# STUDIES ON PROVENANCE, NURSERY MIXTURE AND PRE SOWING TREATMENTS ON SEED QUALITY AND CJARACTERIZATION IN PONGAMIA

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# 1. INTRODUCTION

India ranks sixth in terms of consumption of energy, which is 3.5 percent of the total world's commercial energy. The current consumption of diesel in India is about 40 million tonnes (40% of the total petroleum product consumption) and is expected to reach 80 million tonnes to 120 million tonnes in the next ten years. Where as domestic production of crude oil and natural gas will remain around 33.97 million tonnes during 2006-07. Hence there will be a huge gap between demand and supply which needs to be met through increasing fuel imports or increasing production of bio diesel through developing bio diesel plantations without sacrificing the food security of the country. Bio diesel is renewable energy resource generated from rehabilitation of waste and degraded lands. (Wani and Sreedevi, 1995).

Self reliance in energy is vital for overall economic development of our country. The need to search for alternative sources of energy which are renewable, safe and non polluting assumes top priority in view of the fact that fossil fuel sources are finite and are the major source of releasing sequesteral carbon to atmosphere as CO2 and CO causing global warming. In addition, uncertain supplies and frequent price hikes of fossil fuels in the international market stresses the need for exploration of alternative ecofriendly sources like bio diesel are of great concern. Among the many tree species, which can yield oil as a source of energy in the form of bio diesel, *Pongamia pinnata* has been found to be one of the most suitable species. In India being widely grown, it is N2-fixing tree, not browsed by animals and oil is non-edible. The species has various favorable attributes like its hardy in nature, high oil recovery and quality of oil will serve as bio diesel plant. It can be planted on degraded lands through Joint Forest Management (JFM), farmer's field boundaries, wastelands / fallow lands. Indigenous production of pongamia oil will save foreign exchange worth of several million dollars and also generate employment opportunities in rural areas. Pongamia seed oil as a bio fuel has physical properties very similar to conventional diesel. Emission properties, however, are cleaner for bio fuel than for conventional diesel. It has no polyaromatic compounds and reduced toxic smoke and soot emissions. A drastic reduction in sulphur content (<350ppm) and higher cetane number (>51) will be required in the petroleum or diesel produced by Indian refineries. However, bio fuel meets these two important specifications and would help in improving the lubricity of low sulphur (0.13- 0.16%) diesel.

Pongamia (*Pongamia pinnata* (L) pier.) locally known as honge or hulaga is an indigenous tree to India. It belongs to the family Leguminous and sub family Pappilionaceae. *Pongamia pinnata* (L.) pier or *Pongamia glabra* is its botanical name. The word pongamia is derived from the Tamil name for the tree Ponga or Pongam. It is found all most through out India upto an altitude of 1200 m and the tree is considered to be native to Western Ghats. It is chiefly found along the banks of streams and river or near sea coast in beach and tidal forests. It can be grown in a variety of soils and climatic conditions. Even it can be grown in dirty tracts up to an elevation of 1000m. Pongamia can grow on most soil types ranging from stony to sandy to clayey. It does not do well on dry sands. It is common along waterways or seashores, with its roots in fresh or salt water. Highest growth rates are observed on well drained soils with assured moisture.

Pongamia is often grown as road side avenue tree nearly all over India. It resists drought well, moderately frost hardy and highly tolerant to salinity. The tree is used for afforestation, especially in watersheds, in drier parts of the country and also in social forestry plantations. The tree starts bearing at the age of five to seven years. The fruits can be harvested at different periods of the year in different parts of the country, but the harvest season is extended in general from November-December to May-June. The pods are collected and the shells are removed by hand. The yield of fruit varies from 9 to 90 kg per tree for different age trees. There is no systematic organized system for collection of seeds in the forest department. Mixture seeds consist of 95 per cent kernel and are reported to contain about 27 per cent oil. The oil yield is reported to be about 24 to 26.5 per cent if mechanical expellers are used for the recovery of oil from kernels, but it is only 18-22 per cent from village crushers. The crude oil is yellow orange to brown in colour which deepens on standing. It has a bitter taste and disagreeable odour, thus it is not considered for edible purpose.

*Pongamia pinnata* cultivation would be the most popular alternative land use system in the new millennium. The wasteland in India which is around 80 million ha. can be used to raise the bio fuel plants and other fast growing tree species. Besides honge can be grown on unproductive and under productive agricultural lands where economic cultivation of arable crops is not possible. If proper silvicultural practices are followed it is possible to produce 2 to 2.5 tonnes of pongamia oil from one hectare land. There is a need for massive afforestation of wastelands which could be brought under profitable land use.

The tree is under exploited, though all the parts of the tree could be used for various purposes. At present out of total seeds collected 30 percent is used in industries, remaining 70 per cent is used for preparation of ayurvedic medicine and biofuel used for running tractors. The tree responds tremendously for coppicing/pollarding and the lopping is mainly used as green manures in paddy fields in southern parts of India. Its wood with a calorific value of 4600 - 4800 kcal per kg, pongamia is commonly used as fuel wood. Its wood is beautifully grained and medium to coarse textured. However, it is not durable, is susceptible to insect attack, and tends to split when sawn.

NABARD, as an apex institution with regard to policy, planning and operation in the field of agriculture and rural credit, is actively involved in extending credit support for renewable energy development in rural areas along with other financial institutions. Development of wastelands through energy plantations, bio diesel crops / tree borne oilseeds is identified as a thrust area for which NABARD is extending 100 per cent refinance to banks at a concessional rate of interest.

Early growth and survival of seedlings are important aspects of forest management to ensure quick economic returns of the species. Nursery is the pre requisite for raising tree plantations. Raising seedlings in nurseries is a common phenomenon; plantations can be forecasted by inspecting the site of the nursery, composition of the nursery stock and health of the seedlings. In recent years the importance of nursery grown seedlings has increased immensely because of heavy requirements of the seedlings both for supply to public for planting under social forestry programme and for massive afforestation programmes taken up by the government. There are evidences of nursery media affecting the growth and vigour of seedlings as a result of more spread of roots resulting better uptake of available nutrients and moisture. The information on the effect of media on growth of seedlings is absolutely essential for large scale production of healthy seedlings in nursery, the ultimate advantage of good nursery media with good drainage, better water holding capacity and it gives excellent disease free growth of seedling (Noble, 1993)

Besides genetic factor, seed quality is also governed by several factors like biotic and abiotic. Among abiotic factors environment plays a major role as rightly said by Heydecker (1972) as seeds are influenced by location in which they are produced. The seed quality may differ within a lot and between lots irrespective of their production and the season in which they are produced can influence the seed quality to large extent. Variability in seed quality that exists between locations can be related partially to the difference in the habit of the growth and reproduction and partially to the adaptability of the genotype to the environment factors like temperature, relative humidity, sunshine hours and wind velocity besides the edaphic factors.

Many studies have revealed wide variability existing among crop varieties in seed or grain morphology. However, this approach is not possible to employ for characterization of varieties of different crops. Of the alternative techniques available, electrophoresis is the most widely used due to their rapidity and reproducibility.

In view of enormous potentiality of *Pongamia pinnata* for afforestation of degraded land and to meet the target for the bio fuel and at the same time aiming to achieving realization of its multiple uses, to identify and to exploit the available genetic variability with respect to seed yield and more particularly the oil yield, the present investigations was undertaken to popularize the species by way of easing the silvicultural techniques for its effective cultivation by both farming community and forest managers with the following objectives

i. To know the provenance effect on seed quality in pongamia

ii. To identify the suitable nursery mixture for raising pongamia seedlings

iii. To study the effect of hydro priming and fungicide on germination and vigour in pongamia species.

iv. To characterize superior provenances through seed protein and enzyme analysis

# 2. REVIEW OF LITERATURE

The review of literature pertaining to the influence of provenance on seed quality, nursery mixture, hydro priming and seed treatment on seedling quality, seed storage proteins and quantification of enzymes are presented below. The information on these aspects in pongamia is very meager, with intense scrutiny of the literature; it was found that little work has been done on these aspects. Hence the reviews on bio fuel species or other tree species have also been included.

2.1 Influence of Provenance on Seed quality.

2.2 Standardization of suitable nursery mixture for pongamia.

2.3 To study the effect of hydropriming and fungicide seed treatment on germination and vigour of pongamia species.

2.4 Characterization of superior provenances through enzymes and protein analysis.

The term provenance refers to the geographic source of seed or plant material or to the plants from such a source. It is generally true that tree species with a wide geographical distribution exhibits considerable provenance variation in anatomy, morphology and physiology. Genecological studies of tree species provide information on the pattern and extent of phenotypic and genotypic variation. The variability may be related to the distribution of continuous or distinct environmental factors such as soil type altitude, or latitude with their associated factors of precipitation, temperature and photoperiod. The relative contribution of genetics and environment to variation (both in classical taxonomic characters and in more recently studied physiological traits such as photo- or thermoperiodic response) may be evaluated by raising seedlings from various seed sources under relatively uniform conditions as in growth chambers, greenhouses, nurseries or field tests.

One of the important factors that affects seed quality is provenance. Therefore identification of suitable provenances for seed production is important. The success of any afforestation programme mainly depends on the availability and use of high quality seedlings.

## 2.1 Effect of provenance on seed quality

### 2.1.1 Seed morphological characters

Kant *et al.,* (1983), observed that the pea seeds developed and matured at cool temperature at Lahual (mean 17.5C) had higher germination than those produced at warmer temperature (mean 24.5C) at Delhi. The varieties P269, P989 and P 190 which required more than 70 days for flowering recorded higher germination than P1069 and P200 which took 68 and 64 days to flowering respectively.

Agro- ecological conditions largely comprising edaphic and environmental factors can have more than one effect on the performance of the seeds. Success in the establishment and productivity is a function not only of the species used but also the source of seed within the species The place of production has greater influence on seed quality characteristics such as, seed weight, shelling percentage, germination, seedling growth, vigour, oil content etc. The quality of the seed influenced by the weather conditions such as temperature, relative humidity, photoperiod, wind velocity, soil type, nutrition and soil chemical reactions vary from location to location (Lopez- Mata, 1987).

Lopez – Mata (1987) observed geological differences in provenance of *Brosinm alicastrum* tree of moist tropical forest. Significant difference in plant height and stem girth due to provenances was observed in Eucalyptus. Similarly significant variation with respect to morphological and physiological attributes in Sandal seeds was reported (Sindhuveerendra *et al*., 1999).

Bagchi (1992) reported that the reports on *Acacia nilotica* shows that bigger seeds produce vigorous seedlings and the vigour is maintained throughout its growth period. Among provenances of *Acacia nilotica* from each of which seed length, seed width and seed thickness were measured and the data revealed significant difference with respect to all these parameters and they concluded that the higher intercluster distance in different groups indicates higher variability with in the groups and it is quite likely that extreme individuals from different groups may help in selection. Hybridization between widely divergent groups may also help in producing greater genetic diversity which may be utilized for further selection.

Narayanaswamy (1994) collected groundnut seeds of JL-24 from 8 locations and TMV-2 from 12 locations. He observed significant differences among different locations for test weight (range varied from 38.2g to 46.5g for JL.24 and 25.7g to 34.90g for (TMV-2), germination percentage (74.67 to 94.67% for JL.24 and 75.00 to 83.33% for TMV-2) and germination percentage after accelerated ageing test (32.67 to 79.33 for JL.24 and 34.00 to 78.67 for TMV-2).

Deshpande and Mahadevappa (1996) evaluated the seeds of rice genotypes (Pushpa B, Mangala B, Pragthi B and Madhu B) produced from Bangalore, Mandya, Shimoga and Muidgere for various seed quality parameters. Significant differences were noticed due to provenances for seed characters and seed quality parameters. Seeds produced at Mandya and Bangalore recorded higher 1000 seed weight and density, as compared to the seeds produced at Shimoga and Mudigere.

Suresh *et al.,* (1997) studied the effect of seed source on seed and seedling quality and revealed that seed source having higher quality germination have resulted in higher shoot and root length, root / shoot ratio and they opined that clay and loamy soils are ideal environment for seed collection of *Acacia nilotica*. The 100 seed weight recorded significant trend among the different seed sources, root length of the seedlings also showed significant values between sources at 21 days after sowing. Performance trial of 25 provenances of six species of Eucalyptus revealed significant difference with respect to height, diameter breast height, basal area and volume (Chandra *et al*., 1998)

Thapliyal *et al.,* (1997) reported that there were significant difference among seed sources of *Pinus Roxburghi* in seed weight, germination per cent, germination value, root and shoot growth and seedling height after three months. Seed weight significantly correlated with cotyledon numbers, germination per cent where as, germination value significantly correlated with seedling height, seed weight and cotyledon numbers with longitude of the seed source.

Devagiri *et al.,* (1998) studied sixty seed sources of *Dalbergia sissoo* and observed there was significant variation for several pod and seed traits between seed sources. Seed weight and number of seeds per pod showed large amount of variation and could be taken as an important criteria in selecting and delineating seed source.

Mohit gera (1995) studied 20 provenances or seed sources of *Dalbergia sissoo.* Roxb. Scattered over wide range in India were studied for the pattern of genetic variation and character association. The results revealed the presence of highly significant variations among the provenances for height, number of branches and survival per cent. There are fair differences between phenotypic and genotypic co-efficient of variability indicating that these parameters are sensitive to environmental changes, the estimates of heritability and expected genetic gain were low to moderate for all characters, except number of branches which registered comparatively higher values of heritability (61.95%) and genetic gain (28.45%).

Sindhuveerendra *et al.,* (1999) reported that Sandal (*Santalum album*) seeds from various seed sources showed significant variation for morphologically and physiological traits. Data on seed length, seed width and seed weight showed significant amount of variation among different seed provenances.

Tyagi *et al.,* (1999) reported that for seed characters and germination the different provenances showed significant difference among seven provenances and the provenances revealed the existence of genetic variability in *Grewia optiva*.

Nautiyal *et al.,* (2000) reported that seeds of *Quercus leucotrichophora* collected from seven places in Ghahwal and Kumaun regions varying considerably in their longitude, latitude and altitude and tested for their seed attributes, germinability, seedling growth and survival. Provenance differed from each other in mean seed weight, germinability of seeds and seedling growth, but differences were significant more in rate of germination than total germination per cent.

Shivanna *et al.,* (2002) studied the provenance effect on seed quality in *Acacia nilotica*. They noticed significant difference in germination and vigour due to provenances. Similarly significant difference with respect to 100-seed weight, germination, root length, shoot length, seedling dry weight and vigour index was reported due to provenances in Acacia (Devarnavadagi *et al*., 2003). They also reported significant difference in oil content, Azardiractin content, collar girth, germination and vigour due to provenances in Neem.

Dhanai *et al.,* (2003) conducted a study to identify suitable seed source for production of quality seedlings for mass afforestation in agroforestry systems at central Himalayas in *Albizia chinensis*. Significant variations were recorded among 13 populations for pod and seed morphology. Altitude of seed sources was found non- effective. Among all the pod- seed characters, number of seeds/ pod and seed weight were found most variable characters, and, number of seed / pod had higher genotypic, phenotypic and environmental co-efficient of variability. This preliminary investigation will be useful for further genetic improvement of *Albizia chinensis*

Neelannavar *et al.,* (2003) carried out a study to estimate the genetic divergence among 30 seed sources of *Albezia lebbek* (L.) collected from all over India, to identify the promising seed source to be utilized in the breeding programme. Observations on seven characters namely seed length (mm), seed breadth (mm), seed thickness (mm), seed shape index, seed volume, 100 seed weight (g) and germination per cent were recorded. The study revealed that among the characters studied 100 seed weight contributed (44.37%) largely to genetic diversity followed by the seed shape index (15.63%).

Lavania and Virendra Singh (2004) effect of different seed sources was studied on germination, survival and early seedling growth of *Populus ciliate*. The study revealed that seed sources had statistically significant effects on seed germination and seedling growth. Germination percentage was positively and significantly correlated with shoot length, root length, total seedling length, vigour index and number of leaves.

Pradeep kumar *et al.,* (2007) collected 48 accessions of Pongamia and the data on various seed parameters, viz., pod length, pod width, seed length, seed width and 100 seed weight were recorded. The seed and seed oil content differed significantly among different accessions of Pongamia, the results of the study indicated that the pods and seeds of different accessions were polymorphic for seed length, seed width and 100 seed weight, oil content varied from 14. 30 to 33. 51 percent among the seeds of different accessions of Pongamia, indicating the considerable scope for selection of genotype for high oil content.

Dabgar *et al.,* (2007) collected seed samples of Jatropha from Uttar Kannada, Haveri and Shimoga of Karnataka to identify superior seed source, a total of 25 promising seed sources were collected. Data on various seed parameters. *Viz.,* seed length, seed width and 100 seed weight were recorded. The seed oil content differed significantly among different seed sources of *Jatropha curcas*. The minimum values for seed length (16.42 mm) in CPT-23 (Bisalakoppa), sed width (9.9 mm) in CPT- 22 (Ahrekoppa), 100 seed weight (53.75 g) in CPT- 4 (Byathnalaz), where as maximum values were recorded in CPT 15 with respect to seed length (19.45mm) seed width (12.54 mm) 100 seed weight (77.69 g).

### 2.1.2 Seed quality

Burris (1977) reported that the Maize seeds produced from three locations differed significantly in germination, shoot and root growth. Similarly in Safflower 28 genotypes of safflower planted at three locations in Marathwoda region of Maharastra showed differences in capsules per plant and yield. Average number of capsules per plant was more at Prabhani (54.96), followed by Bandapur (40.82) and Latur (36.86). Average yield per plant was maximum at Bandapur (36.57g) followed by Parbhani (33.01g) and Latur (29.99g) as reported by Manke and Sharma (1979)

Dhawan *et al*., (1981) reported that there was not much effect of location on protein and oil content of Groundnut kernels (bunch types). The range reported was from 46.75 to 49.33 percent at Ambala and at Sirsa it was 46.87 to 49.00 percent of oil content.

Umamaheshwar (1983) studied the influence of four different locations (Hebbal, Mandya, Madikeri and Sirsi) on seed quality of three rice varieties (Jaya, Pushpa and Prakash). He observed no significant differences with respect to germination, field emergence, speed of germination and seedling length.

Vanangamudi and Karivaratharaju (1985) reported that sorghum seeds produced at North Arcot gave 49 percent germination where as seeds produced at Coimbatore gave 65 percent germination.

Narayanaswamy (1994) collected groundnut seeds of JL-24 from 8 locations and TMV-2 from 12 locations. He observed significant differences among different locations for germination percentage (74.67 to 94.67% for JL.24 and 75.00 to 83.33% for TMV-2) and after accelerated ageing test germination percentage (32.67 to 79.33 for JL.24 and 34.00 to 78.67 for TMV-2).

Mohit gera *et al*., (1995) studied seed germination pattern of 30 provenances belonging to five sub species of *Acacia nilotica* and revealed that Indian provenances species gave maximum percentage of seed germination (75%), significantly a good correlation was evident between cumulative seed germination and number of days elapsed. Relative delay in the initiation of seed germination was found maximum in provenances of sub species *tomentosa* and sub species, *nilotica*.

Deshpande and Mahadevappa (1996) evaluated the seeds of rice genotypes (Pushpa B, Mangala B, Pragthi B and Madhu B) produced from Bangalore, Mandya, Shimoga and Muidgere for various seed quality parameters. Significant differences were noticed due to provenances for seed quality parameters. Seeds produced at Mandya and Bangalore recorded higher germinability and vigour index as compared to seeds produced at Shimoga and Mudigere.

Kumar and Toky (1996) reported that there were significant differences among most of the provenances of *Albiziz lebbeck* for seed germination that varied 5 percent to 94 percent in incubator and 8 per cent to 50 per cent in the nursery. The dry weights of the seedling were random and did not show any significant relationship with latitude or longitude of seed source.

Kajamaidden *et al.,* (1997) studied effect of geographic and seed viability and vigour in *Casurina euesetifolia* and observed the significant differences due to geographic variation in respect of all seed and seedling characters investigated, namely germination, root growth, shoot elongation and vigour index.

Suresh *et al.,* (1997) studied effect of seed source on seed and seedling quality and revealed that high seed quality germination have resulted in higher shoot and root length, root / shoot ratio and they opined that clay and loamy soils are ideal environment for seed collection of *Acacia nilotica*.

Thapliyal and Dhiman (1997) reported that there was significant differences among seed sources of *Pinus Roxburghi* in seed weight, germination per cent, germination value, root and shoot growth and seedling height after three months.

Nautiyal *et al.,* (2000) reported that seeds of *Quercus leucotrichophora* collected from seven places in Ghahwal and Kumaun regions varying considerably in their longitude, latitude and altitude and tested for their seed attributes, germinability, seedling growth and survival. Provenance differed from germinability of seeds and seedling growth, but differences were significant more in rate of germination than total germination per cent.

Shivanna *et al.,,* (2002) studied the provenance effect on seed quality in *Acacia nilotica*. They noticed significant difference in germination and vigour due to provenances. Similarly significant difference with respect germination, root length, shoot length, seedling dry weight and vigour index was reported due to provenances in Acacia (Devarnavadagi *et al*., 2003). They also reported higher oil content and Azardiractin content and significant difference in germination and vigour due to provenances in Neem.

Nayak *et al*., (2005) seeds of *Azardiracta indica* collected from different agro climatic zones of Karnataka showed significant difference with respect to germination and other seed quality parameters.

### 2.1.3 Seedling growth parameters

Lopez – Mata (1987) observed geological differences in provenance of *Brosinm alicastrum* tree of moist tropical forest. Significant difference in plant height and stem girth due to provenances was observed in Eucalyptus (Kapur and Dogran 1987, Chaturvedi *et al*., 1989). Balakrishna and Toky (1995) observed significant variation in stem height, number of branches and leaf and spine growth due to provenances in *Acacia*. Similarly significant variation with respect to morphological and physiological attributes in Sandal seeds was reported (Sindhuveerendra *et al*., 1999).

Manathuraginath *et al.,* (1992) studied growth performance of five provenances of *Casurina cunninghamiana* and compared with *Casurina equseitifolia* of two different sites and observed the height, Diameter breast height and volume up to end of fifth year, *Casurina cunninghamiana* is good in both the sites studied among the tried five provenances. But not to the extent of *Casurina equseitifolia*.

Kaushalendra kumar and Chhimunal (1993) reported growth and survival of sixteen different provenances of *Eucalyptus camaldulensi* showed insignificant differences both in case of diameter and height.

Suresh *et al.,* (1997) studied effect of seed source on seed and seedling quality and revealed that higher shoot and root length, root / shoot ratio and they opined that clay and loamy soils are ideal e3nvironment for seed collection of *Acacia nilotica*. Performance trial of 25 provenances of six species of Eucalyptus and the data revealed significant with respect to height, diameter breast height, basal area and volume (Chandra *et al* ,1998).

Mohit gera (1999) studied ten provenances or seed source of *Dalbergia sisso* Roxb. Scattered over wide range of its natural occurrence were studied for nursery and early field performance significant variation among the provenances were observed in parameters namely seedling height and collar diameter and field height and survival per cent.

Manga and David (2000) studied 40 genotypes of *Prosopis cineraria* Druce., collected from different districts of Rajasthan, Gujarat and Haryana and there genotypes were grouped into 11 clusters. Genotypes with high dry shoot weight, taller seedlings and higher values for collar diameter were grouped into different clusters and seedling height was found to be the major contributor towards divergence.

