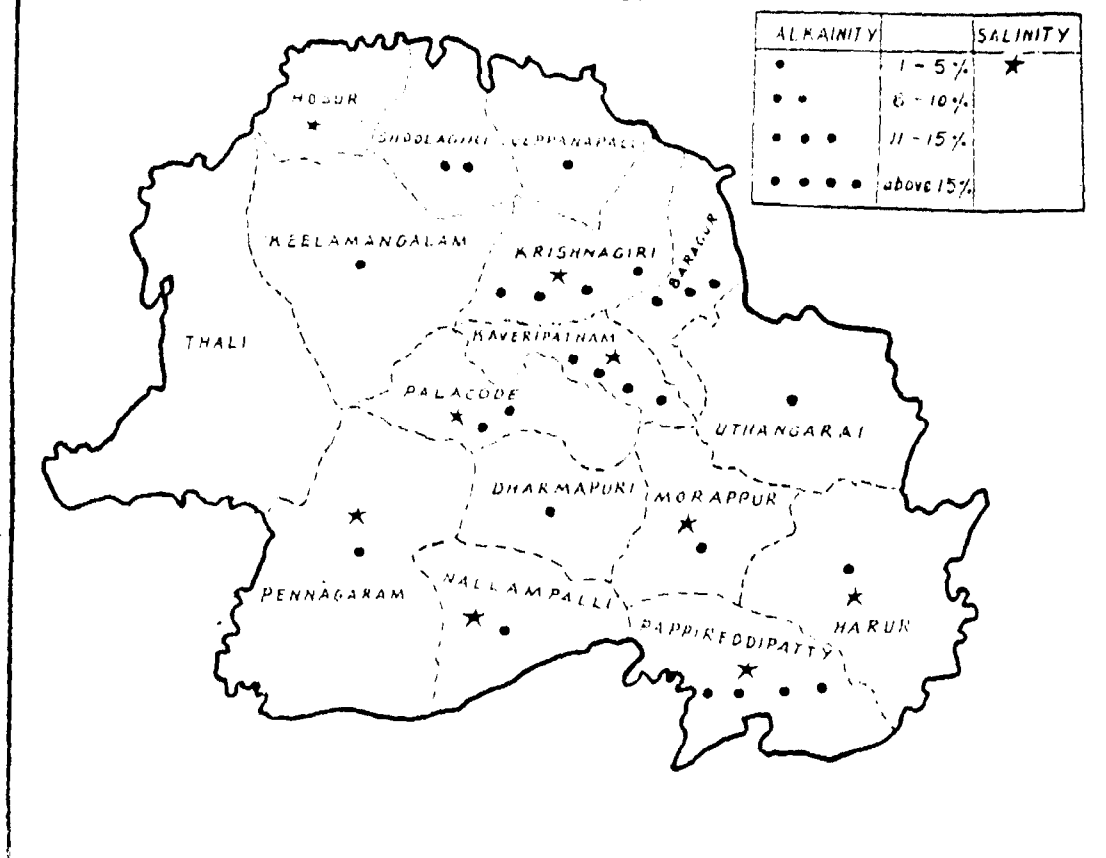


SOIL CONDITIONS OF COIMBATORE DISTRICT

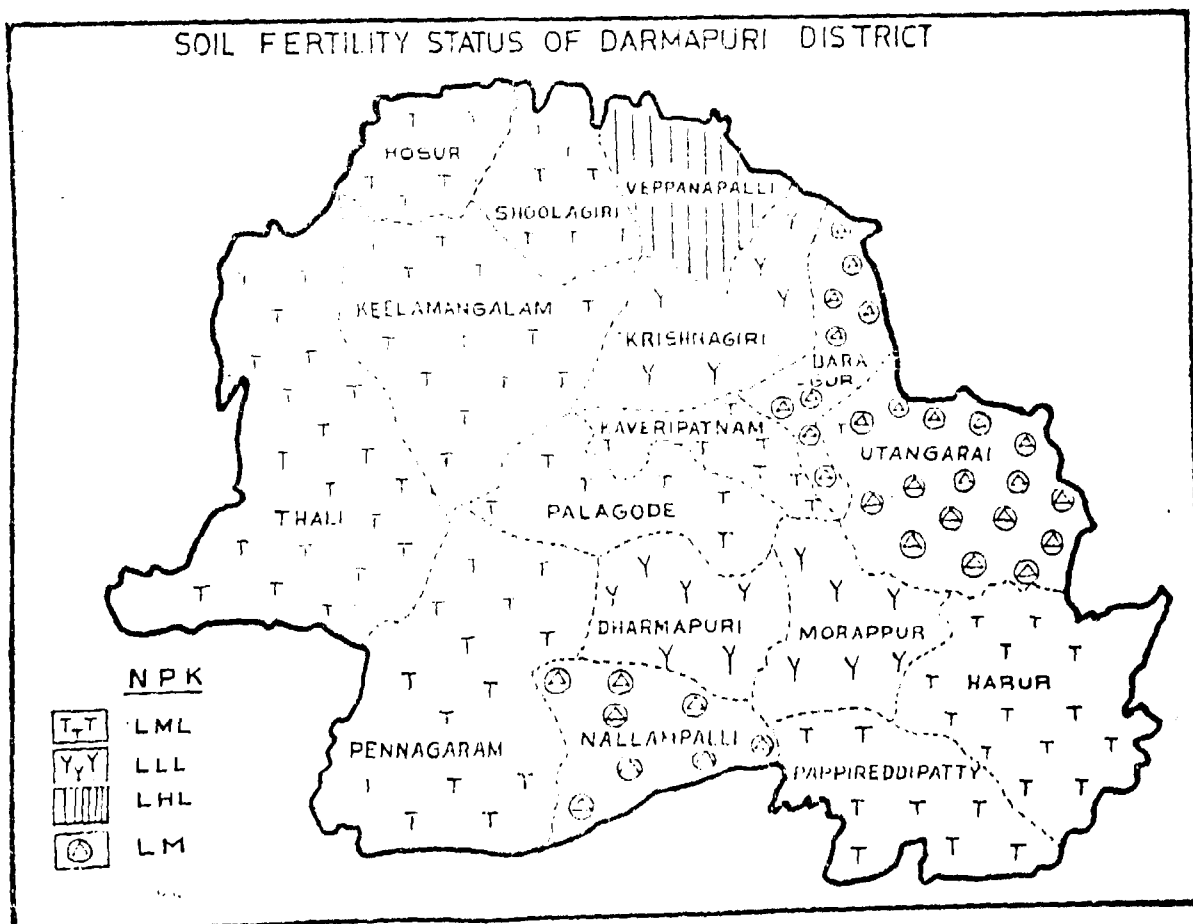