Ramakrishna Hegde *et al.,* (2000) studied early introduction of *Acacia ariculiformis* to India resulted a land race of poor from the new seed collections were compared with earlier introductions for seed and seedling characters and early performance in the field, *Acacia ariculiformis* had larger and heavier seed and more seedling biomass than *Acacia mangium* but the species did not differ in the shape of the seed.

Sharma *et al.,* (2000) reported that 10 provenances of *Acacia nilotica* which were suitable species for sodic soil, were screened for their relative performance. Mean survival of provenances was (95.33%) mean height of the plants were also increased from 98.08cm to 243.18cm and they concluded that Sholapur of Maharashtra was found to be most suitable provenance followed by Dhawnd for the sodic soil.

Shivanna *et al.,* (2002) observed significant difference with respect to germination value and seedling fresh weight in *Acacia nilotica* seeds obtained from different sources.

Kapoor *et al*., (2004) was carried out a field trial comprising of fifteen provenances of *Populus ciliate* Wall. Ex Royle at Solang Nallah, Manali (HP). Significant differences with respect to growth performance were observed amongst various provenances. Based on the over all growth in respect of height and diameter provenances, viz., Mussorie and Kullu Gushani had shown better performance over the remaining provenances under trial. These two provenances have therefore, been recommended for large scale plantation in Manali region of Kullu valley, (HP)

Mohit gera *et al., (*2004) reported that the analysis of variance of the data obtained on germination, seedling and field performance showed that the differences between seed sources were statistically non- significant for most of the traits studied in *Derris indica*. Except seedling height and height attained in the field. The extent of variation in most of the parameters studied was small and varied from 4.22 % (germination per cent) to 14.3 % (field height), respectively. The present study indicated that the seeds of different seed sources were polymorphic for seed length, seed width and 100 seed weight.

## 2.2 Standardization of suitable nursery mixture for Pongamia

### 2.2.1 Seedling emergence

The soil is one of the most important environmental factors, which plays an important role in seedling growth and establishment. Optimization of plant growth by matching species to suitable soil media is one of the most important nursery techniques in raising healthy growing stock.

The findings of Rimando (1981) revealed that Humus and sand in the ratio of 2:1 gave good results in producing seedlings of *Casuraina equisetifolia*. The seedlings had superior seedling parameters.

Shafiq *et al*., (1978) noticed the suitability of soil mixture 2:1:1 of alluvium sandy soil, heavy clay soil and FYM for the height and root growth of *Eucalyptus camaldulensis* and the ratio of 1:1:1 for height and root growth in *Pinus bruti* and *Casuarinas equisetifolia*.

The findings revealed that the species required sandy loam than the clayey loam or sandy soils. Bahuguna *et al.,* (1987) in *Acacia albida* and Bahuguna and Pyarelal (1990) in *Acacia nilotica* recommended the use of soil / sand (2:1) media until the time of pricking out and there after the addition of FYM to growing media for the production of healthy seedlings. They drawn this inference because best germination percent was noticed in soil mix containing no FYM and addition of FYM was needed to boost up the growth of seedlings at later stages.

The teak seedlings raised in the nursery mixture of Red soil: Compost (1:1) produced seedlings with highest values of vigour index, shoot: root ratio and leaf area compared to other nursery mixtures. The mixture is cheap and hence affordable to farmers (Dasappa, 1990).

According to Veerendra and Sharma (1990) the seedling vigour index, shoot: root ratio, leaf area and number of branches were highest in the mixture of Humus: sand (1:1) compared to other mixtures tested in sandal.

Saravanan (1991) opined that addition of optimum dose of NPK to the potting mixture of Red soil: Sand: Compost will help in enhancing the seedling vigour index, shoot: root ratio and leaf area of *Acacia* species compared to mixture alone.

According to Dhar *et al.,* (1992) farm manure was found to be the best medium for raising healthy and vigours seedlings of *Leucaena leucocephala* in polythene bags.

According to Ani and Gopikumar (1993) the seedlings of different dryland tree species produced better seedling vigour and growth parameters when grown in Tank silt: White sand: Compost (1:1:1) nursery media over all combinations. The highest response among different tree species was noticed in Eucalyptus and Casurina.

Bahuguna and Pyarelal (1993) found that for better germination of *Acacia auriculiformis*, the soil medium (soil and sand) should be in the 2:1 ratio. They also emphasized that farm yard manure could be added for the better growth of the seedlings at the time of transplanting. For exotic Pines, such as *Pinus elloti*, *P. greggii* and *P. petula*, the use of pure sand as nursery medium was best for achieving good germination.

Pyarelal and Karnataka (1993) reported that the seedlings of *Quercus leucotrichophora* could be raised by sowing the seeds in soil mixture consisting soil, sand and farm yard manure in 2:1:1 ratio in nursery for better germination and growth parameters.

Deswal *et al.,* (1994) evaluated Dalbergia *sissoo, Prosopis cineraria, Acacia nilotica, Acacia tortitis, Acacia indica and Leuacena leucocephala* in the nursery for root and shoot length. *Leuacena leucocephala* showed the best performance of root and shoot length. *Leuacena leucocephala and Acacia nilotica* were observed to have long growing period as compared to other species. On the basis of root : shoot ratio of different species it could be established that *Prosopis cineraria and Dalbergia sissoo* are drought hardy species, where as *Leuacena leucocephala* required sufficient moisture for proper growth.

Sudhakar *et al.,* (1995) stated that rooting medium containing sand, soil and farm yard manure in the ratio of 1:1:1 was significantly better than the rooting medium with sand and soil in the ratio of 1:1. The seedlings were superior to other media tested. The seedling vigour index leaf area, number of branches and shoot: root ratio were superior in the nursery mixture of soil: sand: FYM (1:1:1) compared to other mixtures.

*Mallotus phillipensis* seeds sown in germination medium containing soil, sand and FYM @1:1:1 ratio, at 01.00 cm depth under shade gave the best results in nursery with superior silvicultural parameters of seedlings (Bahuguna and Pyarelal, 1996).

The neem seedlings were grown in different combinations of nursery mixtures. The higher seedling vigour index, shoot :root ratio and leaf were recorded by tank silt : black sand : FYM (2:1:1) followed by red soil : white sand : FYM (2:1:) and black soil : black sand : FYM. Among all the mixtures tested Black soil based mixtures were found to be cheaper for vertisol dominant tracts of north Karnataka (Devarnavadagi and Sajjan, 1997).

The studies conducted by Devarnavadagi and Sajjan (1997) revealed that the shoot : root ratio, seedling vigour index and number of branches per seedling of *Acacia nilotica* were found to be highest in black soil: black sand : FYM (2:1:1) followed by tank silt : black sand : FYM (2:1:) and red soil : white sand : FYM (2:1:1) suggesting the alternative to traditional nursery mixture of red soil : white sand : FYM (2:1:). Further the potting media with tank silt: black sand: FYM in the proportion of 1:3:1 was superior with respect to field emergence and seedling vigour index followed by black soil: black sand: FYM in the proportion of 1:1:1 in *Acacia nilotica*.

According to Biradar *et al.,* (1998) sandal seed sown in soil mixture of 1:2:1 of sand: soil: FYM recorded highest germination. *Casuraina equisetifolia* grew well on 1:1:1 mixture of alluvial sand soil, heavy clay and farm yard manure (Jayraj, 1998). The growth parameters were superior to all other combinations of nursery mixtures. For obtaining better growth parameters of *Eucalyptus globules*, *Azadirachta indica, Annona squamosa* and *Syzigium cumini*, soil alone proved to be the best medium followed by 1:3 fly ash and soil combination. However, Eucalyptus globules and *Syzigium cumini* could survive equally good on higher proportion of fly ash (Malewar, *et al*., 1998).

The studies made by Vanagamudi *et al.,* (1998) revealed that the seedlings of *Albizia procera* with highest quality were produced when they were raised in soil: sand: compost in 2:1:1 proportion.

Biradar *et al.,* (2001) reported the seedling quality parameters (shoot: root ratio and leaf area) of neem were highest when entirely vermicompost was used as nursery media. The next best were red soil: vermicompost: sand (3:2:1) and red soil: FYM: sand (3:2:1). The later two media are relatively very cheap with good quality parameters desirable for planting.

According to Natarajan (1999) the potting mixture of red soil: sand: compost (2:1:1) ratio recorded better seedling quality parameter like seedling vigour index leaf area, number of branches and shoot: root ratio in *Albezia lebbak*

Venkatesh *et al.,* (1999) found that *Casuraina equisetifolia* seedlings grown in a potting mixture comprising red soil: sand: goat manure at 2:1:1 ratio performed better than other mixtures. The shoot and root length in the medium was better compared to other combinations.

Singh *et al.* (2000) observed that maximum root and shoot length was produced in media containing 2:1:1 proportion of soil, sand and FYM in *Acacia nilotica* and *Dalbergia sissoo* and 1:2:1 proportions of soil, sand and FYM in case of *Prosopis cineraria*. In all the three species, lowest root and shoot length was observed in media containing 1:1:2 soil, sand and FYM.

The replacement of FYM with vermicompost, and red soil with black soil promoted the seedling qualities to a certain extent. It might be due to the higher availability of the nutrients in vermicompost and black soil. But ultimately it indicated that black soil based nursery mixture with vermicompost was superior in nutrient status than the traditional nursery mixture (Anon, 2005 and Biradar *et al.,* 2001).

The seedling vigour index shoot: root ratio and number of branches produced by Tank silt: vermicompost: black sand (2:1:1) were superior to all other combinations. The next best were black soil: FYM: black sand (2:1:1) followed red soil: white sand: FYM (2:1:1) combination. The quality parameters Pongamia seedlings produced by black soil: FYM: black sand (2:1:1) were comparable with other media and the cost of production was much cheaper (Anon, 2002).

Venkatesh (2000) identified that the potting mixture containing red soil: sand: goat manure at 2:1:1 ratio gave higher germination and produced vigorous seedlings in *Acacia nilotica.*

### 2.2.2 Seedling growth characters

Chattopadhya and Mohanta (1988) found that the height of tamarind seedlings was best in cow dung manure followed by sand and cow dung manure and the number of leaf was greatest in the cow dung manure

Ani and Gopikumar (1988) tested the effects of five growing media (soil and mixtures of equal proportions of soil/sand, soil/sand/cowdung, soil/vermiculite and soil/vermiculite/cowdung) on the seedling growth of *Artocarpus hirsutus* and *Tectona grandis.* The growth parameters of seedlings such as height, collar diameter and number of leaves in *Artocarpus hirsutus* were superior in media containing equal proportions of soil/sand, soil/sand/cow dung and soil/vermicompost/cow dung over soil alone. However, such significant differences were not revealed for *Tectona grandis.*

Kim and Suh (1989) reported that for peach cuttings shoot growth was best in media consisting of 3:2:1 or 2:4:1 soil, compost and sand mixtures. Shiembo *et al.,* (1996) found that saw dust was the best medium for the rooting of bush mango (*Irvingia gabonensis*) cuttings. The survival and growth of seedlings in field condition is dependent on its quality parameters like number of branches, shoot: root ratio and seedling vigour index.

In case of *Acacia nilotica* better germination and growth parameters were produced by nursery mixture of Soil: Sand: FYM in 2:1:1 (Bahuguna and Pyarelal, 1990).

Bahuguna and Pyarelal (1992) observed that dibbling of seeds in the nursery bed and irrigation twice a day enabled production of maximum number of healthy plantable seedlings in *Acacia auriculiformis* under moist climatic conditions of Dehra Dun.

According to Gupta (1992) the best potting mixture for *Albizia lebbeck* was 10% tank silt + 40 % FYM + 40 ppm N, which recorded increased height of seedlings at 120 days after sowing. He concluded from his studies that for the production of healthy seedlings in arid zone, 10 percent of tank silt and 2 percent of FYM should be mixed with sand for *Dalbergia sissoo* and 10 percent of tank silt, 4 percent of FYM and 10 ppm of nitrogen for *Albizia lebbek* and 10 percent of tank silt alone for *Prosopis juliflora*. Further he reported that healthy seedling of *Dalbergia sissoo* (10 percent Tank silt + 2 percent FYM + Sand), *Albizia lebbeck* (10 percent Tank silt + 4 percent FYM + 40 ppm nitrogen) and *Prosofis cineraria* (10 percent silt + sand) could be raised with better seedling growth characters.

The stump length and girth of teak seedlings grown in nursery medium of red soil: sand: FYM (3:1:1) were better than media. Even the seedlings quality parameters were also found to be of higher order (Tewari, 1992).

Among the different nursery mixtures tested to raise silver oak seedlings, the mixture with loamy soil: sand: FYM (1:1:1) produced better seedlings with a plant height (107.16 cm) and collar diameter (1.41 cm). The mixture was also found to be economical (Misra and Jaiswa 1998).

The potting mixture containing soil, compost and sand at 1:1:1 ratio gave better results in the Shivan seedlings of *Gmelina arborea* (Mohan, 1994). The plant height, collar diameter and root length were superior to other mixtures.

According to Shamel *et al.,* (1994) potting mixture of soil, sand, moss and FYM @ 1:1:1 ratio gave maximum height growth in *Pinus gerardiana* while soil, sand and moss in equal proportions gave larger caliper (diameter) growth. Maximum seedling survival (79 percent) achieved at ½ " layer saw dust mulch where as height and caliper growth were best in ½ " layer needle mulch.

Medium containing 90 percent sugar cane baggasse and 10 percent mixed additive (soil: green manure: manure in the proportion of 1:8:3) promoted better growth of *Acacia mangium* seedlings in terms of plant height and collar diameter (Lempang, 1995).

Nayital *et al.,* (1995) stated that the growth of Bauhinia variegate seedlings was best in soil medium containing soils / sand / FYM in the ratios of 1:3:6. Better growth of seedlings of *Grewia optiva* was obtained in the soil medium containing soil / sand / FYM in the ratio of 1:3:6.

The seedling vigour index leaf area were superior in the nursery mixture of soil: sand: FYM (1:1:1) compared to other mixtures (Sudhakar *et al.,* 1995)

According to Biradar *et al.,* (1998) *Casuraina equisetifolia* grew well on 1:1:1 mixture of alluvial sand soil, heavy clay and farm yard manure (Jayraj, 1998). The growth parameters were superior to all other combinations of nursery mixtures. For obtaining better growth parameters of *Eucalyptus globules*, *Azadirachta indica, Annona squamosa* and *Syzigium cumini*, soil alone proved to be the best medium followed by 1:3 fly ash and soil combination.

Bahuguna and Lal (1998) revealed that nursery mixture of Soil: Sand (2:1) could produce the seedling with better growth attributes in case of *Acacia auriculiformis*.

The observations of Chakrabarti *et al.,* (1998) revealed that nursery mixture with 2:2:1 (Soil: Compost: Sand) produced excellent quality seedlings of Poplar with better growth attributes than other mixtures.

The studies conducted by Shrivastava *et al.,* (1998) revealed that the seedlings of Eucalyptus raised in nursery media of soil: compost : sand (2:1:1) produced maximum plant height (36.88cm) and collar diameter (10.55cm) four months after sowing among the different nursery media tested.

Devarnavadagi *et al.,* (1998) studied for performance of 10 Subabul genotypes under nursery condition at Bijapur. The results revealed that more than 90 % of germination was noticed in case of K-67, K-740, K-28 and K-36 *Leucaena* genotypes. Significantly highest shoot height and shoot girth was recorded by K-67 genotypes (84.80 and 2.44 cm respectively). The shoot girth and seedlings recorded significantly positive correlation with length of root only and the highest leaf area, leaf area index and dry matter accumulation were noticed highest in case of K-67 genotype.

The seedling parameters of *Dalbergia sissoo* were superior with nursery mixture of sand: compost (1:4) with a plant height (57.00 cm), collar diameter (5.88 mm) and tap root length (8.22 cm). However the mixture was costly compared to the next best that is Soil: Sand: Compost (1:1:3), (Ginwal *et al.,* 2002).

## 2.3 To study the effect of hydro priming and fungicide seed treatment on germination and vigour of Pongamia species

Hydro priming is the process of controlled hydration of seeds to a level that permits pre- germinative metabolic activity to proceed, but that prevents actual emergence of the radicle, it is done in order to increase the speed and uniformity of germination particularly under adverse condition of temperature, moisture and salinity.

King *et al.,* (1960) reported that seedlings produced from fumigated seeds of barley, oat, wheat, rice, cotton, maize and cowpea were less vigorous than those from unfumigated seeds.

Juobrt and Du-toit (1965) fumigated the seeds of maize, wheat, sorghum, groundnut and cowpea with ethylene oxide and carbon dioxide. In all these crops except sorghum, germination was slightly affected while; emergence was significantly affected due to repeated fumigation.

Fujikura *et al*.,(1993) studied Hydropriming for Cauliflower Brassica oleracea L. cv. Alpha Paloma) consists of soaking of seeds in water for 5 hours followed by incubation in a closed container with 100 per cent relative humidity at room temperature for 3 days. Germination of primed seeds was tested at 10, 20 and 30C. Hydro priming of imaged seeds caused a great improvement in the rate of germination, especially at 10C, even more so than Osmopriming.

Chojnowski *et al.,* (1997) reported that priming with PEG -6000 for 3-5 days at 15ºC strongly increases germination at sub optimal temperatures, longer the priming treatment, the higher is the amount of germination but at the same time higher is the sensivity of seed to accelerated ageing, vigour also increases with priming but decreases during ageing.

Nagar *et al.,* (1998) they studied the efficacy of hydro priming treatments on field emergence and crop growth of four maize genotypes. Priming of seed enhanced the speed of emergence and improved the field stand and plant growth, both at vegetative stage and at maturity. It also reduced the period to anthesis and silking by about one day each, treatment effects were significant in spite of the genotypic difference.

Bruggink *et al*., (1999) found that the species tested, desired longevity could be obtained by keeping the seeds, after a priming treatment, under a mild water or temperature stress for a period of several hours to days.

Krishna murthy *et al.,* (2003) reported that fungicides captafal and Bavistin @ 2g per Kg of seed showed maximum control of seed borne pathogens and similarly captafal and bavistin have increased germination up to 92% and 90% over the control of 65% and 71% in cowpea and greengram, respectively and these chemicals increased vigour index up to 2260 and 1960 over the control of 1034 and 1401 in the respective crops. The bio- control agent *Trichoderma harzianum* has also increased the germination per cent and vigour index of the seedlings considerably up to 84 % and 1767 over control.

Mehra *et al.,* (2003) reported that in both Brassica junceia and Brassica campestris, the rate of germination, final germination (per cent normal seedlings) and germination after the controlled deterioration test increased after aerated hydration treatment in seeds that initially had reduced seed quality, they noticed that optimum timing of treatment was 12 hour in both species. Germination increased at temperature both above 33-37ºC and below (8-10, 13-14ºC) the optimum for germination (22-23ºC) thus extending the range of temperature for successful germination.

Toselli and Caserane (2003) evaluated seed germination in water and under water stress at 25ºC and 16 hour photoperiod hydro priming did not affect germination in water or under water stress. Osmotic priming reduced germination in both instances by increasing the length of the treatment and the concentration of osmoticum used.

Sudipta basu, (2005) reported the seeds of parental lines viz., CM202, CM111, CM501 of maize were subjected to priming. Hydro priming and its efficacy was evaluated on their field emergence, vegetative growth, flowering and seed yield during winter and spring summer season. Hydro priming treatment (12h at $25^0$C and 48h at $10^0$C, followed by 12h at $25^0$C). Significantly improved the field emergence, its rate uniformity and early seedling growth but had no effect on vegetative growth, flowering behaviour and seed yield of the parental lines in both the season. The beneficial effect of hydro priming was less pronounced in spring summer than winter. The study highlighted the potential of hydro priming treatment in improving field emergence and early seedling growth during winter and spring- summer season.

## 2.4 Characterization of superior provenances through enzymes and protein analysis

### 2.4.1 Studies on seed storage protein through SDS- PAGE

Rawat *et al.,* (1998) reported identification of provenance based on leaf morphology in *Tectona grandis* and revealed that certain diagnostic characters or genetic markers on the basis of which different provenances can be easily identified.

The banding pattern produced following polyacrylamide gel electrophoresis of total seed storage proteins in the presence of sodium dodecylsulphate (SDS-PAGE) have proved an effective laboratory method for distinguishing cultivar of largely cross- fertilized legumes and grasses (Ferguson and Grabe, 1984, Gardner and Forde, 1987)

Electrophoresis of total protein was found to be extremely useful technique for distinguishing rice genotypes by several workers (Inocencio *et al.,* 1980; Iwasaki *et al.,* 1989). Ivanova (1983) was able to differentiate subspecies, varietals groups and individual genotypes on the basis of specificity of protein banding pattern in ñ5 indica and no japonica genotypes through electrphoresis.

Chen and Chang, (1986;) Bhomik *et al.,* (1990). Suggested the application of SDS-PAGE as useful technique for grouping rice genotypes into several classes.

Koryani (1989) through SDS- PAGE of protein monomers revealed differences between Maize inbreds and hybrids; he also gave code for interpreting the banding patterns.

Moller and Spoor (1993) examined 65 seed lots of six Italian rye grass cultivars, 18 perennial rye grass and four hybrid rye grass varieties, differences in the resulting seed protein banding patterns enable differentiation of the three Lolium species and all cultivars were analyzed. Identification of 17 out of 20 unknown samples after electrophoretic analysis showed the potential of this technique for variety identification.

Mishra *et al.,* (1996) analyzed the seed protein patterns of ten genotypes by SDS- PAGE. A high similarity index (70.4-96.4 %) between the genotypes indicated a close evolutionary relationship among them. Some genotypes have unique bands which may help in identifying them in the germplasm. Several genotypes can also be identified by absence of particular bands.

Robert *et al.,* (1997) reported that the seed specifity and pattern of expression during germination suggests that the protein is a homologue of the seed specific 65-kDa biotinuylated protein and in presence of 2-ME these proteins appeared as a single 85kDa band.

Lawrence *et al*., (1999) identified Sunflower hybrids APSH-11 and KBSH 1, their parental lines and the variety modern was possible from the genotype specific intensity of dark, light and faint bands as well as their relative position in the seed protein profile analyzed by PAGE. Their characterization was difficult through the total number of protein bands and their relative mobility pattern as several of them were common in more than one genotype.

Varma *et al.,* (2005) studied differences in banding patterns obtained from electrophoresis of seed proteins for 10 genotypes of Maize for their identification at laboratory level. The differences were either in the total number of bands present, location of bands or intensity of band or it can even be the presence or absence of four categories of bands namely very light, light, medium and dark intense bands. This technique was found more suitable for distinguish even among closely related genotypes and can be used by breeders to characterize differences and by seed certification agencies to make available good quality seed to the growers.

Kanchan singh, (2006) reported that the Lentil varieties were analyzed for varietal identification through electrophoresis of seed protein. In all 15 bands were recorded with relative mobility of 0.90 presence or absence of any particular band helps in demarcation and identification of variety. Similarity index was calculated to have an idea about evolutionary relationship among varieties which varied from 53.3 % to 93.3 %.

### 2.4.2 Quantification of enzymes like catalase, peroxidase, phosphatase and amylases

Muthuraj *et al.,* (1999) screened twenty nine soybean cultivars for peroxidase test. Seeds of 14 soybean cultivars showed a positive and the rest 15 cultivars a negative reaction with respect to peroxidase treatment. However seeds of only 11 cultivars were pure for peroxidase test, in the rest off types for peroxidase activity ranged from four to 40 %. The probable reason for the presence of such off types in certain cultivars could be the hidden variation.

Loss of seed viability in storage has been related to enzymatic activity. Abdul- Baki (1980) pointed out that respiratory and associated enzymes viz., peroxidase, glutamic acid oxidase and catalase activity decreased with loss of seed viability while the activity of hydrolytic enzymes viz., phylase, protease and phosphatase increased during storage. The increased activity of these enzymes was associated with the degradation of organellar membranes, nucleoproteins etc. similar decline in peroxidase activity with increase in storage period has been reported by Nkang (1988).

# 3. MATERIALS AND METHODS

Experiments were conducted to study the effect of provenance and nursery mixture on seed and seedling quality and characterization in Pongamia at Regional Agricultural Research Station, Bijapur, Karnataka state during the year 2006-07. The details of the materials used and techniques adopted during the course of investigation are presented below.

## 3.1 General description of pongamia

### 3.1.1 Location of the experimental site

Three pot culture experiments were laid out at Regional Agricultural Research Station, Bijapur, University of Agricultural Sciences, Dharwad, during kharif 2006. Bijapur is situated at 16˚49[1] N latitude, 75˚43[1] E longitude and 593 m elevation. Bijapur comes under Northern Dry Zone of Karnataka with annual rainfall of 590.7 mm.

### 3.1.2 Description of pongamia

*Pongamia pinnata* grows throughout the greater parts of India and it is indigenous to the Western ghats of south India. It is mostly found along the river banks and on plains up to an elevation of 600 m to 1200 m in the south, now found throughout the tropics. It can be grown under variety of soil conditions like loamy soils, clayey soils, murrams and gravely soils and saline and alkaline soils but not in dry sand.

*Pongamia pinnata* belongs to the family Leguminosae, and sub family Papilionaceae. It is a medium tree which can be grown up to a height of 15 m and 0.5 m DBH (diameter at breast height). It can be successfully cultivated in areas with annual rainfall of 500 mm to 2500 mm. The kernel contains 35-37% oil. It is a medium sized deciduous tree that generally attains a height of about 8m and trunk diameter of more than 50 cm. However, (Devaranavadagi *et al*, 2003) reports trees attaining height of 18 m. The trunk is generally short with branches, spreading into a dense hemispherical crown of dark green leaves. The bark is grey to greyish-green and yellow on the inside. The taproot is thick and long lateral roots are numerous and well developed. Leaves are alternate, compound consists of 5 or 7 leaflets, which are arranged in 2 or 3 pairs on single terminal leaflets. The leaflets are 5-10 cm long, 4-6 cm wide and pointed at the tip and upper surface is shining. The three-inch-long, pinnately compound, glossy green leaves are briefly deciduous, dropping for just a short period of time in early spring but being quickly replaced by new growth. Flowers, borne on racemes, are pink, light purple, or white. Pods are elliptical, 3-6 cm long and 2-3 cm wide, thick walled, and usually contain a single seed. Seeds are 10-20 cm long, fig oblong and light brown in color.

## **3.2** Influence of provenance on seed quality in pongamia

### 3.2.1 Treatment details

Treatments: 40 provenances (40 candidate plus trees (CPT) from 10 agro-climatic zones of Karnataka state that is 4 CPTs from each zone)

Replication: Three

#### 3.2.1.2 Seed source

Seeds were drawn randomly form the pods harvested from 40 identified candidate plus trees, four each from 10 different agro-climatic zones of Karnataka. The seed of 40 provenances required for the experiment were supplied by the Principal Investigator of the ad-hoc project entitled " National Net-work on Integrated Development of Karanja" at Regional Agricultural Research Station, Bijapur The locations of each zone for seed collection is as below.

Zone-1 Bidar

Zone-2 Gulbarga

Zone-3 Bijapur

Zone-4 Chitradurga

Zone-5 Bangalore

Zone-6 Hassan

Zone-7 Shimoga

Zone-8 Dharwad

Zone-9 Sirsi

Zone-10 Mangalore

#### 3.2.1.3 Design and layout

The experiment was laid out as pot culture experiment under CRD design.

#### 3.2.1.4 Season

Kharif -2006

#### 3.2.1.5 Nursery rising

The Pongamia seedlings were raised by dibbling seeds dry dressed with Captan (2 g per kg of seed) in polythene bags having dimension of 9x6$^{11}$ filled with Black soil+ Black sand+ FYM in the ratio of 2:1:1.

#### 3.2.1.6 After care

The crop was weeded at 30 days, then at an interval of 15 days till 90 days.

Irrigation: Crop was irrigated twice a week without fail

### 3.2.2 Observations recorded

Observations such as germination, shoot length, root length, vigour index were recorded on seedlings raised in polythene bags. For the seeds collected from 40 provenances the observations on oil percentage, 100 seed weight, seed colour, seed shape were recorded

#### 3.2.2.1 Germination (%)

Four hundred seeds were drawn randomly from the seeds harvested from each candidate plus trees were dibbled in four replications of 100 seeds each in polythene bags filled with nursery media. After 30 days of dibbling the number of normal seedlings emerged in each replication was counted and recorded as germination percentage.

#### 3.2.2.2 Shoot length (cm)

The length from the collar region to the tip of the shoot apex was measured for five randomly selected plants in each treatment. The average of five plants measurement was recorded as shoot length in centimeter.

#### 3.2.2.3 Root length (cm)

The length from collar region to the tip of the root was measured for five randomly selected plants in each treatment. The average of five plants measurement was recorded as root length in centimeter.

#### 3.2.2.4 Seedling vigour index

It was calculated by adding the values of root length and shoot length which was randomly selected and multiplying with their corresponding germination percentage and the values are recorded. (Abdul- Baki and Anderson, 1973)

Seedling vigour index = Germination in (%) × (Root length + Shoot length in cm)

#### 3.2.2.5 Collar diameter

The diameter of shoot above the root collar region was recorded using vernier caliper and expressed in centimeter.

#### 3.2.2.6 Crown spread

The crown spread of seedlings in north-south and east-west direction was measured. Its average was expressed as crown spread of seedlings in centimeter

3.2.2.7 Oil percentage

Seed samples drawn from pods harvested from each candidate plus trees were sent to TERI for the analysis of oil percentage.

3.2.2.8 100 seed weight (g)

It was calculated by weighing 100 seeds from each treatment each replication and recorded the weight in grams as per ISTA (1985) procedure.

3.2.2.9 Seed colour

The Seed colour was recorded by visual observation for all the seeds collected from 40 candidate plus trees.

3.2.2.10 Seed shape

The Seed shape was also recorded by visual observation for the seeds collected from 40 Candidate plus trees and their shape was recorded as oval or round.

3.2.2.11 Seedling dry weight (g)

Five normal seedlings selected randomly from each treatment were kept for oven drying at $60^0$C continuously for three days. After drying the dried samples were allowed for cooling at room temperature, then the weight of the samples were taken, the average of the five dried seedlings was recorded as seedling dry weight in gram per seedling.

3.2.2.12 Survey

Survey of potential pongamia growing areas was carried out in 10 agro climatic zones of Karnataka. From each zone 10 farmers were identified and interviewed to collect the knowledge on pongamia, about its uses, silvicultural characters of pongamia, silvicultural manipulation, their interest in pongamia cultivation, marketing, technical and financial assistance from the government. The data collected from 100 farmers across the zones was subjected for analysis.

## 3.3 Standardization of suitable nursery mixture for pongamia.

3.3.1 Treatment details

Number of treatments: 9

T1- Black soil+ Black sand+ FYM (2:1:1)

T2- Red soil+ White sand+ FYM (2:1:1)

T3- Black soil+ Black sand+ Vermicompost (2:1:1)

T4- Black soil+ Black sand+ Poultry manure (2:1:1)

T5- Black soil+ Black sand+ Pig manure (2:1:1)

T6- Black soil+ Black sand+ Pongamia cake (2:1:1)

T7- Black soil+ Black sand+ Neem cake (2:1:1)

T8- Black soil+ Black sand+ Press mud (2:1:1)

T9- Black soil+ Black sand+ Peat (2:1:1)

(The mixtures were prepared on weight basis)

Replications : four

### 3.3.1.1Seed source

The seeds for the evaluation of nursery mixture experiment were supplied by the Principal Investigator of the ad - hoc project entitled “National Net-works on integrated development of Karanja” at Regional Agricultural Research Station, Bijapur

3.3.1.2 Design and layout

The experiment was laid out as pot culture experiment under the Completely Randomized Design.

Seed treatment: seeds were treated with Bavistin 2%

3.3.1.3 Season

Kharif- 2006

3.3.1.4 After care

Weeding was done for every 15 days but the first weeding was done at 30 days after sowing and there after for every 15 days. Weeding was continued upto 90 days and there after not much weeds were noticed.

Irrigation was given for the nursery at 5 days interval.

### 3.3.2 Observations recorded

3.3.2.1Germination percentage

The germination in each treatment was recorded at 30 days after planting in each treatment Number of normal seedlings were counted and expressed as germination percentage.

3.3.2.2 Seedling height

The seedling height of seedlings was measured from the root collar to the tip of the shoot and expressed in centimeter after 60, 90 and 120 days.

3.3.2.3 Root length

The seedlings were removed from the ploythene bag without damaging the root and the length was measured from the collar region to the tip of the root and expressed in centimeter.

3.3.2.4 Shoot length

The length from the collar region to the tip of the shoot apex was measured for five randomly selected plants in each treatment. The average of five plants measurement was recorded as shoot length in centimeter.

3.3.2.5 Collar diameter

The diameter of shoot above the root collar region was recorded using vernier caliper and expressed in centimeter.

3.3.2.6 Crown spread

The crown spread of seedlings in north-south and east-west direction was measured. Its average was expressed as crown spread of seedlings in centimeter.

3.3.2.7 Seedling vigour index

It was calculated by adding the values of root length and shoot length which was randomly selected and multiplying with their corresponding germination percentage and the values are recorded.

3.3.2.8 Leaf area

Leaf area was measured by disc method. The leaves from five randomly selected plants from each treatment were taken. By the help of the punch leaves were punched and discs were obtained and their area was measured. Then they were kept in an oven for two days along with the punched leaves and the weight of the discs and leaves was taken and leaf area is expressed in $cm^2$

3.3.2.9 Statistical analysis and interpretation of the data

The data recorded on various characters was subjected to Firsher's method of analysis of variance and interpretation of data was made as given by Gomez and Gomez (1984). The level of significance on 'F' test and 'T' test was at five per cent probability.

The percentage data on germination was converted into arcsin transformation values and that was subjected to the statistical analysis.

## 3.4 Effect of hydro priming and fungicide seed treatment on germination and vigour in Pongamia

### 3.4.1 Treatment details

Factor I: Hydro priming:- seeds were hydrated and dehydrated to original moisture content (H).

One kg of kernels were soaked in three liters of water for 12, 16, 20 and 24hrs. Soaked seeds were dried under shade for one day and then dried under sun for two days to get the original moisture content.

Soaking duration: $H_0$:0 hours, $H_{1:}$12 hours, $H_2$:16 hours, $H_3$:20 hours, $H_4$:24 hours.

Factor II: Fungicide treatment (F)

$F_0$: without fungicide

$F_1$: with fungicide (Bavistin @ 2 g per kg of seed) dry dressed.

3.4.1.1 Seed source

The seeds for the hydro priming and fungicide experiment were supplied by the Principal Investigator of the ad- hoc project entitled "National Net-works on Integrated Development of Karanja" at Regional Agricultural Research Station, Bijapur, three months old seeds were used for the experiment.

Design and layout

The experiment was laid out under Randomized block design with factorial concept.

3.4.1.2 Observations recorded

Seedlings were raised in polythene bags filled with (Red soil + White sand + FYM, 2:1:1) nursery mixture and for each treatment observations on germination, shoot length, root length, vigour index and rate of germination were recorded.

3.4.1.3 Germination (%)

Four hundred seeds were drawn randomly from the seeds harvested from each candidate plus trees were dibbled in four replications of 100 seeds each in polythene bags filled with nursery media. After 30 days of dibbling the number of normal seedlings emerged in each replication was counted and recorded as germination percentage.

3.4.1.4 Germination rate index

This was done by taking germination count every day until germination was completed. An index of the speed of germination was then calculated by adding the quotients of the daily counts divided by the number of days of germination.

3.4.1.5 Root length (cm)

The seedlings were removed from the ploythene bag without damaging the root and the length was measured from the collar region to the tip of the root and expressed in centimeter.

3.4.1.6 Shoot length (cm)

The length from the collar region to the tip of the shoot apex was measured for five randomly selected plants in each treatment. The average of five plants measurement was recorded as shoot length in centimeter.

3.4.1.7 Seedling vigour index

It was calculated by adding the values of root length and shoot length which was randomly selected and multiplying with their corresponding germination percentage and the values are recorded.

3.4.1.8 Seedling dry weight (g)

Five normal seedlings selected randomly from each treatment used to measure root and shoot length were kept for oven drying at $60^0$C continuously for three days. After drying the dried samples were allowed for cooling at room temperature, then the weight of the samples were taken, the average of the five dried seedlings was recorded as seedling dry weight in gram per seedling.

## 3.5 Characterization of varieties through enzymes and protein analysis

### 3.5.1 Quantification of enzymes like Peroxidase, Catalase, Phosphatases and Amylases

3.5.1.1 Catalase

Materials required

1. Phosphate buffer, 0.067M (pH 7.0). Dissolve 3.522 g KH2PO4 and 7.268 g of $Na_2HPO_4$ in distilled water and made up the volume to one liter.
2. Hydrogen peroxide-phosphate buffer. Diluted 0.16 mL of H2O2 (10% w/v) to 100 mL with phosphate buffer. The absorbance of the solution was about 0.5 at 240nm with a one cm light path.

Enzyme extract

Homogenized plant tissue in a blender with M/150 phosphate buffer at 1-4ºC and centrifuged. The sediment was stirred with cold phosphate buffer, allowed to stand in the cold with occasional shaking and then repeated the extraction once or twice. The extraction should not take longer than 24 hr. used the combined supernatants for the assay. The catalase activity can change considerably on storage of the tissue. In comparative studies, therefore, used the same conditions of extraction, storage and temperature (Sadhashivam and Manikyam, 1986).

Procedure

1. 3 mL of hydrogen peroxide- phosphate buffer + 50 µL of enzyme extract was taken.
2. Cuvett was read at 240 nm.
3. The time was recorded when the absorbance decreased by 0.05 units.

Calculation

One gram was homogenized in a total volume of 20 mL, diluted 1 to 10 volumes with water and taken 0.01 mL. The absorbance at 240 nm decreased 0.05 units is noted down and calculated.

3.5.1.2 Peroxidase

Materials

1. Phosphate buffer 0.1 M (pH 7.0)
2. Guaciacol solution 20 mM dissolved 240 mg guaciacol in water and made up to 100mL. It can be stored frozen for many months.
3. Hydrogen peroxide solution (0.042% = 12.3 mM). 0.14 mL of 30% $H_2O_2$ was diluted to 100 mL with water. The extinction of this solution was 0.485 at 240 nm. Freshly prepared solution was used.

Enzyme extract

One gm of fresh plant tissue was extracted in 3mL of 0.1M phosphate buffer pH 7.0 by grinding with a pre cooled mortar and pestle. And it was centrifuge at 18000 rpm at 5C for 15min and the supernatant used as enzyme source within 2-4 hours. It should be stored on ice till the assay is carried out (Sadhashivam and Manikyam, 1986).

Procedure

1. 3 mL buffer solution, 0.05 mL guaciacol solution, 0.1 mL enzyme extract and 0.03 mL hydrogen peroxide solution was taken into a cuvett.
2. Mixed well and the cuvett is placed in the spectrophotometer.
3. Waited until the absorbance had increased by 0.05. Start a stop watch and note time required in seconds to increase the absorbance by 0.1.

3.5.1.3 Phosphatases

Materials

1. Sodium hydroxide 0.085 N, prepared by dissolving 0.85 g sodium hydroxide in 250 mL water.
2. Substrate solution, is prepared by dissolving 1.49g EDTA, 0.84 g citric acid and 0.03 g p- nitro phenol phosphate in 100 mL water and adjust to pH 5.3.
3. Standard, by weighing 69.75 mg p- nitro phenol and dissolving in 5.0 mL distilled water (100 mM).
4. Enzyme extract, was prepared by homogenizing 1g fresh tissue in 10 mL of ice-cold 50 mM citrate buffer (pH 5.3) in a pre chilled pestle and mortar. Filtered through four layers of cheese cloth. And the filtrate was Centrifuged at 10000 rpm for 10 min and the supernatant was used as enzyme source.

Procedure

1. 3 mL of substrate solution was incubated at 37ºC for 5min.
2. 0.5 mL enzyme extract was added and mixed well.
3. Removed immediately 0.5 mL and mixed it with 9.5 mL of sodium hydroxide 0.085 N. this corresponds to zero time assay (blank).
4. And the remaining solution was incubated (substrate + enzyme) for 15 min at 37ºC
5. 0.5 mL of the sample was drawn and mixed with 9.5 mL sodium hydroxide solution.
6. The absorbance of blank and incubated tubes was measued at 450 nm.
7. Took 0.2 to 1.0 mL of the standard, diluted to 10.0 mL with NaOH solution and read the colour and drawn the standard curves (Sadhashivam and Manikyam, 1986).

3.5.1.4 Amylases

Materials required

1. Sodium acetate buffer 0.1 M pH 4.7
2. Starch, 1% solution, prepared a fresh solution by dissolving 1g starch in 100 mL acetate buffer. Slightly warm, if necessary.
3. Dinitrosalicylic acid reagent, dissolved 1g in 100 mL of water.
4. 40% Rochelle salt solution (Potassium sodium tartrate).
5. Maltose solution, dissolved 50 mg maltose in 50 mL distilled water in a standard flask and stored it in a refrigerator.
6. Extraction of Amylases, extracted 1 g of sample material with 5-10 volumes of ice-cold 10 mM calcium chloride solution overnight at 4ºC or for 3 hr at room

temperature. The extract was centrifuged at 54000 rpm at 4ºC for 20 min. the supernatant was used as enzyme source.

7. Extraction of β- Amylases, the free β-amylases from acetone defatted sample material in 66mM phosphate buffer (pH 7.0) containing 0.5M NaCl. The extract is centrifuged at 20000 rpm for 15 min. the supernatant was used as a source of free β-amylase. The pellet is then extracted with phosphate buffer containing 0.5% 2- mercaptaethanol. The clear extract is used as source of bound β-amylase. All operation should be carried out at 4ºC.

Procedure

1. 1mL of starch solution was pipetted out and 1mL of properly diluted enzyme in a test tube.
2. Incubated the above mixture at 27ºC for 15 min.
3. 2 mL of dinitrosalicylic acid reagent was added and the reaction was stopped.
4. The solution was heated in a boiling water bath for 5 min.
5. While the tubes were warm, 1 mL potassium sodium tartrate solution was added.
6. Then it was cooled in running tap water.
7. The volume was made upto 10 mL by addition of 6 mL water.
8. The absorbance was read at 560 nm.
9. The reaction was terminated at zero time in the control tubes.
10. A standard graph was prepared with 0-100 µg maltose (Sadhashivam and Manikyam, 1986).

### 3.5.2 Studies on seed storage protein through SDS- PAGE

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS- PAGE) of seed storage protein was done at 12 per cent polyacrylamide gels according to Laemmli (1970) with some modifications. The electrophoresis was done in vertical slab gels of 16 cm x 14 cm x 1 mm dimension. Tris-glycine (0.025 M, pH 8.3) with 0.1 per cent SDS served as reservoir buffer. The gels were polymerized chemically by using ammonium persulphate.

#### 3.5.2.1 Reagents

1. Acrylamide concentrate: 30 g of acrylamide and 0.8 g of methylene bisacrylamide were dissolved in 70 mL of distilled water. When the acrylamide was completely dissolved, volume was made up to 100 mL.
2. Resolving gel buffer (1.5M Tris HCL, pH 8.8): 18.17 g of Tris base was dissolved in 80 mL of distilled water, the pH was adjusted to 8.8 with concentrated HCL and final volume was made to 100 mL with distilled water.
3. Stacking gel buffer (0.5 Tris-HCL, pH 6.8): 6.06 g of Tris base was dissolved in 80 mL of distilled water, the pH was adjusted to 6.8 with concentrated HCL and the final volume was made to 100 mL with distilled water.
4. 10% (w/v) Sodium dodecyl sulphate (SDS): 10 g of SDS was dissolved in 60 mL of distilled water and final volume was made to 100 mL with distilled water.
5. 10% (w/v) Ammonium persulphate (APS): 1 g of APS was dissolved in 10 mL distilled water. This solution was prepared freshly before every use.
6. Electrode buffer/Reservoir buffer (0.025 M Tris, 0.192 M glycine, 0.1% (w/v) SDS, pH 8.3): 3 g Tris base, 14.1 g glycine, 10mL of 10% SDS were dissolved in distilled water and the volume was made up to 1000 mL. The pH of the electrode buffer was not adjusted, but confirmed that it was nearer to 8.3.
7. Tris-Glycine (25 mM, pH 8.3) extraction buffer: 3 g of Tris base was dissolved in 50 mL distilled water, pH was adjusted to 8.3 with glycine and then volume was made up to 100 mL with distilled water.

8. Stock sample buffer (0.06 M Tris-HCL, pH 6.8, 2% SDS, 10% glycerol, 0.025% Bromophenol blue) : 4.8 mL distilled water, 1.2 mL 0.5M Tris-HCL (pH 6.8), 2 mL 10% SDS, 1 mL glycerol and 0.5 mL of 0.5% Bromophenol Blue were thoroughly mixed and stored at room temperature.
9. Working sample buffer: This was prepared by adding 50 µL of 2-mercaptoethanol to each 0.95 mL of stock buffer before use.

#### 3.5.2.2 Sample preparation

Seeds were ground to fine powder. The ground single seed sample was put into eppendorf tubes and 0.2 mL of Tris Glycine extraction buffer was added. These suspensions were agitated thoroughly and kept at 8ºC overnight for protein extraction. Then the suspensions were centrifuged at 10,000 rpm for 30 minutes. The clear supernatant was collected. This protein extract was dissolved in an equal amount of working sample buffer and kept in boiling water for 2 minutes, cooled and again centrifuged at 10,000 rpm for 2 minutes. These samples were used for loading.

#### 3.5.2.3 Electrophoresis

Resolving gel (10%) solution was prepared by mixing 11.6 mL distilled water, 10 mL Acryl amide solution, 7.5 mL resolving gel buffer, 0.6mL SDS, 0.3 mL 10% APS and 30 µL TEMED and quickly pipetted under a layer of saturated 2_butanol for 45 minutes.

Stacking gel (4%) solution was prepared by mixing 8.9 mL distilled water, 2 mL acrylamide solution 3.75 mL stacking gel buffer, 0.15 mL 10% SDS 0.15 mL 10% APS and 15 µL TEMED. Just before pouring the stacking gel, the top of the resolving gel was thoroughly rinsed with distilled water and then the stacking gel solution was poured on top of the resolving gel. Immediately a comb was inserted to form wells of depth 2.5 cm taking care not to trap air bubbles under the teeth. The gel was allowed to polymerise for about half an hour. Then the acrylic comb was removed and the wells were rinsed with distilled water.

The upper and lower reservoir was filled with electrode buffer. Then 25 µL of the prepared sample was loaded into the wells in the stacking gel by layering them under electrode buffer using a micropipette. With cathode at the top, a current of 1.5 mA per well with voltage 80 volts was applied until the tracking dye (Bromophenol Blue) crossed the stacking gel. Later the current was increased to 2 mA per well and voltage to 120 volts. The electrophoresis was stopped when the tracking dye reached the bottom of the resolving gel.