SOIL CONDITIONS OF DHARMAPURI DISTRICT

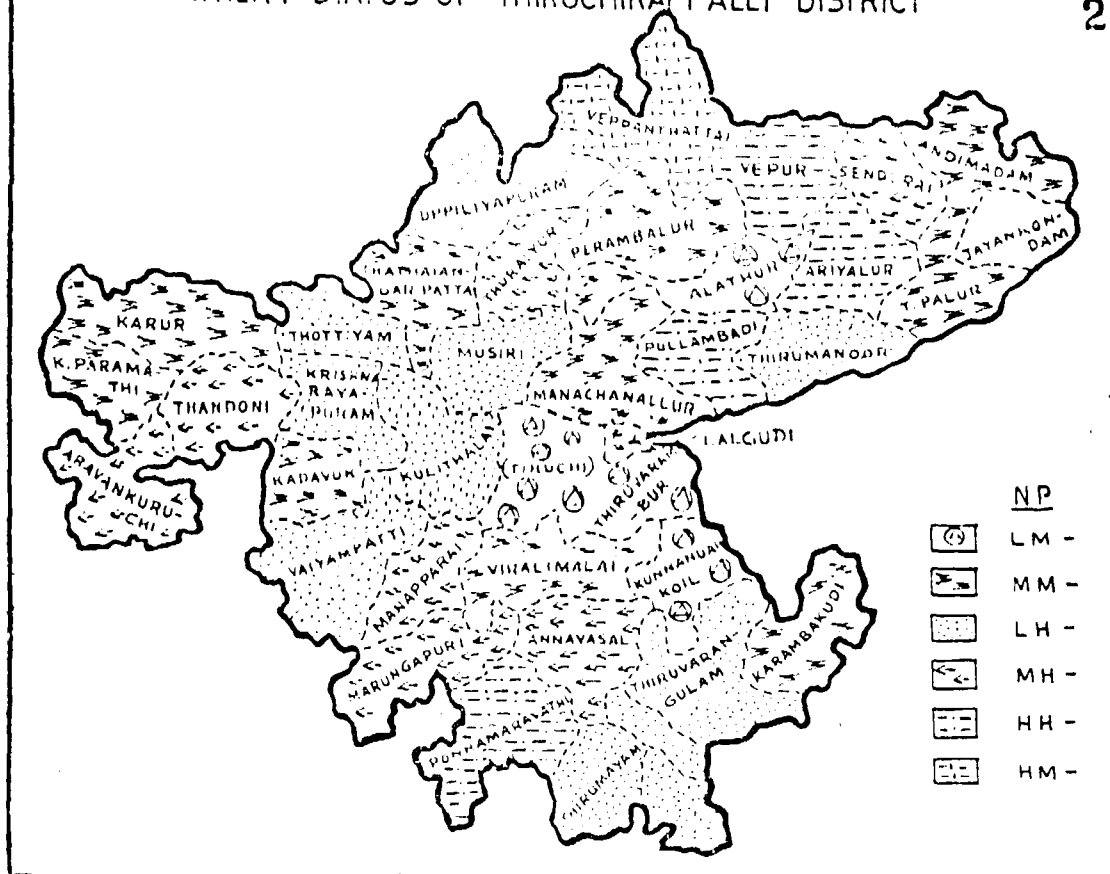


SOIL FERTILITY STATUS OF DHARMAPURI DISTRICT