#### 3.5.2.4 Staining

The gel was transferred directly from the electrophoretic apparatus to the staining solution of 0.1 % coomassive brilliant blue, 7.5 % acetic acid and 50 % methanol. And it is kept for 4 hours for staining and then the stain is poured off and then rinsed the gel several times with water before adding a destaining solution consisting of 10 % methanol and 7.5 % acetic acid. The destain will have to be changed every 1-24 hours. After this the gel can be preserved by drying.

# 4. EXPERIMENTAL RESULTS

The results of present investigation on various aspects such as effect of provenance, nursery mixture and hydropriming on seed quality and characterization of superior provenances through enzyme and seed protein analysis in Pongamia are presented in this chapter.

## 4.1 Experimental I: Influence of provenance on seed quality in Pongamia.

### 4.1.1 Morphological characters of seed in Pongamia

The data on the influence of provenance on shelling percentage, seed length, seed width, seed breadth, seed weight, seed colour and seed shape are presented in Table 1.

#### 4.1.1.1 Shelling percentage

The data on shelling percentage revealed significant difference due to provenance. Among different candidate plus trees (CPT's) evaluated, the highest shelling percentage (54.56 %) was recorded by CPT 13 and followed by CPT 12 (53.97 %). The lowest shelling percentage (30.55 %) was recorded by CPT 2. out of 40 CPT's evaluated for shelling percentage, six were in the range of 30 to less than 40 per cent, twenty nine were in the range of 40 to less than 50 per cent and five in the range of 50 to 55 per cent.

#### 4.1.1.2 Seed length

The data on seed length showed significant difference due to provenance. The seed length among 40 CPT's varied between 1.80 and 2.80 cm. the highest seed length (2.80 cm) was recorded by CPT 18 and CPT 20 and the lowest was (1.80 cm) with CPT 3, CPT 7, CPT 13 and CPT 21.

#### 4.1.1.3 Seed breadth

The data on seed breadth was found to be significant due to provenance. Seed breadth among 40 CPT's varied between 0.90 and 2.80 cm. The highest seed breadth (2.80 cm) was recorded by CPT 39 and the lowest breadth (0.90 cm) with CPT 2.

#### 4.1.1.4 Seed width

The data on seed width revealed significant difference due to provenance. Among 40 CPT's tested the seed width varied between 0.4 and 2.0 cm. the highest (2.00 cm) seed width was observed with CPT 38 and the lowest (0.8 cm) with CPT 7.

#### 4.1.1.5 100 seed weight

The data on 100 seed weight revealed significant difference due to provenance. The 100 seed weight varied between 56.00 and 279.51 g among the 40 CPT's evaluated. The highest (279.51 g) 100 seed weight was recorded by CPT 18 and lowest (56.00 g) with CPT 2.

#### 4.1.1.6 Seed colour

The visual observations of seeds of 40 CPT's for seed colour indicated existence of two colures *viz.,* tan red and brown. Majority of the CPT's showed Tan red colour (34 CPT's) while others were of brown colour (6 CPT's.)

#### 4.1.1.7 Seed shape

The visual observation of seed shapes of 40 CPT's showed the existence of two types of shapes *viz.,* oval and round. Among 40 CPT's as many as 33 CPT's showed oval seed shape. While remaining 7 CPT's showed round seed shape. The predominant seed shape in Pongamia species is oval.

### 4.1.2 Provenance effect on seed quality

The data on seed quality parameters like germination, root length, shoot length, vigour index and oil content are presented in Table 2.

#### 4.1.2.1 Germination

The data on germination percentage revealed significant difference due to provenance. The germination percentage varied between 17.00 and 94.00 per cent among the 40 CPT's evaluated. The highest (94.33 %) germination percentage was recorded by CPT 11 (Zone-3) and was lowest (17.00 %) with CPT 39 (Zone-10). The highest (75.5 %) mean germination was recorded by the CPT's of zone seven (CPT 25, 26, 27 and 28). The lowest (19.5 %) mean germination was recorded by the CPT's of zone ten (CPT 37, 38, 39 and 40) of Karnataka.

#### 4.1.2.2 Root length

There was significant difference in seedling root length due to provenance. The root length varied from19.33 and 41.33 cm among the 40 CPT's evaluated. The highest (41.33 cm) root length was recorded by CPT 3 and 11 and it was lowest (19.33 cm) in CPT 25 and CPT 38.

#### 4.1.2.3 Shoot length

The data on shoot length revealed significant difference due to provenance. The shoot length among 40 CPT's tested varied from 21.00 to 3.33 cm. the highest (21.00 cm) shoot length was observed with CPT 23 and was lowest (6.66 cm) with CPT 10, 16 and 30.

#### 4.1.2.4 Vigour index

The data on vigour index showed significant difference due to provenance. The vigour index among 40 CPT's evaluated varied between 4552 and 537. The highest (4552) vigour index was recorded by CPT 11 (Zone-3) followed by CPT 12 (4118) and was lowest (537.00 with CPT 39 (Zone-10). Among 10 agro climatic zones, the CPT's of zone-3, 7 and 8 found to be superior over CPT's of other zones and were on par with each other with respect to vigour index. The CPT's of coastal zone (Zone-10) were found to be inferior among all other zones tested.

#### 4.1.2.5 Oil content

Significant difference in oil content was observed due to provenance. Among 40 provenances tested the oil content varied between 42.79 and 28.98 per cent. The highest (42.79 %) oil content was recorded by CPT 20 (Zone-5) and was lowest (28.98 %) with CPT 34. Among 40 CPT's evaluated 20 CPT's recorded more than 35 per cent oil content and three CPT's have recorded more than 40 per cent oil content. Among different agro climatic zones the mean oil content was highest (38.45 %) with zone -5 and was lowest (32.77 %) with zone -9.

#### 4.1.2.6 Seedling height

The data on the influence of provenance on plant height in pongamia is presented in Table 3.

The data on plant height revealed significant difference due to provenance at different stages of the plant growth. The mean plant height among 40 CPT's tested varied from 22.33 and 51.66 cm. The highest (51.66 cm) plant height was observed with CPT 20 and was lowest (22.66 cm) with CPT 22. Among different agro climatic zones, zone -5 recorded the highest mean plant height (47.80 cm) and the plant height was lowest with zone-10 (25.07 cm).

#### 4.1.2.7 Number of leaves

The data on the influence of provenance on number of leaves is presented in Table 4.

The data on number of leaves revealed significant difference due to provenance. The number of leaves among 40 CPT's tested varied from 6.88 and 31.44. The highest (31.44) number of leaves were observed with CPT 18 and 20, and was lowest (6.88) with CPT 35 and CPT 39. Among different agro climatic zones, zone -5 recorded the highest mean leaf number (30.24) and was lowest with zone-10 (9.90).

Table 1: Provenance effect on morphological characters of seed in pongamia.

| Location | Shelling (%) | Seed length (cm) | Seed breadth (cm) | Seed width (cm) | 100 seed weight (g) | Seed Colour | Seed Shape |
|---|---|---|---|---|---|---|---|
| CPT 1 | 44.91 | 2.30 | 1.20 | 0.70 | 089.13 | Brown | Oval |
| CPT 2 | 30.55 | 2.10 | 0.90 | 0.60 | 056.11 | Brown | Oval |
| CPT 3 | 36.40 | 1.80 | 1.60 | 0.70 | 058.04 | Tan red | Round |
| CPT 4 | 30.72 | 2.00 | 1.20 | 0.50 | 097.15 | Tan red | Oval |
| CPT 5 | 50.97 | 2.20 | 1.50 | 0.70 | 130.02 | Tan red | Oval |
| CPT 6 | 50.73 | 2.30 | 1.30 | 0.80 | 126.60 | Tan red | Oval |
| CPT 7 | 46.28 | 1.80 | 1.10 | 0.40 | 120.30 | Tan red | Oval |
| CPT 8 | 48.11 | 2.30 | 1.10 | 0.70 | 069.82 | Tan red | Oval |
| CPT 9 | 47.77 | 2.10 | 1.50 | 0.73 | 142.38 | Tan red | Oval |
| CPT 10 | 43.86 | 2.10 | 1.70 | 0.70 | 140.48 | Tan red | Oval |
| CPT 11 | 41.08 | 2.30 | 1.20 | 0.73 | 094.81 | Tan red | Oval |
| CPT 12 | 53.97 | 2.50 | 2.00 | 0.90 | 226.72 | Tan red | Oval |
| CPT 13 | 54.56 | 1.80 | 1.70 | 0.70 | 153.25 | Tan red | Round |
| CPT 14 | 47.02 | 2.10 | 1.30 | 0.70 | 119.78 | Tan red | Oval |
| CPT 15 | 51.26 | 2.00 | 1.16 | 0.70 | 112.84 | Tan red | Oval |
| CPT 16 | 42.83 | 2.10 | 1.20 | 0.60 | 083.26 | Tan red | Oval |
| CPT 17 | 44.38 | 1.90 | 1.70 | 0.80 | 266.03 | Tan red | Oval |
| CPT 18 | 44.24 | 2.80 | 2.00 | 0.70 | 279.51 | Tan red | Oval |
| CPT 19 | 40.56 | 2.60 | 1.80 | 0.90 | 249.03 | Tan red | Oval |
| CPT 20 | 41.56 | 2.80 | 1.80 | 0.83 | 270.70 | Tan red | Oval |
| CPT 21 | 36.40 | 1.80 | 1.40 | 0.80 | 146.31 | Brown | Round |
| CPT 22 | 44.45 | 2.30 | 2.00 | 0.80 | 110.00 | Brown | Round |
| CPT 23 | 45.01 | 2.00 | 1.40 | 0.63 | 104.50 | Tan red | Oval |
| CPT 24 | 45.73 | 2.10 | 1.70 | 0.60 | 107.00 | Tan red | Oval |
| CPT 25 | 49.14 | 2.70 | 1.80 | 0.80 | 167.77 | Tan red | Oval |
| CPT 26 | 48.47 | 1.90 | 1.20 | 0.70 | 144.19 | Tan red | Oval |
| CPT 27 | 47.75 | 2.30 | 1.70 | 1.56 | 147.02 | Brown | Oval |
| CPT 28 | 47.38 | 2.10 | 1.70 | 1.13 | 149.00 | Tan red | Round |
| CPT 29 | 43.43 | 1.90 | 1.30 | 0.80 | 159.74 | Tan red | Oval |
| CPT 30 | 48.20 | 1.90 | 1.30 | 0.80 | 166.95 | Tan red | Oval |
| CPT 31 | 47.42 | 2.40 | 1.40 | 0.80 | 102.63 | Tan red | Oval |
| CPT 32 | 48.95 | 2.30 | 1.50 | 0.90 | 147.12 | Tan red | Oval |
| CPT 33 | 43.33 | 2.10 | 1.70 | 0.60 | 142.09 | Tan red | Oval |
| CPT 34 | 42.14 | 2.30 | 1.80 | 0.60 | 163.91 | Tan red | Oval |
| CPT 35 | 39.44 | 1.90 | 1.50 | 0.70 | 158.12 | Tan red | Round |
| CPT 36 | 37.34 | 2.20 | 1.70 | 0.80 | 145.22 | Tan red | Round |
| CPT 37 | 46.60 | 2.30 | 1.70 | 0.70 | 204.33 | Tan red | Oval |
| CPT 38 | 42.38 | 2.70 | 2.00 | 2.00 | 187.77 | Tan red | Oval |
| CPT 39 | 43.61 | 2.40 | 2.80 | 1.70 | 200.52 | Tan red | Oval |
| CPT 40 | 43.21 | 2.30 | 1.70 | 0.90 | 182.55 | Brown | Oval |
| SEm ± | 0.7202 | 0.11 | 0.11 | 0.10 | 1.474 | | |
| CD at 5% | 2.027 | 0.31 | 0.32 | 0.28 | 4.149 | | |

CPT- Candidate plus tree

Table 2: Provenance effect on germination, root length, shoot length, vigour index and oil content in Pongamia

| Location | Germination (%) | Root length (cm) | Shoot length (cm) | Vigour index | Oil content (%) |
|---|---|---|---|---|---|
| CPT 1 | 50.00 (45.00)* | 29.33 | 13.33 | 2131 | 36.14 |
| CPT 2 | 69.00(56.18) | 21.00 | 12.66 | 2322 | 40.40 |
| CPT 3 | 62.00(51.96) | 41.33 | 07.33 | 3117 | 37.10 |
| CPT 4 | 82.66(65.43) | 30.66 | 12.00 | 3528 | 38.78 |
| CPT 5 | 70.00(56.79) | 28.00 | 11.00 | 2731 | 32.64 |
| CPT 6 | 80.00(63.51) | 31.33 | 11.33 | 3424 | 38.95 |
| CPT 7 | 63.00(52.54) | 21.33 | 10.00 | 1973 | 37.71 |
| CPT 8 | 40.33(39.43) | 29.00 | 08.33 | 1505 | 38.71 |
| CPT 9 | 37.00(37.46) | 31.33 | 07.33 | 1433 | 37.68 |
| CPT 10 | 32.00(34.44) | 29.00 | 06.66 | 1142 | 36.64 |
| CPT 11 | 94.33(72.59) | 41.33 | 08.66 | 4552 | 36.19 |
| CPT 12 | 87.00(68.90) | 35.66 | 11.66 | 4118 | 36.24 |
| CPT 13 | 79.00(62.73) | 24.33 | 07.33 | 2502 | 35.63 |
| CPT 14 | 83.00(65.69) | 33.33 | 11.33 | 3707 | 34.52 |
| CPT 15 | 61.00(51.36) | 22.66 | 13.33 | 2194 | 36.63 |
| CPT 16 | 32.00(34.43) | 22.00 | 06.66 | 915 | 34.77 |
| CPT 17 | 52.00(46.17) | 27.66 | 09.33 | 1924 | 37.81 |
| CPT 18 | 67.00(54.94) | 23.33 | 12.33 | 2330 | 40.33 |
| CPT 19 | 58.33(42.12) | 28.66 | 07.00 | 1605 | 32.87 |
| CPT 20 | 58.00(49.60) | 24.00 | 09.33 | 1929 | 42.79 |
| CPT 21 | 55.00(47.87) | 35.66 | 10.33 | 2530 | 33.40 |
| CPT 22 | 51.00(45.57) | 30.33 | 16.00 | 2363 | 32.46 |
| CPT 23 | 50.00(45.00) | 25.33 | 21.00 | 2410 | 33.94 |
| CPT 24 | 67.00(54.94) | 32.33 | 09.33 | 2533 | 36.52 |
| CPT 25 | 74.00(59.41) | 19.33 | 13.33 | 2745 | 37.57 |
| CPT 26 | 58.00(49.60) | 21.66 | 11.66 | 2224 | 34.91 |
| CPT 27 | 76.00(60.68) | 24.00 | 13.33 | 3437 | 30.87 |
| CPT 28 | 81.00(64.26) | 33.33 | 07.00 | 2866 | 35.87 |
| CPT 29 | 87.00(68.90) | 34.44 | 11.33 | 3900 | 35.62 |
| CPT 30 | 62.33(53.14) | 23.33 | 06.66 | 2085 | 35.95 |
| CPT 31 | 83.00(65.67) | 35.33 | 09.00 | 3185 | 34.84 |
| CPT 32 | 73.33(58.91) | 25.33 | 08.00 | 2258 | 34.46 |
| CPT 33 | 67.00(54.94) | 29.66 | 07.00 | 2303 | 32.43 |
| CPT 34 | 37.00(37.46) | 32.33 | 12.33 | 1656 | 28.98 |
| CPT 35 | 64.00(53.13) | 20.66 | 12.66 | 2220 | 32.89 |
| CPT 36 | 27.00(31.29) | 20.66 | 10.00 | 887 | 36.75 |
| CPT 37 | 20.00(26.55) | 20.66 | 10.00 | 613 | 31.38 |
| CPT 38 | 21.00(27.26) | 19.33 | 08.66 | 595 | 32.22 |
| CPT 39 | 17.00(24.33) | 22.00 | 12.33 | 537 | 31.90 |
| CPT 40 | 20.00(26.57) | 29.00 | 13.50 | 852 | 36.35 |
| SEm± | 1.02 | 0.007 | 1.22 | 193 | 0.72 |
| CD at 5% | 2.871 | 2.80 | 3.43 | 543 | 2.02 |

* -Figures in parentheses are angular transformed values CPT- Candidate plus tree

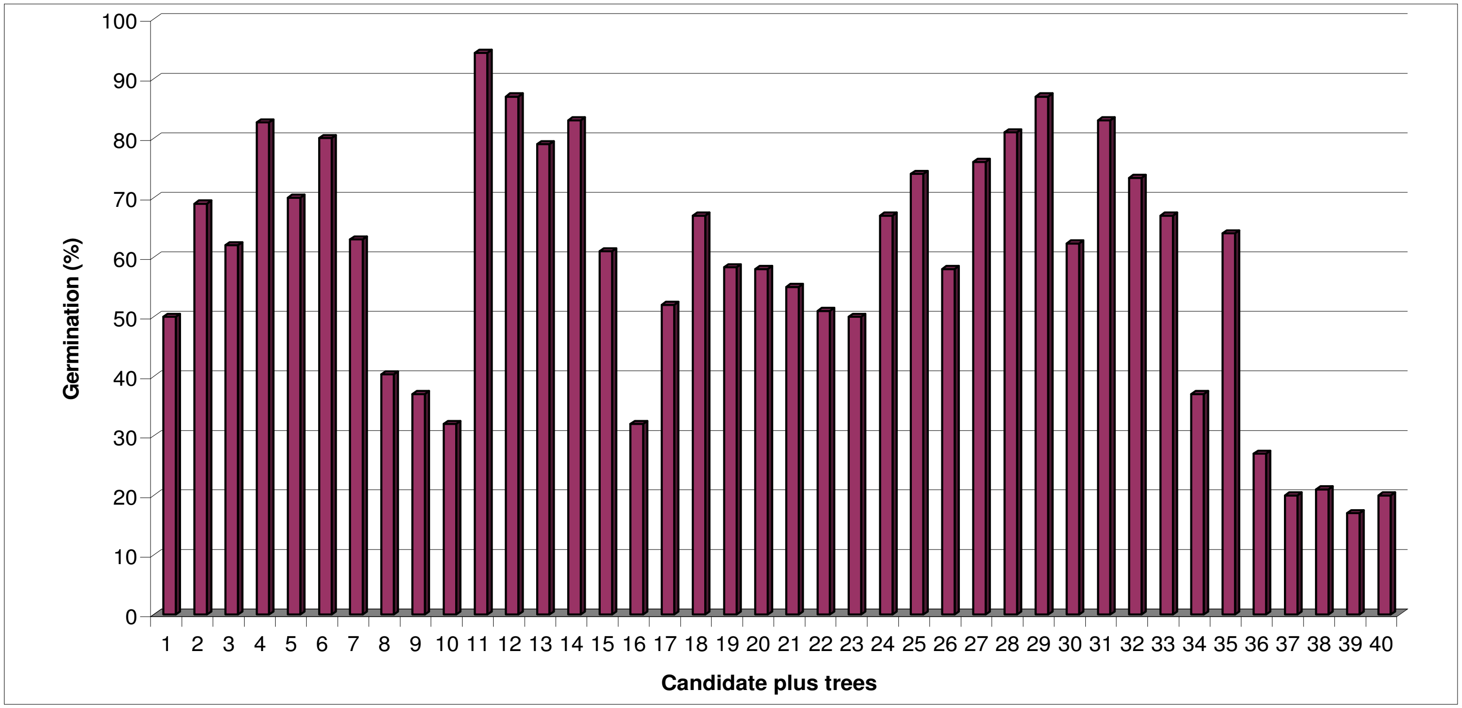



**Fig. 1. Effect of provenance on germination**

Fig.1. Effect of provenance on germination

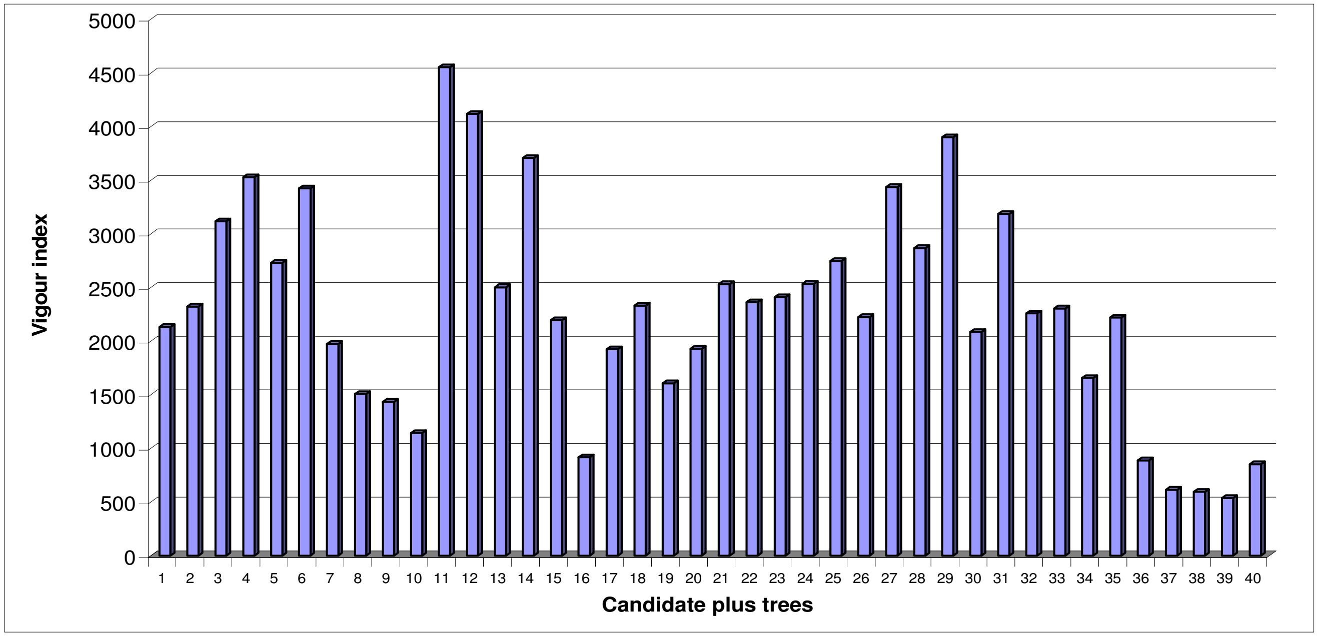



**Fig. 2. Effect of provenance on vigour**

Fig.2. Effect of provenance on vigour

Table 3: Effect of provenance on plant height at different stages of growth in pongamia.

| Location | Plant height (cm) | | | |
|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean |
| CPT1 | 32.66 | 36.33 | 38.00 | 35.66 |
| CPT2 | 24.00 | 26.00 | 26.33 | 25.66 |
| CPT3 | 24.33 | 28.00 | 29.00 | 27.11 |
| CPT4 | 32.00 | 33.00 | 38.33 | 34.44 |
| CPT5 | 33.66 | 38.33 | 41.00 | 37.66 |
| CPT6 | 39.00 | 39.66 | 45.00 | 41.22 |
| CPT7 | 39.33 | 43.66 | 48.00 | 43.66 |
| CPT8 | 25.66 | 26.00 | 26.00 | 25.88 |
| CPT9 | 28.66 | 33.00 | 33.00 | 31.55 |
| CPT10 | 27.66 | 31.33 | 35.66 | 31.51 |
| CPT11 | 32.33 | 36.00 | 37.00 | 35.11 |
| CPT12 | 42.00 | 43.33 | 46.00 | 43.77 |
| CPT13 | 31.33 | 38.33 | 42.33 | 37.33 |
| CPT14 | 33.33 | 33.66 | 39.00 | 35.33 |
| CPT15 | 33.66 | 35.33 | 38.33 | 35.77 |
| CPT16 | 31.33 | 31.66 | 33.33 | 32.10 |
| CPT17 | 43.33 | 46.00 | 47.66 | 45.66 |
| CPT18 | 43.33 | 48.66 | 57.33 | 49.77 |
| CPT19 | 40.33 | 43.33 | 48.66 | 44.10 |
| CPT20 | 46.00 | 49.66 | 59.33 | 51.66 |
| CPT21 | 33.33 | 37.33 | 42.00 | 37.55 |
| CPT22 | 31.33 | 32.33 | 33.33 | 22.33 |
| CPT23 | 29.66 | 31.33 | 32.33 | 31.10 |
| CPT24 | 29.33 | 30.00 | 33.00 | 29.77 |
| CPT25 | 35.66 | 40.00 | 41.33 | 38.99 |
| CPT26 | 35.00 | 35.66 | 43.66 | 38.10 |
| CPT27 | 36.33 | 37.66 | 43.00 | 38.99 |
| CPT28 | 37.00 | 40.66 | 44.00 | 40.55 |
| CPT29 | 37.00 | 40.00 | 45.33 | 39.77 |
| CPT30 | 35.00 | 35.00 | 37.66 | 35.88 |
| CPT31 | 25.00 | 29.66 | 32.00 | 28.88 |
| CPT32 | 30.33 | 35.00 | 40.33 | 35.22 |
| CPT33 | 36.66 | 37.00 | 42.66 | 38.77 |
| CPT34 | 26.00 | 29.66 | 35.66 | 30.44 |
| CPT35 | 29.33 | 29.66 | 36.33 | 28.44 |
| CPT36 | 32.66 | 34.00 | 37.33 | 34.66 |
| CPT37 | 22.33 | 23.00 | 23.33 | 23.55 |
| CPT38 | 25.33 | 27.00 | 29.00 | 27.11 |
| CPT39 | 17.66 | 25.00 | 25.33 | 22.66 |
| CPT40 | 26.66 | 26.33 | 28.00 | 26.99 |
| SEm± | 1.24 | 1.44 | 1.31 | |
| CD at 5% | 3.60 | 4.06 | 3.70 | |

CPT- Candidate plus tree DAS- Days after sowing

#### 4.1.2.8 Crown spread

The data on crown spread as influenced by provenance in pongamia is presented in Table 5.

There was significant difference in crown spread due to provenance. Crown spread varied from 14.55 and 27.66 cm among the 40 CPT's evaluated, the highest (27.66 cm) crown spread was recorded by CPT 20 and the lowest crown spread was (14.55 cm) with CPT 39. Among different agro climatic zones, zone -5 recorded the highest mean crown spread (24.88 cm) and was lowest with zone-10 (16.46 cm).

#### 4.1.2.9 Collar diameter

The data on the influence of provenance on collar diameter in pongamia is presented in Table 6.

The data on collar diameter revealed significant difference due to provenance. The collar diameter among 40 CPT's tested varied between 0.39 and 0.63 cm. The highest (0.63 cm) collar diameter was observed with CPT 18 and the collar diameter was lowest (0.39 cm) with CPT 38. Among different agro climatic zones, zone -5 recorded the highest mean collar diameter (0.58) and was lowest with zone-10 (0.43).

#### 4.1.2.10 Seedling dry weight

The data on the influence of provenance on seedling dry weight in pongamia is presented in Table 7.

The data on seedling dry weight revealed significant difference due to provenance at different stages of the plant growth. The mean seedling dry weight among 40 CPT's tested varied between 2.68 and 6.16 g. The highest (6.16 g) seedling dry weight was observed with CPT 20 and was lowest (2.68 g) with CPT 35. Among different agro climatic zones, zone -5 recorded the highest mean seedling dry weight (4.90g) and was lowest with zone-10 (3.17g).

### 4.1.3 Survey results

The survey of potential Pongamia growing areas was carried out in 10 agro climatic zones of Karnataka from each zone 10 farmers were identified and interviewed to collect information about their knowledge on Pongamia cultivation, farming system, manipulation, marketing and its uses. The data colleted from 100 farmers across the zone was subjected for analysis and assessed the frequency and percentage of yes/ good/ fair/ poor. The results pertaining to various parameters have been explained as below.

#### 4.1.3.1 Use and growing of Pongamia

The data on farmers knowledge about Pongamia revealed that the awareness of farmers with regard to use of Pongamia as oil, green manure, growing as silvipasture and agri silvipasture, across the zone was 31, 83, 11 and 4 percent respectively. Among different zones the farmers of zone V and VI had fairly better knowledge about Pongamia's use as oil than other zone farmers. All the respondents of zone VI, VII and IX had the knowledge of use of Pongamia as green manure. None of the respondents in zone I, II and VII were aware of growing Pongamia as silvipasture. None or negligible number of farmers in allmost all the zones were aware of growing Pongamia in agri- silvipastural system.

#### 4.1.3.2 Silvicultural characters

The data on knowledge of farmers about silvicultural characters like resistance to fire, resistance to browsing, pests, disease and average yield (kg/ plant) was 60, 87, 42, 53 percent and 37.17 kg/ plant, respectively across the zones. All the respondents of zone IV were of the opinion that pongamia was resistant to fire. All the respondents of zone II, IV and V and most of the respondents of other zones opined that pongamia was resistant to browsing, many respondents in different zones were aware that Pongamia is resistant to pests and diseases attack. Respondents of different zones were of the opinion that the average yield per plant was 37.17 kg and in the each zone it was 31.00 to 46.00 kg per plant.

Table 4: Effect of provenance on number of leaves at different stages of growth in pongamia

| Location | Number of leaves | | | |
|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean |
| CPT1 | 19.33 | 24.33 | 28.00 | 23.88 |
| CPT2 | 15.66 | 20.00 | 20.66 | 18.77 |
| CPT3 | 19.00 | 19.66 | 21.00 | 19.88 |
| CPT4 | 21.33 | 25.33 | 27.00 | 27.88 |
| CPT5 | 19.66 | 24.00 | 26.33 | 23.33 |
| CPT6 | 23.00 | 24.00 | 27.33 | 24.77 |
| CPT7 | 17.33 | 24.00 | 24.66 | 21.99 |
| CPT8 | 18.66 | 24.33 | 24.66 | 22.55 |
| CPT9 | 18.33 | 20.33 | 23.00 | 20.55 |
| CPT10 | 24.33 | 25.33 | 26.66 | 25.44 |
| CPT11 | 16.33 | 18.66 | 23.33 | 19.44 |
| CPT12 | 20.33 | 24.33 | 24.33 | 22.99 |
| CPT13 | 19.66 | 20.66 | 25.66 | 21.99 |
| CPT14 | 22.66 | 22.66 | 25.00 | 23.44 |
| CPT15 | 16.66 | 18.00 | 21.66 | 18.77 |
| CPT16 | 23.33 | 23.66 | 25.33 | 24.10 |
| CPT17 | 21.33 | 30.00 | 35.66 | 28.99 |
| CPT18 | 23.66 | 33.66 | 37.00 | 31.44 |
| CPT19 | 23.66 | 29.00 | 34.66 | 29.10 |
| CPT20 | 24.66 | 29.66 | 40.00 | 31.44 |
| CPT21 | 12.33 | 15.66 | 19.66 | 15.88 |
| CPT22 | 13.33 | 14.00 | 17.33 | 18.22 |
| CPT23 | 13.33 | 16.66 | 22.00 | 17.33 |
| CPT24 | 14.00 | 16.00 | 19.66 | 16.55 |
| CPT25 | 17.33 | 20.33 | 29.33 | 22.33 |
| CPT26 | 19.00 | 21.33 | 25.66 | 21.99 |
| CPT27 | 20.33 | 22.33 | 25.66 | 22.77 |
| CPT28 | 22.33 | 23.66 | 25.00 | 23.66 |
| CPT29 | 14.33 | 14.66 | 20.66 | 16.55 |
| CPT30 | 10.00 | 11.66 | 14.33 | 11.99 |
| CPT31 | 13.33 | 15.33 | 20.66 | 16.44 |
| CPT32 | 15.66 | 19.33 | 21.33 | 18.77 |
| CPT33 | 19.66 | 19.66 | 21.00 | 23.44 |
| CPT34 | 10.33 | 11.00 | 11.66 | 10.99 |
| CPT35 | 06.33 | 06.66 | 07.33 | 06.88 |
| CPT36 | 14.00 | 16.66 | 17.33 | 15.99 |
| CPT37 | 11.66 | 11.66 | 12.66 | 11.99 |
| CPT38 | 11.33 | 13.33 | 16.00 | 13.55 |
| CPT39 | 04.66 | 06.00 | 11.00 | 06.88 |
| CPT40 | 06.66 | 07.33 | 07.66 | 07.21 |
| SEm± | 0.96 | 1.35 | 1.41 | |
| CD at 5% | 2.70 | 3.81 | 3.98 | |

CPT- Candidate plus tree DAS- Days after sowing

Table 5: Effect of provenance on crown spread at different stages of rowth in pongamia

| Location | Crown spread (cm) | | | |
|---|---|---|---|---|
| | **60 DAS** | **90 DAS** | **120 DAS** | **Mean** |
| CPT1 | 23.66 | 24.00 | 26.66 | 24.77 |
| CPT2 | 17.33 | 21.33 | 23.00 | 21.55 |
| CPT3 | 21.66 | 24.66 | 26.33 | 24.21 |
| CPT4 | 21.66 | 24.66 | 24.66 | 23.66 |
| CPT5 | 19.33 | 25.66 | 28.33 | 24.44 |
| CPT6 | 18.33 | 27.66 | 30.00 | 25.33 |
| CPT7 | 22.00 | 24.00 | 30.66 | 25.55 |
| CPT8 | 17.33 | 20.66 | 25.33 | 21.10 |
| CPT9 | 18.00 | 22.33 | 25.00 | 21.77 |
| CPT10 | 17.33 | 20.66 | 30.33 | 22.77 |
| CPT11 | 23.33 | 25.66 | 26.66 | 25.21 |
| CPT12 | 18.66 | 19.00 | 24.33 | 20.66 |
| CPT13 | 19.66 | 22.66 | 24.66 | 22.32 |
| CPT14 | 19.00 | 26.33 | 34.00 | 26.44 |
| CPT15 | 20.66 | 21.66 | 33.66 | 25.32 |
| CPT16 | 17.33 | 20.66 | 21.00 | 19.66 |
| CPT17 | 20.66 | 25.33 | 27.00 | 24.33 |
| CPT18 | 22.33 | 23.33 | 29.66 | 25.10 |
| CPT19 | 15.00 | 21.33 | 31.00 | 22.44 |
| CPT20 | 26.33 | 28.66 | 29.00 | 27.66 |
| CPT21 | 20.33 | 22.00 | 27.33 | 23.22 |
| CPT22 | 17.33 | 18.33 | 21.33 | 18.99 |
| CPT23 | 15.66 | 20.00 | 25.66 | 20.44 |
| CPT24 | 16.66 | 18.00 | 18.66 | 17.77 |
| CPT25 | 14.33 | 22.33 | 24.66 | 20.44 |
| CPT26 | 19.66 | 25.33 | 35.33 | 26.77 |
| CPT27 | 21.00 | 21.66 | 31.00 | 24.55 |
| CPT28 | 22.66 | 23.66 | 24.66 | 23.66 |
| CPT29 | 18.66 | 19.33 | 21.33 | 19.77 |
| CPT30 | 17.33 | 19.00 | 26.00 | 20.77 |
| CPT31 | 16.66 | 21.33 | 23.00 | 20.33 |
| CPT32 | 18.00 | 20.33 | 21.00 | 19.77 |
| CPT33 | 15.33 | 16.33 | 19.33 | 16.99 |
| CPT34 | 15.33 | 16.66 | 23.66 | 18.21 |
| CPT35 | 16.66 | 21.33 | 24.33 | 20.77 |
| CPT36 | 18.00 | 23.33 | 26.00 | 22.44 |
| CPT37 | 15.00 | 16.33 | 23.33 | 18.22 |
| CPT38 | 13.33 | 14.66 | 20.66 | 16.21 |
| CPT39 | 13.66 | 15.33 | 16.66 | 14.55 |
| CPT40 | 15.33 | 16.66 | 18.66 | 16.88 |
| **SEm±** | **1.02** | **1.20** | **1.43** | |
| **CD at 5%** | **2.87** | **3.38** | **4.01** | |

CPT- Candidate plus tree     DAS- Days after sowing

Table 6: Effect of provenance on collar diameter at different stages of growth in pongamia

| Location | Collar Diameter (cm) | | | |
|---|---|---|---|---|
| | **60 DAS** | **90 DAS** | **120 DAS** | **Mean** |
| CPT 1 | 0.50 | 0.53 | 0.56 | 0.53 |
| CPT 2 | 0.40 | 0.50 | 0.63 | 0.51 |
| CPT 3 | 0.36 | 0.46 | 0.56 | 0.46 |
| CPT 4 | 0.50 | 0.50 | 0.70 | 0.56 |
| CPT 5 | 0.43 | 0.50 | 0.53 | 0.48 |
| CPT 6 | 0.50 | 0.56 | 0.56 | 0.54 |
| CPT 7 | 0.53 | 0.53 | 0.60 | 0.55 |
| CPT 8 | 0.40 | 0.40 | 0.43 | 0.41 |
| CPT 9 | 0.46 | 0.50 | 0.56 | 0.51 |
| CPT 10 | 0.46 | 0.56 | 0.56 | 0.52 |
| CPT11 | 0.43 | 0.50 | 0.53 | 0.48 |
| CPT 12 | 0.50 | 0.53 | 0.53 | 0.52 |
| CPT 13 | 0.56 | 0.60 | 0.60 | 0.58 |
| CPT 14 | 0.50 | 0.53 | 0.53 | 0.52 |
| CPT 15 | 0.50 | 0.50 | 0.56 | 0.52 |
| CPT 16 | 0.40 | 0.50 | 0.53 | 0.47 |
| CPT 17 | 0.53 | 0.63 | 0.63 | 0.59 |
| CPT 18 | 0.56 | 0.60 | 0.63 | 0.59 |
| CPT 19 | 0.46 | 0.50 | 0.56 | 0.51 |
| CPT 20 | 0.53 | 0.66 | 0.70 | 0.63 |
| CPT 21 | 0.46 | 0.53 | 0.53 | 0.51 |
| CPT 22 | 0.43 | 0.43 | 0.43 | 0.42 |
| CPT 23 | 0.40 | 0.50 | 0.56 | 0.48 |
| CPT 24 | 0.50 | 0.53 | 0.53 | 0.52 |
| CPT 25 | 0.43 | 0.50 | 0.60 | 0.51 |
| CPT 26 | 0.46 | 0.50 | 0.60 | 0.52 |
| CPT 27 | 0.46 | 0.50 | 0.63 | 0.53 |
| CPT 28 | 0.53 | 0.56 | 0.60 | 0.56 |
| CPT 29 | 0.40 | 0.43 | 0.70 | 0.51 |
| CPT 30 | 0.40 | 0.50 | 0.63 | 0.51 |
| CPT 31 | 0.43 | 0.46 | 0.56 | 0.48 |
| CPT 32 | 0.46 | 0.50 | 0.73 | 0.55 |
| CPT 33 | 0.43 | 0.50 | 0.56 | 0.49 |
| CPT 34 | 0.43 | 0.43 | 0.50 | 0.46 |
| CPT 35 | 0.43 | 0.43 | 0.56 | 0.47 |
| CPT 36 | 0.50 | 0.50 | 0.56 | 0.52 |
| CPT 37 | 0.46 | 0.46 | 0.50 | 0.47 |
| CPT 38 | 0.33 | 0.40 | 0.46 | 0.39 |
| CPT 39 | 0.33 | 0.43 | 0.50 | 0.42 |
| CPT40 | 0.40 | 0.46 | 0.46 | 0.44 |
| **SEm±** | **0.003** | **0.03** | **0.04** | |
| **CD at 5%** | **0.08** | **0.08** | **0.11** | |

CPT- Candidate plus tree DAS- Days after sowing

Table 7: Effect of provenance on Seedling dry weight at different stages of growth in pongamia

| Location | Seedling dry weight (g) | | | |
|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean |
| CPT 1 | 4.16 | 4.48 | 5.74 | 6.12 |
| CPT 2 | 2.81 | 2.96 | 5.84 | 3.87 |
| CPT 3 | 3.33 | 3.55 | 5.51 | 4.13 |
| CPT 4 | 2.62 | 3.13 | 3.23 | 2.99 |
| CPT 5 | 4.09 | 4.28 | 4.67 | 4.34 |
| CPT 6 | 3.03 | 4.34 | 4.54 | 3.97 |
| CPT 7 | 4.07 | 4.38 | 4.63 | 4.36 |
| CPT 8 | 3.27 | 3.48 | 4.25 | 4.00 |
| CPT 9 | 2.67 | 2.81 | 4.26 | 3.24 |
| CPT 10 | 3.85 | 4.02 | 5.41 | 4.43 |
| CPT 11 | 4.91 | 5.08 | 5.58 | 5.19 |
| CPT 12 | 4.97 | 5.17 | 5.31 | 5.15 |
| CPT 13 | 2.80 | 3.82 | 4.01 | 3.54 |
| CPT 14 | 3.98 | 4.13 | 4.66 | 4.25 |
| CPT 15 | 3.19 | 3.75 | 3.87 | 3.60 |
| CPT 16 | 3.40 | 3.47 | 4.20 | 3.69 |
| CPT 17 | 4.23 | 4.93 | 5.13 | 4.76 |
| CPT 18 | 4.33 | 4.39 | 4.52 | 4.41 |
| CPT 19 | 4.03 | 4.28 | 4.44 | 4.25 |
| CPT 20 | 5.88 | 6.27 | 6.35 | 6.16 |
| CPT 21 | 3.88 | 4.08 | 4.42 | 4.12 |
| CPT 22 | 2.86 | 3.10 | 4.04 | 4.00 |
| CPT 23 | 2.39 | 2.39 | 4.11 | 2.96 |
| CPT 24 | 2.82 | 2.96 | 3.44 | 3.07 |
| CPT 25 | 2.84 | 2.94 | 4.25 | 3.34 |
| CPT 26 | 3.17 | 3.24 | 5.05 | 3.82 |
| CPT 27 | 3.90 | 4.08 | 5.07 | 4.35 |
| CPT 28 | 4.63 | 4.87 | 5.07 | 4.85 |
| CPT 29 | 3.12 | 3.25 | 3.81 | 3.39 |
| CPT 30 | 2.77 | 2.88 | 4.32 | 3.32 |
| CPT 31 | 3.07 | 3.13 | 4.58 | 3.59 |
| CPT 32 | 2.84 | 2.91 | 4.67 | 3.47 |
| CPT 33 | 3.53 | 3.74 | 4.33 | 3.87 |
| CPT 34 | 1.87 | 1.94 | 5.24 | 3.01 |
| CPT 35 | 1.83 | 1.90 | 4.33 | 2.68 |
| CPT 36 | 3.03 | 3.23 | 4.70 | 3.65 |
| CPT 37 | 2.66 | 2.86 | 4.94 | 3.48 |
| CPT 38 | 2.26 | 2.39 | 4.27 | 2.97 |
| CPT 39 | 2.74 | 2.92 | 4.56 | 3.40 |
| CPT 40 | 2.05 | 2.13 | 4.32 | 2.83 |
| SEm± | 0.21 | 0.24 | 0.15 | |
| CD at 5% | 0.61 | 0.67 | 0.43 | |

CPT- Candidate plus tree DAS- Days after sowing

Table 8: Knowledge of farmers of Karnataka about pongamia

| Particulars | Frequency/ percentage of yes | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zones | | | | | | | | | | |
| 1. Farmers knowledge about Pongamia | I | II | III | IV | V | VI | VII | VIII | IX | X | |
| Use as oil | 1 | 2 | 3 | 2 | 6 | 6 | 4 | 4 | 1 | 2 | 31 |
| Use as green manure | 7 | 8 | 7 | 7 | 7 | 10 | 10 | 7 | 10 | 9 | 83 |
| Growing as silvipasture | 0 | 0 | 1 | 2 | 1 | 2 | 0 | 2 | 2 | 1 | 11 |
| Growing as agri-silvipasture | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 4 |
| 2. Farmers knowledge about silvicultural characters of pongamia | | | | | | | | | | | |
| Resistance to fire | 4 | 5 | 5 | 10 | 2 | 7 | 8 | 7 | 5 | 7 | 60 |
| Resistance to browsing | 10 | 7 | 7 | 10 | 10 | 9 | 8 | 9 | 8 | 8 | 87 |
| Average yield (kg/ plant) | 33.0 | 32.0 | 31.0 | 36.5 | 40.5 | 46.0 | 40.0 | 38.0 | 35.5 | 38.0 | 37.17 |
| Resistance to pests | 4 | 5 | 6 | 4 | 3 | 5 | 3 | 4 | 5 | 3 | 42 |
| Resistance to diseases | 6 | 2 | 8 | 2 | 6 | 7 | 5 | 8 | 5 | 4 | 53 |

#### 4.1.3.3 Uses of pongamia

The data on farmers knowledge about pongamia revealed that the awareness of farmers with regard to uses of pongamia as mixing with diesel, used for industries, used as bio- fuel, transesterification and other religious uses, across the zones was 29, 71, 0 as fair, poor and good, respectively and 10, 53, 37 of the farmers opined that it would be good , fair, and poor if it is used for industries, 2, 24, 74 farmers said that it would be good, fair and poor if it is used as bio- fuel and 1, 34, 65 of the farmers said that it would be good, fair and poor on transesterification and 21, 62, 17 of the farmers opined that it would be good, fair and poor for other religious uses.

Among different zones all the farmers of zone VII said it would be poor if it is mixed with diesel and in rest of the zones farmers opined that it would be fairly better if it is mixed with diesel. And in rest of all the zones farmers had fairly better opinion on using it for industries, using it as bio- fuel, transesterification and for other religious uses.

#### 4.1.3.4 Knowledge about silvicultural manipulation

The data on farmers knowledge about silvicultural manipulation revealed that the awareness of farmers with regard to silvicultural manipulation as coppicing, pollarding, planting method, nursery techniques and water harvesting across the zones was 41, 81, 3, 0 and 51 respectively. Among different zones all the farmers of zone V and VII had said that pollarding should be completely manipulated, the farmers of zone VI, VII and VIII opined that 80 percent of the coppicing should be manipulated, none of the respondents in all the zones wanted manipulation in nursery techniques, none or negligible number of farmers wanted manipulation in planting method. In all the zones farmers said that water harvesting should be manipulated.

#### 4.1.3.5 Knowledge about market and interest in cultivation

The data on farmers knowledge about silvicultural manipulation revealed that the awareness of farmers with regard to market and interest in cultivation across the zones was 12, 32 and 36 percent good, fair and poor, respectively. Some of the farmers had fair knowledge about the information on market, and in all the zones only few farmers had interest in cultivation.

#### 4.1.3.6 Interest of farmers in pongamia cultivation

The data on farmers knowledge about silvicultural manipulation revealed that the awareness of farmers with regard to cultivation of Pongamia in entire plantation, border plantation, agroforestry models, along the streams and none, across the zones was 2, 74, 4, 72 and 50 percent, respectively. All the farmers of zone VI and VIII had interest and knowledge about growing pongamia along the streams, and the farmers of zone I, II, III and V had fairly better interest in growing it has border plantation. None or negligible farmers were interested in growing it as agro forestry model.