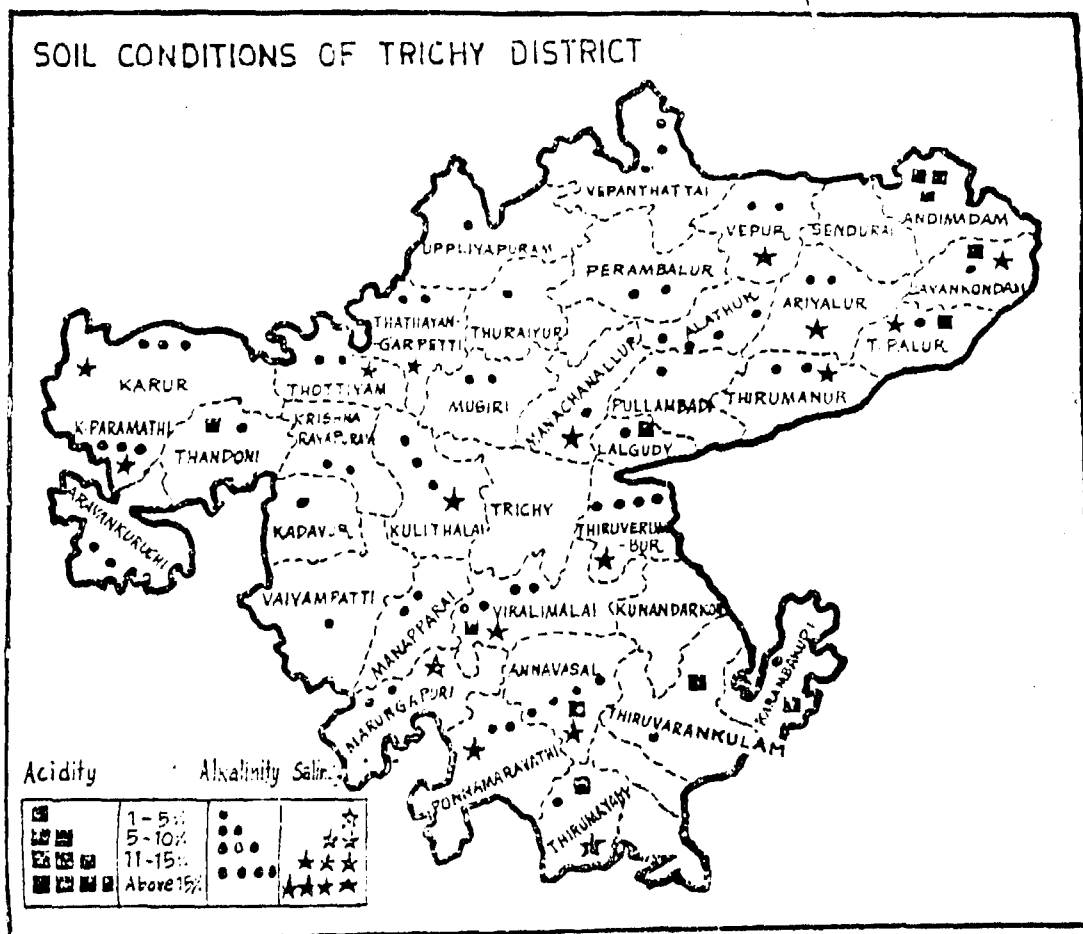


SOIL FERTILITY STATUS OF THIRUCHIRAPPALLI DISTRICT

256

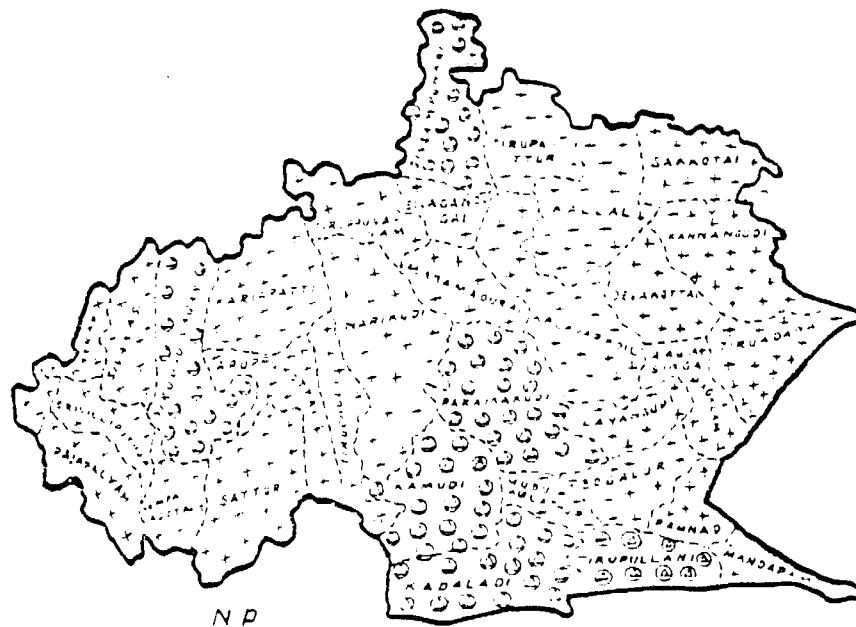


SOIL CONDITIONS OF TRICHY DISTRICT



SOIL FERTILITY STATUS OF RAMANATHAPURAM DT.

258



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