#### 4.1.3.7 Any other information

The data on farmers knowledge about extra information on Pongamia revealed that need for financial assistance, welcome as national programme, need for subsidy bound financial assistance, need for technical support to take up plantation, and need for market information, across the zones was 41, 51, 76, 80 and 86 percent, respectively. All the farmers of zone V were in need of subsidy, financial assistance and they were in need of technical support to take up plantation and all the farmers of above mentioned zone were in requirement of market information and in zone VIII all the farmers were in need of market information.

## 4.2 Experiment II: Standardization of suitable nursery mixture.

### 4.2.1 Germination

The data on germination percentage as influenced by different nursery mixtures are presented in Table 14.

The data revealed significant difference due to nursery mixture with respect to germination. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$)

Table 9: Awareness of farmers of Karnataka about interest in pongamia cultivation

| Particulars | Zones | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Interests of farmers in pongamia plantation | I | II | III | IV | V | VI | VII | VIII | IX | X | |
| Entire plantation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Border plantation | 9 | 9 | 9 | 7 | 9 | 6 | 4 | 8 | 8 | 5 | 74 |
| Agroforestry models | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Along the streams | 5 | 4 | 6 | 8 | 7 | 10 | 7 | 10 | 8 | 7 | 72 |
| None | 3 | 4 | 6 | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 50 |

Table 10: Awareness of farmers of Karnataka about market and interest in cultivation pongamia

| Zones | Particulars | | | | | |
|---|---|---|---|---|---|---|
| | Market | | | Interest in cultivation | | |
| | Good | Fair | Poor | Good | Fair | Poor |
| Zone 1 | 0 | 3 | 7 | 0 | 1 | 9 |
| Zone 2 | 0 | 2 | 8 | 0 | 1 | 9 |
| Zone 3 | 0 | 6 | 4 | 0 | 5 | 5 |
| Zone 4 | 0 | 5 | 5 | 0 | 3 | 7 |
| Zone 5 | 0 | 7 | 3 | 0 | 4 | 6 |
| Zone 6 | 3 | 6 | 1 | 2 | 5 | 3 |
| Zone 7 | 1 | 7 | 2 | 0 | 5 | 5 |
| Zone 8 | 2 | 8 | 0 | 0 | 10 | 0 |
| Zone 9 | 7 | 1 | 2 | 0 | 6 | 4 |
| Zone 10 | 0 | 7 | 3 | 1 | 4 | 5 |
| Across the Zones | 12 | 52 | 36 | 3 | 44 | 53 |

Table 11: Awareness of farmers of Karnataka about different uses of pongamia

| Zones | Particulars | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mixing with diesel | | | Use for industries | | | Use as bio-diesel | | | Transestrification | | | Other uses (religious) | | |
| | Good | Fair | Poor | Good | Fair | Poor | Good | Fair | Poor | Good | Fair | Poor | Good | Fair | Poor |
| Zone 1 | 0 | 3 | 7 | 0 | 5 | 5 | 0 | 1 | 9 | 0 | 3 | 7 | 0 | 6 | 4 |
| Zone 2 | 0 | 2 | 8 | 0 | 3 | 7 | 0 | 1 | 9 | 0 | 4 | 6 | 0 | 7 | 3 |
| Zone 3 | 0 | 1 | 9 | 0 | 3 | 7 | 1 | 2 | 7 | 1 | 2 | 7 | 1 | 7 | 2 |
| Zone 4 | 0 | 3 | 7 | 0 | 5 | 5 | 0 | 2 | 8 | 0 | 3 | 7 | 1 | 7 | 2 |
| Zone 5 | 0 | 5 | 5 | 1 | 5 | 4 | 1 | 4 | 5 | 0 | 4 | 6 | 2 | 6 | 2 |
| Zone 6 | 0 | 5 | 5 | 0 | 9 | 1 | 0 | 3 | 7 | 0 | 4 | 6 | 6 | 4 | 0 |
| Zone 7 | 0 | 0 | 10 | 1 | 6 | 3 | 0 | 1 | 9 | 0 | 3 | 7 | 2 | 7 | 1 |
| Zone 8 | 0 | 4 | 6 | 5 | 5 | 0 | 0 | 5 | 5 | 0 | 5 | 5 | 2 | 7 | 1 |
| Zone 9 | 0 | 4 | 6 | 1 | 8 | 1 | 0 | 1 | 9 | 0 | 5 | 5 | 5 | 3 | 2 |
| Zone 10 | 0 | 2 | 8 | 2 | 4 | 4 | 0 | 4 | 6 | 0 | 1 | 9 | 2 | 8 | 0 |
| Across the zones | 0 | 29 | 71 | 10 | 53 | 37 | 2 | 24 | 74 | 1 | 34 | 65 | 21 | 62 | 17 |

Table 12: Awareness of farmers of Karnataka about silvicultural manipulation pongamia

| Particulars | Frequency / percentage of yes | | | | | | | | | | Across Zones |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zones | | | | | | | | | | |
| Any other information | I | II | III | IV | V | VI | VII | VIII | IX | X | |
| Do not need financial assistance | 4 | 4 | 5 | 5 | 3 | 4 | 5 | 4 | 2 | 5 | 41 |
| Need financial assistance | 1 | 6 | 2 | 4 | 4 | 7 | 7 | 7 | 8 | 5 | 51 |
| Welcome as national programme | 2 | 3 | 3 | 4 | 4 | 6 | 6 | 8 | 6 | 6 | 48 |
| Need subsidy bound financial assistance | 9 | 7 | 6 | 8 | 10 | 7 | 7 | 7 | 7 | 7 | 76 |
| Need technical support to take up plantations | 6 | 5 | 9 | 7 | 10 | 9 | 7 | 9 | 9 | 9 | 80 |
| Require market information | 9 | 8 | 9 | 9 | 10 | 6 | 7 | 10 | 9 | 9 | 86 |
| 2. Knowledge about silvicultural manipulation | | | | | | | | | | | |
| Coppicing | 3 | 2 | 3 | 3 | 4 | 6 | 6 | 6 | 5 | 3 | 41 |
| Pollarding | 8 | 9 | 7 | 7 | 10 | 8 | 10 | 6 | 9 | 7 | 81 |
| Planting method | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 |
| Nursery techniques | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Water harvesting | 4 | 7 | 5 | 5 | 4 | 4 | 5 | 7 | 7 | 4 | 51 |

Table 13: Opinion of farmers of Karnataka about pongamia

| Sl. No. | Particulars | Percentage of yes |
|---|---|---|
| I | Farmers knowledge about pongamia | |
| 1 | Use as oil | 31(%) |
| 2 | Use as green manure | 83 (%) |
| 3 | Growing as silvipasture | 11 (%) |
| 4 | Growing as agri- silvipasture | 04 (%) |
| II | Farmers knowledge about silvicultural characters of pongamia | |
| 1 | Resistance to fire | 60 (%) |
| 2 | Resistance to browsing | 87 (%) |
| 3 | Average yield(kg/ plant) | 37.17 (%) |
| 4 | Resistance to pests | 42 (%) |
| 5 | Resistance to diseases | 53 (%) |
| III | Uses of pongamia | |
| 1 | Mixing with diesel | 29 (%) |
| 2 | Use for industries | 53 (%) |
| 3 | Use as bio fuel | 24 (%) |
| 4 | Transesterification | 34 (%) |
| 5 | Other uses (religious) | 62 (%) |
| IV | Knowledge about silvicultural manipulation | |
| 1 | Coppicing | 41 (%) |
| 2 | Pollarding | 81 (%) |
| 3 | Planting method | 03 (%) |
| 4 | Nursery techniques | 00 (%) |
| 5 | Water harvesting | 51(%) |
| V | Knowledge about | |
| 1 | Market | 52 (%) |
| 2 | Interest in cultivation | 44 (%) |
| VI | Interests of farmers in pongamia cultivation | |
| 1 | Entire plantation | 02 (%) |
| 2 | Border plantation | 74 (%) |
| 3 | Agroforestry models | 04 (%) |
| 4 | Along the streams | 72 (%) |
| 5 | None | 50 (%) |
| VII | Any other information | |
| 1 | Do not need financial assistance | 41 (%) |
| 2 | Need financial assistance | 51 (%) |
| 3 | Welcome as national programme | 48 (%) |
| 4 | Need subsidy bound financial assistance | 76 (%) |
| 5 | Need technical support to take up plantations | 80 (%) |
| 6 | Require market information | 86 (%) |

recorded significantly the highest (94.00 %) germination followed by ($T_2$) Red Soil + White Sand+ FYM (85.00 %). The lowest germination (40.33 %) was observed with Black soil + Black sand + Poultry manure ($T_4$).

## 4.2.2 Root length

The data on root length as influenced by different nursery mixtures at different growth stages of pongamia is presented in Table 15.

Significant difference in root length at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest root length of 32.33, 32.33 and 35.66 cm at 60, 90 and 120 days after sowing, respectively followed by ($T_2$) Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest root length of 6.33, 8.33 and 14.66 cm was observed with (30.55cm). The lowest root length (9.77 cm) was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing, respectively.

### 4.2.3 Shoot length

The data on shoot length as influenced by different nursery mixtures at different growth stages of Pongamia is presented in Table 15.

Significant difference in shoot length at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest shoot length of 12.33, 11.00 and 11.00 cm at 60, 90 and 120 days after sowing, respectively followed by Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest shoot length of 4.33, 4.33 and 6.00 cm was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing respectively.

## 4.2.4 Number of leaves

The data on number of leaves as influenced by different nursery mixtures at different growth stages of pongamia is presented in Table 16.

Significant difference in number of leaves at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest number of leaves 23.66, 24.00 and 23.66 at 60, 90 and 120 days after sowing, respectively followed by Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest number of leaves 15.66, 7.00 and 11.33 was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing respectively.

## 4.2.5 Seedling height

The data on seedling height as influenced by different nursery mixtures at different growth stages of Pongamia is presented in Table 16.

Significant difference in seedling at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest seedling height of 36.33, 36.00 and 36.66 cm at 60, 90 and 120 days after sowing, respectively followed by Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest seedling height 23.66, 15.33 and 17.33 cm was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing, respectively.

## 4.2.6 Crown spread

The data on crown spread as influenced by different nursery mixtures at different growth stages of Pongamia is presented in Table 17.

Significant difference in crown spread at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest crown spread of 25.00, 24.00 and 26.66 cm at 60, 90 and 120 days after sowing, respectively, followed by Red Soil + White

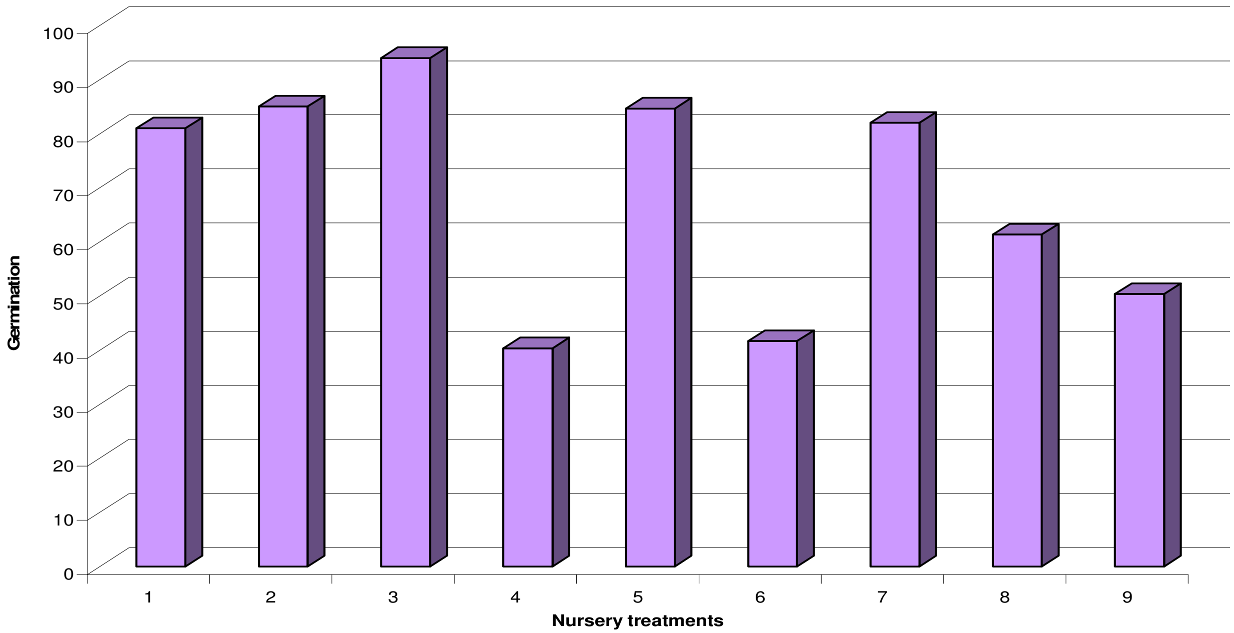



**Fig. 3. Effect of nursery mixture on germination**

Fig.3. Effect of nursery mixture on germination

Table 14: Influence of nursery mixture on germination of Pongamia

| Treatment | Germination (%) |
|---|---|
| T1:: Black soil + Black sand + FYM (2:1:1) | 81.00 (75.82) * |
| T2: Red soil + White sand + FYM (2:1:1) | 85.00 (67.21) |
| T3: Black soil + Black sand + Vermicompost (2:1:1) | 94.00 (66.89) |
| T4: Black soil + Black sand + Poultry manure (2:1:1) | 40.33 (39.41) |
| T5: Black soil + Black sand + Pig manure (2:1:1) | 84.66 (64.16) |
| T6: Black soil + Black sand + Pongamia cake (2:1:1) | 41.66 (40.22) |
| T7: Black soil + Black sand + Neem cake (2:1:1) | 82.00 (64.80) |
| T8: Black soil + Black sand + Press mud (2:1:1) | 61.33 (51.53) |
| T9: Black soil + Black sand +Peat (2:1:1) | 50.33 (45.17) |
| SEm± | 1.11 |
| CD at 5% | 3.31 |

* Figures in parentheses are angular transformed values

Table 15: Influence of nursery mixture on root length, shoot length (cm) and vigour index at different stages of growth in Pongamia.

| Treatment | Root length (cm) | | | | Shoot length (cm) | | | | Vigour index |
|---|---|---|---|---|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean | 60 DAS | 90 DAS | 120 DAS | Mean | |
| $T_1$: Black soil + Black sand + FYM (2:1:1) | 22.66 | 24.00 | 31.66 | 28.88 | 07.66 | 09.00 | 09.00 | 08.55 | 2789 |
| $T_2$: Red soil + White sand + FYM (2:1:1) | 28.33 | 32.33 | 35.66 | 30.55 | 08.33 | 09.33 | 10.66 | 9.44 | 2906 |
| $T_3$: Black soil + Black sand + Vermicompost (2:1:1) | 32.33 | 32.33 | 35.66 | 31.21 | 11.00 | 11.00 | 12.33 | 11.44 | 4200 |
| $T_4$: Black soil + Black sand + Poultry manure (2:1:1) | 06.33 | 08.33 | 14.66 | 09.77 | 04.33 | 04.33 | 06.00 | 04.88 | 430 |
| $T_5$: Black soil + Black sand + Pig manure (2:1:1) | 21.33 | 23.66 | 35.33 | 24.21 | 07.66 | 07.67 | 10.00 | 08.44 | 2410 |
| $T_6$ :Black soil + Black sand + Pongamia cake (2:1:1) | 15.33 | 27.66 | 31.00 | 27.44 | 06.00 | 08.00 | 08.00 | 07.33 | 878 |
| $T_7$: Black soil + Black sand + Neem cake (2:1:1) | 23.66 | 26.33 | 29.66 | 24.10 | 05.66 | 07.00 | 07.66 | 08.03 | 2209 |
| $T_8$: Black soil + Black sand + Press mud (2:1:1) | 22.00 | 22.33 | 31.66 | 25.33 | 06.66 | 08.00 | 08.00 | 07.55 | 1705 |
| $T_9$: Black soil + Black sand + Peat (2:1:1) | 11.00 | 20.66 | 24.66 | 18.77 | 05.66 | 06.66 | 08.33 | 06.89 | 1470 |
| SEm± | 3.57 | 3.33 | 4.04 | | 1.84 | 1.78 | 1.11 | | 300 |
| CD at 5% | 10.62 | 9.90 | 12.02 | | 5.49 | 9.52 | 3.30 | | 891 |

DAS- Days after sowing

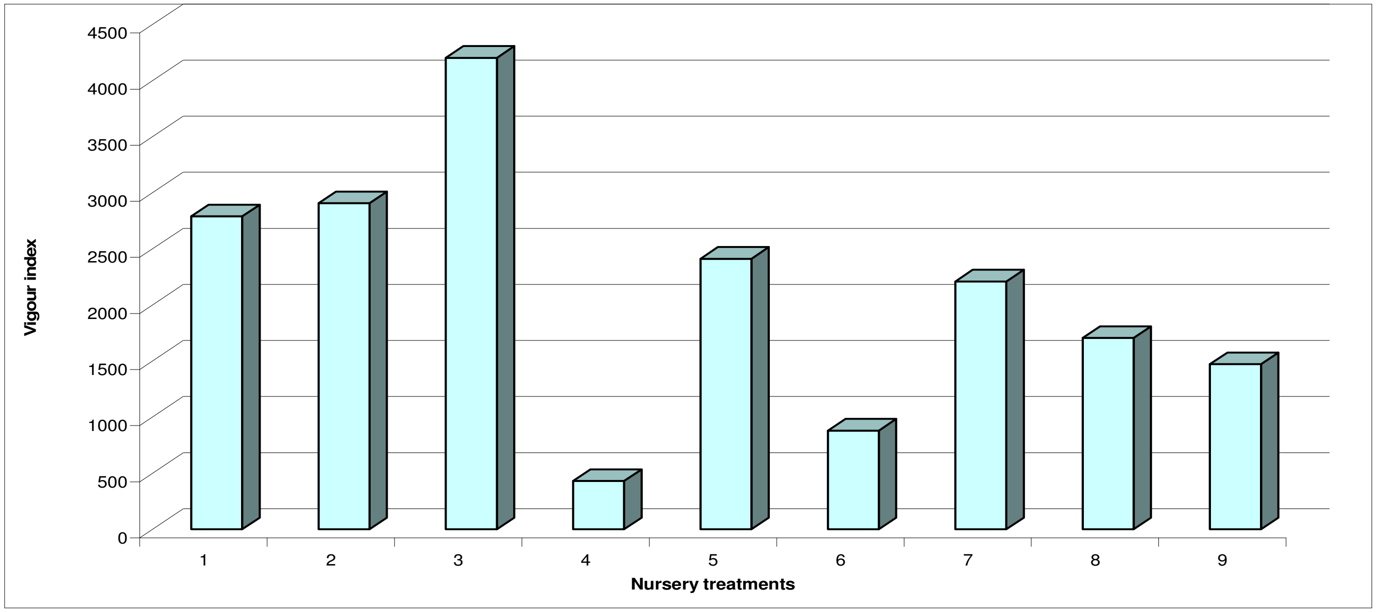



**Fig. 4. Effect of nursery mixture on vigour index**

Fig.4. Effect of nursery mixture on vigour index

Table 16: Influence of nursery mixture on number of leaves and plant height at different stages of growth in pongamia.

| Treatment | Number of leaves | | | | Plant height (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean | 60 DAS | 90 DAS | 120 DAS | Mean |
| T1: Black soil + Black sand + FYM (2:1:1) | 19.66 | 19.00 | 21.33 | 19.99 | 30.00 | 32.00 | 34.66 | 32.22 |
| T2: Red soil + White sand + FYM (2:1:1) | 20.00 | 21.00 | 23.00 | 21.33 | 32.33 | 33.33 | 36.33 | 33.99 |
| T3: Black soil + Black sand + Vermicompost (2:1:1) | 23.66 | 23.66 | 24.00 | 23.77 | 36.00 | 36.33 | 36.66 | 36.33 |
| T4: Black soil + Black sand + Poultry manure (2:1:1) | 7.00 | 11.33 | 15.66 | 11.33 | 15.33 | 17.33 | 23.66 | 18.77 |
| T5: Black soil + Black sand + Pig manure (2:1:1) | 17.66 | 19.00 | 21.33 | 19.33 | 28.66 | 30.00 | 31.66 | 30.10 |
| T6: Black soil + Black sand + Pongamia cake (2:1:1) | 14.00 | 16.00 | 21.33 | 17.11 | 27.00 | 27.33 | 31.00 | 28.44 |
| T7: Black soil + Black sand + Neem cake (2:1:1) | 15.66 | 17.33 | 17.66 | 16.88 | 24.33 | 26.00 | 30.33 | 26.88 |
| T8: Black soil + Black sand + Press mud (2:1:1) | 15.66 | 16.33 | 16.33 | 16.10 | 21.66 | 25.33 | 27.66 | 24.88 |
| T9: Black soil + Black sand + Peat (2:1:1) | 13.66 | 15.66 | 16.66 | 15.32 | 19.66 | 26.00 | 28.66 | 24.77 |
| SEm± | 2.25 | 2.13 | 3.25 | | 2.57 | 2.21 | 2.86 | |
| CD at 5% | 6.69 | 6.35 | 9.66 | | 7.63 | 6.61 | 8.50 | |

DAS- Days after sowing

Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest crown spread 19.00, 13.33 and 14.33 cm was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing, respectively.

### 4.2.7 Collar diameter

The data on collar diameter as influenced by different nursery mixtures at different growth stages of Pongamia is presented in Table 17.

Significant difference in collar diameter at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest 0.60, 0.63 and 0.73 cm collar diameter at 60, 90 and 120 days after sowing, respectively followed by Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest collar diameter 0.40, 0.46 and 0.56 cm was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing, respectively.

### 4.2.8 Leaf area

The data on leaf area as influenced by different nursery mixtures at different growth stages of Pongamia is presented in Table 18.

Significant difference in leaf area at different stages of the growth of Pongamia due to nursery mixtures was observed. Among nursery mixtures tested, Black soil + Black sand + Vermicompost ($T_3$) recorded significantly the highest leaf area of 23.09, 33.79 and 57.67 $cm^2$at 60, 90 and 120 days after sowing, respectively followed by Red Soil + White Sand+ FYM ($T_2$) and Black soil + Black sand + FYM ($T_1$). The lowest leaf area 20.67, 22.99 and 31.39 $cm^2$ was observed with Black soil + Black sand + Poultry manure ($T_4$) at 60, 90 and 120 days after sowing, respectively.

### 4.2.9 Disease scoring

None of the nursery mixture treatments showed incidence of diseases like damping off and leaf spot at seedling and later stages of the crop growth

## 4.3 Experiment: III Effect of hydropriming and fungicide treatment on vigour and germination in Pongamia species

### 4.3.1 Germination

The data on the influence of hydro priming and seed treatment on germination, shoot length and root length in Pongamia are presented in Table 19.

The data on germination percentage showed significant difference due to hydro priming treatments. Among different hydro priming treatments tested, seed soaking for 16 hours ($H_2$) recorded significantly the highest germination (74.33 %) followed by seed soaking for 20 hours ($H_3$). All the hydro priming treatments were found to be superior over control ($H_0$). While fungicide seed treatments did not show any significant effect on germination.

The interaction effect between hydropriming and fungicide seed treatment showed significant difference with respect to germination. The treatment combination ($H_2F_1$), seed soaked in water for 16 hours and treated with 0.2 % Bavistin recorded significantly the highest (68.26 %) germination over all other treatments combinations. The control ($H_0F_0$) recorded the lowest (57.72 %) germination.

### 4.3.2 Shoot length

The data on shoot length showed significant difference due to hydropriming treatments. Among different hydro priming treatments seed soaking for 16 hours ($H_2$) recorded significantly the highest shoot length (8.70 cm) followed by ($H_3$) seed soaking for 20 hours (8.50 cm). All the hydropriming treatments were found to be superior over control ($H_0$). While fungicide seed treatments did not show any significant effect on shoot length.

The interaction effect between hydropriming and fungicide treatment did not showed any significant difference with respect to shoot length.

Table 17: Influence of nursery mixture on crown spread (cm) and collar diameter (cm) at different stages of growth in pongamia

| Treatment | Crown spread (cm) | | | | Collar diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean | 60 DAS | 90 DAS | 120 DAS | Mean |
| T1: Black soil + Black sand + FYM (2:1:1) | 22.00 | 23.33 | 24.00 | 23.11 | 0.53 | 0.60 | 0.70 | 0.61 |
| T2: red soil + White sand + FYM (2:1:1) | 23.33 | 24.33 | 25.66 | 24.44 | 0.56 | 0.63 | 0.70 | 0.63 |
| T3: Black soil + Black sand + Vermicompost (2:1:1) | 24.00 | 25.00 | 26.66 | 25.32 | 0.60 | 0.63 | 0.73 | 0.65 |
| T4: Black soil + Black sand + Poultry manure (2:1:1) | 13.33 | 14.33 | 19.00 | 15.55 | 0.40 | 0.46 | 0.56 | 0.47 |
| T5: Black soil + Black sand + Pig manure (2:1:1) | 21.66 | 23.00 | 23.66 | 22.77 | 0.53 | 0.60 | 0.70 | 0.61 |
| T6: Black soil + Black sand + Pongamia cake (2:1:1) | 20.00 | 20.33 | 21.33 | 20.55 | 0.50 | 0.56 | 0.60 | 0.55 |
| T7: Black soil + Black sand + Neem cake (2:1:1) | 20.00 | 20.00 | 23.00 | 21.00 | 0.53 | 0.63 | 0.66 | 0.60 |
| T8: Black soil + Black sand + Press mud (2:1:1) | 16.66 | 19.66 | 19.66 | 18.66 | 0.53 | 0.56 | 0.60 | 0.56 |
| T9: Black soil + Black sand + Peat (2:1:1) | 19.00 | 20.33 | 21.33 | 20.22 | 0.46 | 0.53 | 0.60 | 0.53 |
| SEm± | 2.61 | 2.30 | 2.01 | | 0.04 | 0.05 | 0.04 | |
| CD at 5% | 7.77 | 6.58 | 5.97 | | 0.13 | 0.17 | 0.14 | |

DAS- Days after sowing

Table 18: Influence of nursery mixture on leaf area at different stages of growth in pongamia

| Treatment | Leaf area ($cm^2$) | | | |
|---|---|---|---|---|
| | 60 DAS | 90 DAS | 120 DAS | Mean |
| T1: Black soil + Black sand + FYM (2:1:1) | 21.40 | 28.20 | 39.21 | 29.60 |
| T2: Red soil + White sand + FYM (2:1:1) | 22.88 | 29.59 | 41.09 | 31.18 |
| T3: Black soil + Black sand + Vermicompost (2:1:1) | 23.09 | 33.79 | 57.67 | 38.18 |
| T4: Black soil + Black sand + Poultry manure (2:1:1) | 18.34 | 21.23 | 25.59 | 21.72 |
| T5: Black soil + Black sand + Pig manure (2:1:1) | 21.17 | 27.81 | 37.10 | 28.69 |
| T6 :Black soil + Black sand + Pongamia cake (2:1:1) | 21.08 | 26.10 | 36.69 | 27.95 |
| T7: Black soil + Black sand + Neem cake (2:1:1) | 19.32 | 24.87 | 36.38 | 26.85 |
| T8: Black soil + Black sand + Press mud (2:1:1) | 20.67 | 24.83 | 31.39 | 25.63 |
| T9: Black soil + Black sand + Peat (2:1:1) | 20.78 | 22.99 | 29.67 | 24.48 |
| SEm± | 1.46 | 1.19 | 2.05 | |
| CD at 5% | 4.35 | 3.55 | 6.09 | |

DAS- Days after sowing

Table19: Effect of hydro priming and fungicide seed treatment on germination, shoot length and root length of Pongamia

| Treatments | Germination (%) | Shoot length (cm) | Root length (cm) |
|---|---|---|---|
| Hydro priming (H) | | | |
| $H_0$ :soaking for zero hours = | 45.66(42.50) * | 7.08 | 32.23 |
| $H_1$ :soaking for twelve hours = | 58.99(55.77) | 8.20 | 34.37 |
| $H_2$ :soaking for sixteen hours = | 74.33(48.29) | 8.70 | 35.87 |
| $H_3$ :soaking for twenty hours = | 70.00(59.09) | 8.50 | 35.55 |
| $H_4$ :soaking for twenty four hours = | 65.99 (57.89) | 7.70 | 33.05 |
| SEm ± | 00. 99 | 0. 33 | 0. 85 |
| C D at 5 % | 02. 96 | 0. 99 | 2. 53 |
| Fungicide ( F) | | | |
| $F_0$ :with out seed treatment = | 57.72 (51.93) | 8.03 | 34.06 |
| $F_1$ :with 0.2 % Bavistin seed treatment= | 68.26 (53.49) | 8.15 | 34.37 |
| SEm ± | 0. 63 | 0. 21 | 0. 54 |
| C D at 5 % | NS | NS | NS |
| Interaction (H x F) | | | |
| $H_0F_0$ (Control) | 40.66 (39.60) | 6.73 | 31.93 |
| $H_1F_0$ | 50.66 (55.97) | 7.43 | 35.00 |
| $H_2F_0$ | 68.66 (51.20) | 7.96 | 34.13 |
| $H_3F_0$ | 68.00 (54.74) | 8.43 | 35.53 |
| $H_4F_0$ | 60.66 (58.12) | 8.33 | 33.70 |
| $H_0F_1$ | 50.66 (45.40) | 7.06 | 32.53 |
| $H_1F_1$ | 67.33 (55.57) | 8.46 | 33.73 |
| $H_2F_1$ | 80.00 (45.38) | 8.93 | 37.60 |
| $H_3F_1$ | 72.00 (63.44) | 8.63 | 35.57 |
| $H_4F_1$ | 71.33 (57.67) | 8.86 | 32.40 |
| SEm ± | 1. 41 | 0. 47 | 01. 20 |
| C D at 5% | 4. 19 | NS | NS |

* -Figures in parentheses are angular transformed values. NS- non significant

### 4.3.3 Root length

The data on root length revealed significant difference due to hydropriming treatments. Among different hydropriming treatments seed soaking for 16 hours ($H_2$) recorded significantly the highest root length (35.87 cm) followed by ($H_3$) seed soaking for 20 hours (35.55 cm). All the hydropriming treatments were found to be superior over control ($H_0$). While fungicide seed treatments did not show any significant effect on root length.

The interaction effect between hydropriming and fungicide treatment did not showed any significant difference with respect to root length.

### 4.3.4 Germination rate index

The data on germination rate index, seedling dry weight and vigour index as influenced by hydropriming and seed treatment in Pongamia are presented in Table 20.

The data on germination rate index showed significant difference due to hydro priming, seed treatment and their interaction. Among different hydropriming treatments seed soaking for 16 hours ($H_2$) recorded significantly the highest germination rate index (1.86) followed by ($H_3$) seed soaking for 20 hours (1.80). All the hydropriming treatments were found to be superior over control ($H_0$). The data on germination rate index with respect to different fungicide seed treatments showed significant difference, seed treated with 0.2 % ($F_1$) found to be superior over untreated control ($F_0$).

The interaction effect between hydropriming and fungicide seed treatment showed significant difference with respect to germination rate index. Among treatment combinations, that is seed soaked in water for 16 hours and treated with 0.2 % Bavistine ($H_2F_1$) recorded significantly the highest (2.04) germination rate index over all other treatments combinations. The control ($H_0F_0$) recorded the lowest (1.06) germination rate index.

### 4.3.5 Vigour index

The data on vigour index showed significant difference due to hydropriming treatments. Among different hydropriming treatments seed soaking for 16 hours ($H_2$) recorded significantly the highest vigour index (3281.67) followed by ($H_3$) seed soaking for 20 hours. (3174.83). All the hydropriming treatments were found to be superior over control ($H_0$). While fungicide seed treatments did not show any significant effect on vigour index.

The interaction effect between hydropriming and fungicide seed treatment showed significant difference with respect to vigour index. The treatment combination, that is seed soaked in water for 16 hours and treated with 0.2 % Bavistin ($H_2F_1$)recorded significantly the highest (3722.66) vigour index over all other treatments combinations. The control ($H_0F_0$) recorded the lowest (1572.00) vigour index.

### 4.3.6 Seedling dry weight

Significant difference due to hydropriming, seed treatment and their interaction was observed with respect to seedling dry weight. Among different hydropriming treatments seed soaking for 16 hours ($H_2$) recorded significantly the highest seedling dry weight (4.49g) followed by seed soaking for 20 hours (3.64) with ($H_3$). All the hydropriming treatments were found to be superior over control ($H_0$). The seedling dry weight with respect to fungicide treatment showed significant difference, seed treated with 0.2 % Bavistin ($F_1$) found to be superior (3.74 g) over untreated control (3.54 g) with ($F_0$).

The interaction effect between hydropriming and fungicide seed treatment showed significant difference with respect to seedling dry weight. The treatment combination, seed soaked in water for 16 hours and treated with 0.2 % Bavistine ($H_2F_1$) recorded significantly the highest (4.75 g) seedling dry weight over all other treatments combinations. The control ($H_0F_0$) recorded the lowest (2.51g) seedling dry weight.

## 4.4 Experiment: IV Quantification of enzymes like catalase, peroxidase, phosphatase, amylase

4.4.1.1 Catalase

Among the twenty different candidate plus trees tested for catalase activity, the maximum activity was noticed in CPT 31 (2428 units / mL of extract) and it was followed by CPT 33 (2125 units / mL of extract) and the lowest enzyme activity was noticed in CPT 27 (708 units / mL extract) Table 21.

4.4.1.2 Peroxidase

The maximum peroxidase activity was varied between 20.83 to 62.5 units per litre. The CPT's 3, 18, 23 showed maximum peroxidase activity (62.5 units) compared to other CPT's and the minimum activity (20.83 units) with CPT's 2 and 22 Table 21.

4.4.1.3 Phosphatase

Twenty CPT's tested for the phosphates activity and the activity varied between 6.5 mM and 12.9mM, the highest activity was noticed with CPT 27 (12.9 mM/ mg protien) and the least activity was recorded with CPT 3 (6.5 mM/ mg protien) Table 21.

4.4.1.4 Amylase

Amylase activity was tested for the selected CPT's and it has been presented in table (21) the highest activity of amylase was noticed with CPT's 31 and 20 (1.00mg respectively) and the lowest activity was recorded in CPT 38 (0.62mg).

### 4.4.1 SDS – PAGE SEED STORAGE PROTEINS

To evaluate the potential of using electrophoretic banding patterns of seed proteins for evaluation of Pongamia genotypes, the seed storage proteins from Pongamia seeds were extracted and separated by SDS- PAGE method. The electrophoregram of total seed storage protein is presented in the Figure 1.

The protein banding pattern obtained could be divided into five regions A to E equivalent to increasing $R_m$ value and decreasing molecular weight.

Region A ($R_m$ 0.080- 0.178; Dalton 97,000 to 68,000): This region typically contained weak to medium stained thin bands. In total three bands were observed in this region.

Region B ($R_m$: 0.196- 0.259; Dalton 68,000 to 43,000): This region was characterized by both high intensity and low intensity bands in allmost all the genotypes. In total five bands were present in this region.

Region C ($R_m$: 0.259-0.482; Dalton 43,000 to 24,000): This region was characterized by thin bands in CPT's ranging from (1-17) and in CPT's ranging from (20-38) it was observed that the bands were little thicker in this region, in total four bands were present.

Region D ($R_m$: 0.509- 0.643; Dalton 24,000 to 14,300): This region was characterized by very less bands and very thin bands, only 2 bands were present in this region.

Region E ($R_m$: 0.643- 0.920; Dalton less than 14,300): This region typically contained very thick bands in all the genotypes and the bands were varying from three to five in this region.

Each of the 38 SDS- PAGE electrophorograms obtained for different Pongamia genotypes contained 3 – 17 bands and were distinctly different bands (2, 3, 4, 5, 6, 8, 16, 17) were common in genotypes (1-19) and bands (1, 3, 5, 6, 9, 14, 16, 17) were common in genotypes (20-38) under study. These bands can serve as a source of reference for inter- gel or inter laboratory comparison. It was interesting to note that band 5 and 6 were unique in CPT's 3, 4, 10, 11, 12, 19, 20, 21, 22, 29 and 30 respectively. This can be used again to identify these genotypes from the gene pool as well as studying the diversity of establishing evolutionary relationship among the genotypes. Similarly, absence off particular band (s) may also be used as an effective criterion for discriminating the genotypes. In the present study, for example, the CPT's 33 and 5 would be identified on the basis of absence of bands (1, 2, 6,

Table 20: Effect of hydro priming and fungicide seed treatment on germination rate index, vigour index and seedling dry weight in pongamia

| Treatments | Germination rate index | Vigour index | Seedling dry weight (g) |
|---|---|---|---|
| Hydro priming (H) | | | |
| $H_0$ :Soaking for zero hours = | 1.19 | 1799 | 3.32 |
| $H_1$ :Soaking for twelve hours = | 1.39 | 2911 | 3.62 |
| $H_2$ :Soaking for sixteen hours = | 1.86 | 3281 | 4.49 |
| $H_3$ :Soaking for twenty hours = | 1.80 | 3174 | 3.64 |
| $H_4$ :Soaking for twenty four hours = | 1.67 | 2276 | 3.11 |
| SEm ± | 0.048 | 105 | 0.09 |
| C D at 5 % | 0.144 | 313 | 0.28 |
| Fungicide (F) | | | |
| $F_0$ :With out seed treatment = | 1.53 | 2618 | 3.54 |
| $F_1$ :With 0.2 % Bavistin seed treatment= | 1.63 | 2759 | 3.73 |
| SEm ± | 0.03 | 66 | 0.06 |
| C D @ 5 % | 0.09 | NS | 0.17 |
| Interaction (H x F) | | | |
| $H_0F_0$ | 1.06 | 1572 | 2.51 |
| $H_1F_0$ | 1.44 | 2946 | 3.74 |
| $H_2F_0$ | 1.68 | 2840 | 4.23 |
| $H_3F_0$ | 1. 80 | 3181 | 4.18 |
| $H_4F_0$ | 1.69 | 2550 | 3.03 |
| $H_0F_1$ | 1.33 | 2026 | 4.14 |
| $H_1F_1$ | 1.34 | 2875 | 3.49 |
| $H_2F_1$ | 2.04 | 3722 | 4.75 |
| $H_3F_1$ | 1.80 | 3168 | 3.09 |
| $H_4F_1$ | 1.66 | 2002 | 3.19 |
| SEm ± | 0.06 | 149 | 0.13 |
| C D at 5% | 0.20 | 443 | 0.40 |

NS- non significant

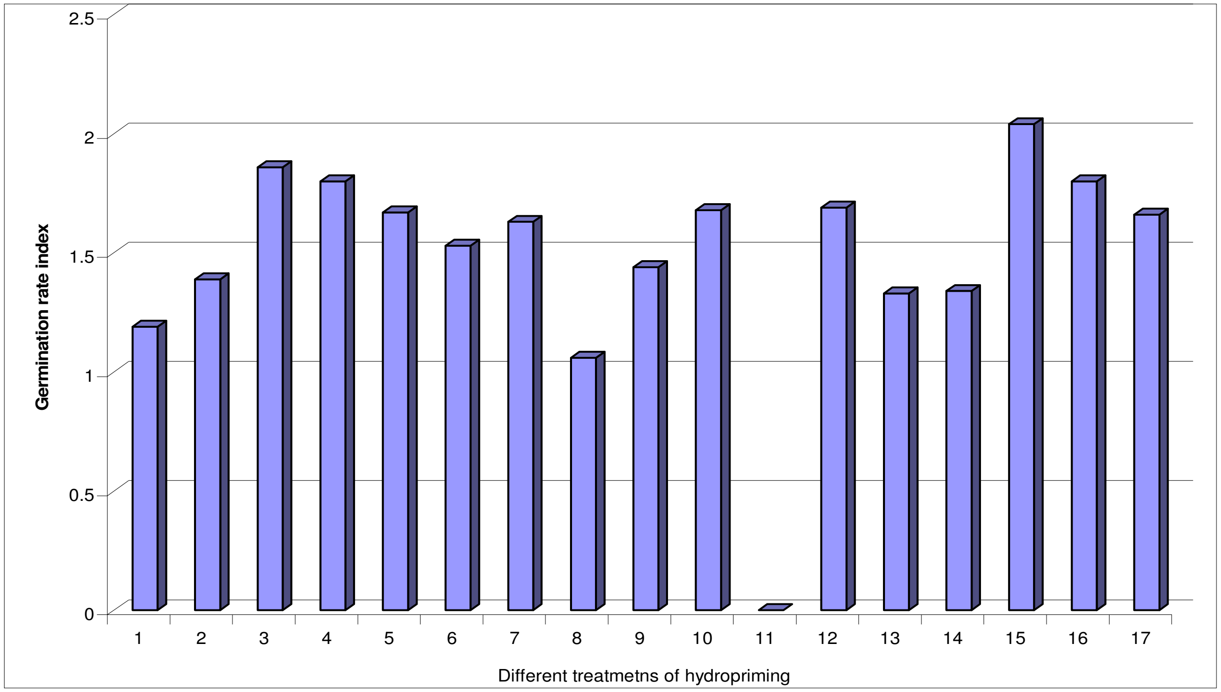


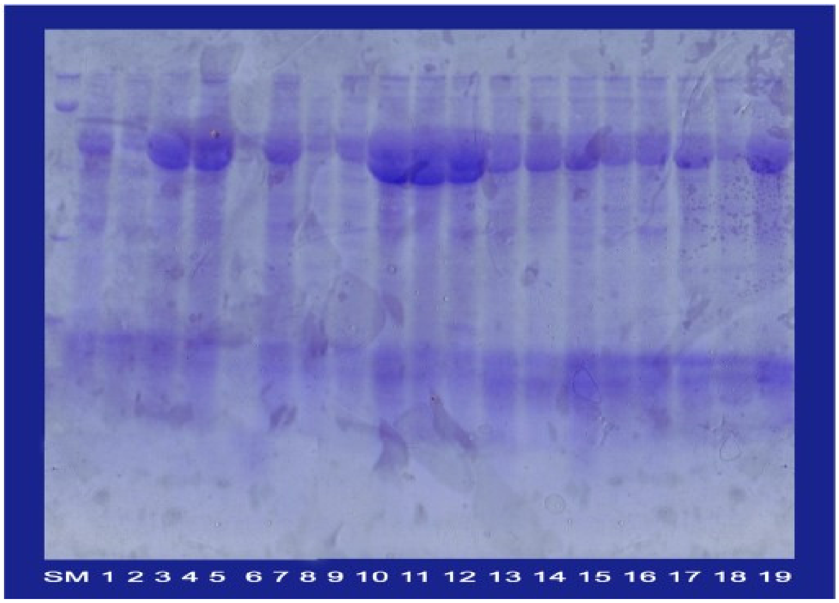

**Fig.5. Effect of hydropriming on GRI**

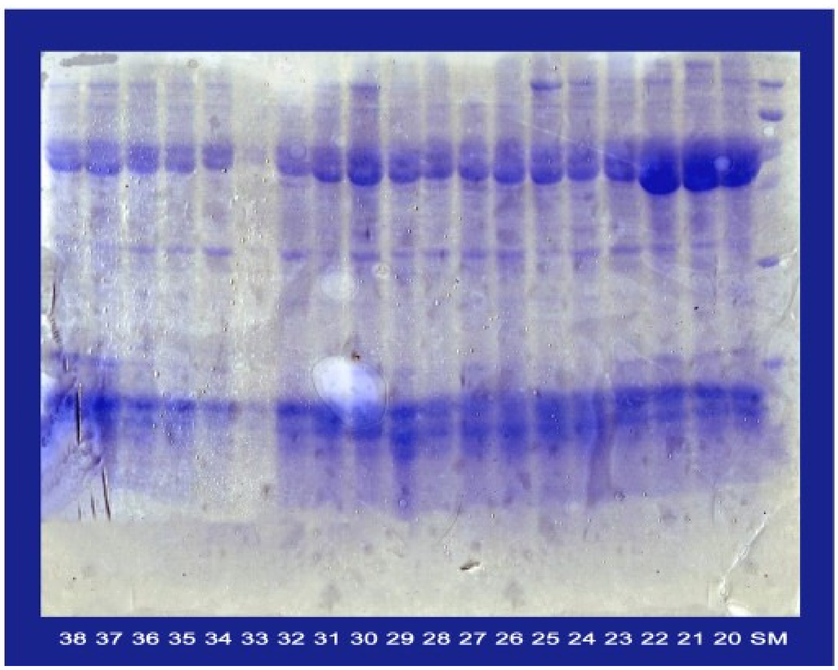
Fig.5. Effect of hydropriming on GRI

Table 21: Enzyme activity in selected genotypes

**Table 21: Enzyme activity in selected genotypes**

| Genotypes | CATALASE Enzyme per mL of extract (units) | PEROXIDASE Enzyme per mL of extract ( OD/ g of protein) | PHOSPHATASE Activity in mM / of protein | AMYLASE Activity in units |
|---|---|---|---|---|
| CPT 1 | 850 | 50.00 | 11.3 | 0.62 |
| CPT 3 | 1700 | 62.50 | 9.0 | 0.65 |
| CPT 4 | 1214 | 33.33 | 12.0 | 0.75 |
| CPT 18 | 1000 | 55.55 | 14.0 | 0.80 |
| CPT 20 | 1700 | 50.00 | 12.7 | 0.82 |
| CPT 21 | 1416 | 41.66 | 12.6 | 0.85 |
| CPT 22 | 1214 | 50.00 | 11.8 | 0.88 |
| CPT 23 | 2428 | 60.50 | 9.7 | 0.89 |
| CPT 24 | 1888 | 55.55 | 8.6 | 0.90 |
| CPT 27 | 2125 | 41.66 | 8.5 | 0.91 |
| CPT 31 | 1214 | 62.50 | 6.5 | 0.92 |
| CPT 32 | 1416 | 45.45 | 9.1 | 1.00 |
| CPT 33 | 1700 | 20.83 | 12.3 | 0.95 |
| CPT 34 | 1416 | 25.00 | 11.4 | 0.94 |
| CPT 35 | 894 | 33.33 | 12.5 | 0.93 |
| CPT 36 | 772 | 45.45 | 13.2 | 1.00 |
| CPT 37 | 1545 | 38.46 | 12.3 | 0.92 |
| CPT 38 | 708 | 41.66 | 12.9 | 0.91 |
| CPT 39 | 850 | 31.25 | 12.7 | 0.98 |
| CPT 40 | 1307 | 45.45 | 12.3 | 0.91 |




Electrophorogram of seed sstorage protein in pongamia

7, 8, 9, 10, 11, 12, 13, 14, 15 and 17). On the other hand, bands 1 and 2 were missing only in three CPT's namely 8, 27 and 32.

# 5. DISCUSSION

Since last decade the global warming has became a major scientific and political issue. The rate of global warming for the past quarter century was greater than any previous period since 1880. Increasing concentration of green house gases affect the heat balance of the earth by absorbing long wave radiations which would otherwise escape to space. The concentration of fossil fuels such as coal, gas and oil has caused a steady increase in the quantity of $CO_2$ level which has increased by about 25 per cent, since 1850 due to consumption of fossil fuel. Carbon dioxide blocks out going radiation from the earth and contributes to global warming. More than half of the green house effect is ascribed to $CO_2$.

Forests are vital in the battle to save the climate because they store 80 per cent of the above ground and 40 per cent of the below ground carbon, which would otherwise be floating around in the atmosphere as carbon dioxide, and making the earth heat up even faster than it is already.

Pongamia is a versatile multipurpose tree species. Being one of the predominant trees of oil seed tree species it serves as a source of bio fuel, medicines, green manure, fire wood etc., would be a most popular tree species for alternative land use system in the millennium. Pongamia can be grown in unproductive and under productive agricultural lands where economic cultivation of arable crops is not possible. There is a need for massive afforestation of waste land which is around 80 m. ha which could be achieved by promoting the cultivation of eco friendly bio fuel tree species like pongamia in waste lands.

In the present investigation an attempt has been made to identify the influence of provenance on seed quality, standardization of nursery mixture and hydro priming technique to produce quality seedlings and characterization of superior provenances in Pongamia. The results generated from the above studies are discussed in this chapter.

## 5.1 Effect of provenance on seed quality

Among 40 provenances evaluated wide variations were observed for shelling percentage, seed length, seed breadth, seed width, 100 seed weight, seed colour and seed shape. The variations ranged from 30.55 to 54.56 per cent, 1.80 to 2.80 cm, 0.90 to 2.80 cm, 0.4 to 2.0 cm, 56.00 to 279.51 g, tan red to brown colour and oval to round shape respectively for the characters mentioned above. This may be mainly attributed to the genetic make up of the candidate plus trees and also due to variation that existed in edaphic and prevailing climatic conditions in different agro climatic zones to which these 40 selected candidate plus trees belonged. Lopez (1987) opined that place of production has greater influence on seed quality characteristics such as seed weight, shelling percentage etc., the quality of the seed influenced by weather conditions such as temperature, relative humidity, photoperiod, wind velocity, soil type, nutrition and soil chemical reaction vary from location to location. Similar results with respect to seed length, breadth and width in *Acacia nilotica* , *Pinus roxburghi*, *Dalbergia sissoo* were reported by Bagchi, (1992) These findings are also in conformity with the findings of Thapiliyal *et al* (1997)in *Pinus roxburghi* , Devagiri *et al* (1998) in *Dalbergia sissoo* and Sindhuveerendra *et al* (1999) in Sandal seeds.

Significant differences in seed quality parameters like germination, root length, shoot length, vigour index and oil content were observed. Among 40 Candidate plus trees of 10 different agro climatic zones of Karnataka. The range varied from 17.00 to 94.00 per cent in germination, 19.33 to 41.33 cm in root length, 6.66 to 21.00 cm in shoot length, 537.00 to 4552.00 in seedling vigour index and 30.87 to 42.79 per in oil content cent for the characters studied. Further, the highest mean data with respect to germination (76.42 %) root length (34.33 cm), shoot length (14.16 cm), vigour index (2857) and oil content (38.45 %) were recorded by Zone 8 and Zone 5 respectively. This revealed that superiority of these zones over other agro climatic zones of Karnataka state. This is mainly attributed to genetic factors besides, the temperature, relative humidity, rainfall distribution and soil conditions that exist in these agro climatic zones chiefly influenced the seed quality parameters. These findings are in conformity with the findings of Mohit gera (1995) in *Dalbergia sissoo*, Kumar and Toky (1996) in *Albizia lebbeck*, Kajamaidden *et al* (1997) in *Casurina euesetifolia* and Suresh *et al* (1997) in *Acacia nilotica* .

Significant variations in plant height, number of leaves, crown spread, collar diameter and seedling dry weight due to provenance were noticed, they ranged from 22.33 to 51.66 cm in plant height. 6.88 to 31.44 for leaf number. The zonal mean values pertaining to plant height, number of leaves, crown spread, collar diameter and seedling dry weight. (47.80cm, 30.24, 24.88cm, 0.58cm and 0.49 g respectively) found to be superior in zone- 5 compared to all other agro climatic zones of the state. It can be attributed to the favourable edaphic and climatic factors that prevailed in zone 5 that had influenced the superiority of candidate plus trees (CPT 17, 18, 19 and 20) with respect to above attributes over other agro climatic zones of the state. Similar results were also reported in *Brosinm alicastrum* (Lopez- Mata 1987) Eucalyptus Kapoor and Dogra, (1987) and (Balakrishna and Toky, 1995) in Eucalyptus.

The Survey results on the knowledge of farmers of different agro climatic zones of Karnataka about Pongamia indicated that, farmers were aware of the use of pongamia for oil extraction, green manure, industrial and religious purposes. They are not much aware of its use as mixing with diesel, bio diesel and transesterification process. Regarding cultivation aspects majority of the farmers were interested in growing Pongamia as border plantation and along the streams, they were not interested in growing as entire plantation and agro forestry models. They knew that pongamia is resistant to fire, browsing, pest and diseases and its average yield per plant was 30-40 kg. Further, they needed subsidy based financial assistance with technical assistance for nursery techniques, plantation and market information. Over all survey results indicated that the farmers of South Karnataka were much aware of the uses and cultivation of pongamia rather than the farmers of North Karnataka, this may be mainly attributed to wide distribution of pongamia in this part and is widely used as green manure for paddy fields and during marriage ceremony and village fairs for erection of pendal as it is considered as sacred by the Hindus of South Karnataka.

## 5.2 Influence of nursery mixture on Pongamia

Nursery mixture can influence the quality of seedlings to a greater extent. The seedlings raised on good media will ensure better establishment and growth when planted to the main field. The ultimate advantage of good potting mixture is good drainage, water holding capacity and thereby, it gives excellent disease free growth of the seedlings (Noble, 1993). Black soil and black sand are prominently and easily available in the Northern dry zone of Karnataka; it is difficult to get red earth and white sand as nursery media in this region, which incurs extra expenditure also. The information on the effect of black soil, black sand, vermicompost and FYM on emergence, growth, vigour and establishment of seedlings is absolutely essential for large scale production of healthy seedlings in the nursery.

Significant variations in germination, root length, shoot length, crown spread, vigour index, collar diameter, number of leaves, plant height and leaf area were observed due to influence of nursery mixtures. They ranged from 41.66 % to 94.00 % in germination, 9.77 to 31.21 cm in root length, 4.88 to 11.44 cm in shoot length, 14.88 to 24.99 cm in crown spread, 0.47 to 0.63 cm in collar diameter, 878 to 4200 in vigour index, 15.32 to 23.22 number of leaves, 24.44 to 34.99 cm in plant height, 24.48 to 38.18 $cm^2$ in leaf area. The maximum values of all the above mentioned parameters were recorded in the treatment ($T_3$) Black soil + Black sand + Vermicompost. This may be attributed to better water holding capacity and soil aeration for better root length. The results were in conformity with the findings of Nayital *et al.,* (1995) in *Grewia optiva* and they further observed pure soil and sand relatively inert because they have low water holding capacity resulting into poor root growth. The maximum collar diameter was 0.63 recorded in seedlings grown in the mixture of Black soil + Black sand + Vermicompost. These results are in agreement with the findings of Bahuguna and Pyarelal (1990) in *Acacia nilotica*, who reported the addition of FYM and Vermicompost recorded better growth of seedlings in the nursery.

The maximum germination was found in Black soil + Black sand + Vermicompost. The germination of the seeds in a medium containing only soil was adversely affected which was exhibited as inferior biometric parameters and high sensitivity to dehydration. Addition of sand or FYM not only improves germination rate but also growth and drought tolerance of the seedlings (Bahuguna and Pyarelal, 1993) in *Acacia auriculiformis* but in the results above mentioned Vermicompost recorded highest germination, since it contains more amount of nutrients than FYM making it to stand first and sand will provide porosity and drainage to the growth medium which will avoid damping off of the seedlings and helps in the better stand.

## 5.3 Effect of hydropriming and fungicide seed treatment on germination and vigour of Pongamia.

Hydropriming treatment is used as pre sowing or mid storage treatment for seed lots that have lost vigour due to improper storage conditions. These treatments activate aspects of pre germination metabolism at low rates. The treated seeds when dried and stored retain the ability to continue with germination process on reimbibition, thus there is a shortening of time taken for radicle protrusion, a state of readiness which is achieved by the slow or fast germinating seeds in a population leading to synchronized germination.

Significant variations with respect to germination, vigour index, seedling dry weight, germination rate index, shoot length and root length were observed due to hydropriming treatments, they ranged from 45.66 % to 74.33 % in germination, 1799 to 3281 in vigour index, 3.11g to 4.49 g in seedling dry weight, 1.19 to 1.86 in germination rate index, 7.08 cm to 8.70 cm in shoot length and 22.23 cm to 35.87 cm in root length. The fungicide seed treatment showed non significant with respect to vigour index, shoot length and root length. While the interaction effect showed significant difference with respect to germination, vigour index, germination rate index and seedling dry weight and it was non significant with root length and shoot length.

The increase in root length and shoot length with priming of seeds may be due to imbibition. These results are in conformity with the findings of Nagar *et al*., (1998) Only seed soaking for 16 hours recorded highest and seed soaking for 20 and 24 hours recorded less than 16 hours of soaking, because the treatment was detrimental for seed quality and probably due to imbibitional injury occurred as a result of rapid uptake of water by the seeds, these findings are in conformity with Srinivasan *et al.,* (1999). The speed of germination was highest in seed soaking for 16 hours since the seeds were vigorous and these results are in conformity with the findings of Casuire *et al.,* (2004). The germination percentage was lower in ($H_1$) even it was soaked for 12-hour because as the seed coat is hard and preliminary tests have not done to identify the seeds that respond better to priming. In the interaction effect, the germination percentage was lower in case of seed soaked for zero hours and treated with bavistin because the seeds treated with 0.2 % Bavistin may caused the reduction in the oxygen concentration and that may promote negative effects on seed germination (Mexal *et al*., 1975).

## 5.4 Characterization of superior provenances through enzyme and protein analysis

### 5.4.1 Quantification of enzymes like catalase, peroxidase, phosphatase and amylase

Among the twenty selected genotypes tested for the activity of different enzymes, the catalase activity was recorded maximum in CPT 31 (2428 units / mL of extract) while the highest peroxidase activity was recorded in CPT's 3, 18, 23 (62.5 units per litre) and the maximum phosphates activity was noticed in CPT CPT 27 (12.9mM) and the highest amylase activity was noticed in CPT CPT's 31 and 20 (1.00mg ).

Catalase and peroxidase are antioxidant enzymes and they reduce reactive oxygen species. Phosphatase enzymes include acid phosphatase and alkaline phosphatase from organic phosaphatase. Plants with secretion of phosphates enzymes cause the solubilazation of organic phosphate and the absorption and metabolism of phosphate increase. So soluble phosphate increase in cytoplasm of cells and their resistance increases. Amylase causes the hydrolysis of starch glucose and so on the isomers of it. So the concentration of solute increases. "Increase in catalase, peroxidase, amylase and phosphates cause the increase or tolerance against adverse condition such as stress".

#### 5.4.1.1 Seed storage protein studies through SDS- PAGE

Electrophorograms of proteins extracted from seeds, seedlings, mature leaves provides reliable key for varietal identification. The possibility of extracting different fractions of proteins and their separation under varying conditions of electrophoresis further extends the resolution of this technique. Electrophoretic separation of seed proteins has been utilised for resolving taxonomic and evolutionary divergence as well as species and cultivar identification in many crops like wheat (Bushuk and Zillman, 1978); soybean (Cardy and Beversdorf, 1984), maize (Smith and Wych, 1986), pasture grass (Gardiner and Ford, 1987), sunflower (Varier *et al*., 1992).

# PRACTICAL UTILITY

1. Among 40 CPT's tested, CPT 11 of Bijapur (Zone-3) was found to be superior over others with respect to germination and vigour. Therefore CPT 11 has been identified as the best mother plant for seed collection in Pongamia.
2. Among nursery mixtures tested Black soil + Black sand + Vermicompost recorded significantly superior values of all the seed quality parameters. Therefore Black soil + Black sand + Vermicompost can be used to raise healthy and vigorous Pongamia seedlings.
3. Characterization of superior provenances through SDS- PAGE revealed that the protein studies can be easily employed for characterization of varieties in Pongamia.
4. Seed soaking for 16 hours and treated with 0.2 % Bavistin gave superior quality seedlings compared to other treatment combinations.

# FUTURE LINE OF WORK

1. There is a need for standardization of germination test for pongamia.
2. Viability is short in pongamia, therefore physiological maturity studies and storability studies under controlled conditions are needed.
3. To asses genetic purity of elite provenances in Pongamia RAPD analysis need to be undertaken.

# 6. SUMMARY AND CONCLUSIONS

The experiments to study the provenance effect on seed quality, to standardize the suitable nursery mixture, to characterize the superior provenances and to know the effect of hydropriming and fungicide seed treatment in Pongamia were carried out at Regional Agricultural Research Station, Bijapur. The data generated from the experiments on the above mentioned aspects are summarized below.

## I. Influence of provenance effect on seed quality in Pongamia

The experiment was carried out with 40 candidate plus trees which were collected from 10 agro climatic zones of Karnataka. The data on seed quality parameters revealed significant difference due to provenance effect. Among 40 candidate plus trees (CPT's) evaluated CPT 11 of Zone 3 was found to be superior with seed quality parameters like germination (94.00 %), vigour index (4552) and seedling root length (41.33 cm) over all other CPT's while zonal mean values with respect to germination (76.42 %) and vigour index (2857) was the highest with zone VIII as compared to all other zones. Significant difference was observed for morphological characters like seed length, seed breadth, seed width, seed shape and seed colour. The range varied from 1.8 to 2.8 cm in seed length, 0.90 to 2.80 cm in seed breadth, 0.40 to 2.00 cm in seed width, tan red to brown colour and oval to round shape for seed length seed breadth seed width seed shape and colour respectively.

There was significant difference in seedling growth parameters like plant height, leaf number, crown spread and collar diameter and seedling dry weight. The values for the above characters increased with the increase in the period of growth stage up to 120 days from the date of sowing.

## II. Standardization of suitable nursery mixture

The experiment consisted of nine different nursery media prepared in 2:1:1 proportion. Different nursery mixtures were tested for various seed quality parameters like germination, shoot length, root length and vigour index. Among different nursery mixtures Black soil + Black sand + Vermicompost recorded significantly higher values with respect to germination (75.82 %), shoot length (11.44 cm), root length (31.21cm)and vigour index (4200.66) over other nursery mixtures.

Seedling growth characters were also significantly influenced by different nursery mixtures. Here also Black soil + Black sand + Vermicompost ($T_3$) found to be superior with respect to plant height (23.77cm), number of leaves (36.33), crown spread (25.32), collar diameter (0.65cm) and leaf area (38.18cm$^2$). There was no incidence of damping off and leaf spot disease during experimentation.

## III. Effect of hydropriming and fungicide seed treatment on germination and vigour of Pongamia

The experiment was carried out with five hydropriming treatments with and without Bavistine seed treatment. The observations were recorded on seed quality parameters like germination, shoot length, root length, vigour index, and germination rate index and seedling dry weight.

The results indicated significant difference with respect to germination, shoot length, root length, vigour index, and germination rate index and seedling dry weight due to hydropriming treatment. Among different hydropriming treatments seed soaking for 16 hours ($H_2$) recorded significantly higher value for germination (74.33 %), shoot length (8.70 cm), root length (35.87 cm), vigour index (3281), germination rate index (1.86) and seedling dry weight (4.49 g) over other treatments.

Fungicide seed treatment did not show any significant difference with respect to germination, shoot length, root length, vigour index and germination rate index.

The interaction effect due to hydropriming and seed treatment with fungicide showed significant difference with respect to germination. Vigour index, germination rate index and seedling dry weight. Among the treatment combinations soaking of seed for 16 hours in 0.2

% Bavistin seed treatment recorded significantly higher values for germination (80.00 %), vigour index (3722), germination rate index (2.04) and seedling dry weight (4.75 g) over all other treatment combinations.

## IV. Characterization of Superior Provenances through enzyme and protein analysis

Among the twenty different candidate plus trees tested for catalase, peroxidase, phosphates and amylase activity, the maximum activity was noticed in CPT 31 (2428 units / mL of extract), CPT 3, 18, 23 (20.83 units per litre) CPT 27 (12.9mM/ mg protien), CPT 31 and 20 (1.00mg), respectively for the above mentioned enzymes.

Each of the 38 SDS- PAGE electrophorograms obtained for different Pongamia genotypes contained 3 – 17 bands and were distinctly different bands (2, 3, 4, 5, 6, 8, 16, 17) were common in genotypes (1-19) and bands (1, 3, 5, 6, 9, 14, 16, 17) were common in genotypes (20-38) under study. These bands can serve as a source of reference for inter- gel or inter laboratory comparison. It was interesting to note that band 5 and 6 were unique in CPT's 3, 4, 10, 11, 12, 19, 20, 21, 22, 29 and 30 respectively. This can be used again to identify these genotypes from the gene pool as well as studying the diversity of establishing evolutionary relationship among the genotypes. Similarly, absence off particular band (s) may also be used an effective criteria for discriminating the genotypes. In the present study, for example, the CPT's 33 and 5 would be identified on the basis of absence of bands (1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 17). On the other hand, bands 1 and 2 were missing only in three CPT's namely 8, 27 and 32.

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* originals not reffered

# APPENDIX

Appendix 1: Candidate plus Trees of Pongamia from Different Agro Climatic Zones of Karnataka

| Zone | CPT | DOC | Latitude | Longitude | Altitude | MAT | MAR | Soil type | Location |
|---|---|---|---|---|---|---|---|---|---|
| I | 1 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 2 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 3 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 4 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| II | 1 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 2 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 3 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| | 4 | 10/03/05 | $10^{o}12^{1}$ | $76^{0}24^{1}$ | 385.9mts | $26.8^{0}C$ | 687.7mm | Shallow black | Sedum |
| III | 1 | 10/02/05 | $15^{0}55^{1}$ | $75^{0}41^{1}$ | 631mts | $28.86^{0}C$ | 575.11mm | Red soil | Gudur |
| | 2 | 10/02/05 | $15^{0}55^{1}$ | $75^{0}41^{1}$ | 631mts | $28.86^{0}C$ | 575.11mm | Red soil | Gudur |
| | 3 | 10/02/05 | $15^{0}55^{1}$ | $75^{0}41^{1}$ | 631mts | $28.86^{0}C$ | 575.11mm | Red soil | Gudur |
| | 4 | 10/02/05 | $15^{0}55^{1}$ | $75^{0}41^{1}$ | 631mts | $28.86^{0}C$ | 575.11mm | Red soil | Gudur |
| IV | 1 | 02/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Chitradurga |
| | 2 | 02/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Chitradurga |
| | 3 | 02/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Chitradurga |
| | 4 | 02/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Chitradurga |
| V | 1 | 01/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | IISc (B'lore) |
| | 2 | 01/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | IISc (B'lore) |
| | 3 | 01/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | IISc (B'lore) |
| | 4 | 01/02/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | IISc (B'lore) |
| VI | 1 | 30/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Belur |
| | 2 | 30/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Belur |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 30/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Belur |
| | 4 | 30/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Belur |
| VII | 1 | 28/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Shimoga |
| | 2 | 28/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Shimoga |
| | 3 | 28/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Shimoga |
| | 4 | 28/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Shimoga |
| VIII | 1 | 27/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Thapovan |
| | 2 | 27/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Thapovan |
| | 3 | 27/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Thapovan |
| | 4 | 27/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Thapovan |
| IX | 1 | 28/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Jog falls |
| | 2 | 28/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Jog falls |
| | 3 | 28/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Jog falls |
| | 4 | 28/01/05 | $15^{0}26^{1}$ | $75^{0}07^{1}$ | 678mts | $22.82^{0}C$ | 801mm | Medium black | Jog falls |
| X | 1 | 29/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Mangalore |
| | 2 | 29/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Mangalore |
| | 3 | 29/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Mangalore |
| | 4 | 29/01/05 | $13^{0}56^{1}$ | $75^{0}40^{1}$ | 650mts | $30^{0}C$ | 833mm | Shallow black | Mangalore |

Appendix II: Proforma for survey of potential Karanja growing areas in Karnataka

I) General information :

| | | | | | |
|---|---|---|---|---|---|
| 1. | Village | : | 3. | District | : |
| 2. | Taluka | : | 4. | Zone | : |

a) Name of the farmer:

b) Land holding :_______acres Irrigated :______ac. Rainfed :______ac.

II) Site Conditions

| | | |
|---|---|---|
| 1. | Soil type | : |
| 2. | Rainfall | : |
| 3. | Latitude | : |
| 4. | Altitude | : |
| 5. | Naturally occurring/planted | : |

III) Farmers knowledge about Pongamia

| | | | |
|---|---|---|---|
| 1. | Use as oil | : | Yes/no |
| 2. | Use as green manure | : | Yes/no |
| 3. | Growing as silvipasture | : | Yes/no |
| 4. | Growing as agri-silviculture | : | Yes/no |

IV) Farmers knowledge about silvicultural characters of Pongamia

| | | | |
|---|---|---|---|
| 1. | Resistance to fire | : | Yes/no |
| 2. | Resistance to browsing | : | Yes/no |
| 3. | Average yield | : | Yes/no |
| 4. | Resistance to Pests | : | Yes/no |
| 5. | Resistance to Diseases | : | Yes/no |

V) Uses of pongamia

| | | | |
|---|---|---|---|
| 1.. | Mixing with diesel | : | Good/Fair/Poor |
| 2. | Use for industries | : | Good/Fair/Poor |
| 3. | Use as Bio-fuel | : | Good/Fair/Poor |
| 4. | Transestrification | : | Good/Fair/Poor |
| 5. | Other uses (Religious) | : | Good/Fair/Poor |
| 6. | If any specify | : | |

VI) Knowledge about silvicultural manipulation

| | | | |
|---|---|---|---|
| 1. | Coppicing | : | Yes/no |
| 2. | Pollarding | : | Yes/no |
| 3. | Planting method | : | Yes/no |
| 4. | Nursery techniques | : | Yes/no |
| 5. | Water harvesting | : | Yes/no |

VII) Knowledge about

| | | | |
|---|---|---|---|
| 1.. | Market | : | Good/Fair/Poor |
| 2. | Interest in cultivation | : | Good/Fair/Poor |

VIII) Interests of farmers in Pongamia plantation

| | | | |
|---|---|---|---|
| 1.. | Entire plantation | : | Yes/no |
| 2. | Border plantation | : | Yes/no |
| 3. | Agroforestry models | : | Yes/no |
| 4. | Along the streams | : | Yes/no |
| 5. | None | : | Yes/no |

IX) Any other information

| | | | |
|---|---|---|---|
| 1.. | Do not need financial assistance | : | Yes/no |
| 2. | Need financial assistance | : | Yes/no |
| 3. | Welcome as national programme | : | Yes/no |
| 4. | Need subsidy bound financial assistance | : | Yes/no |
| 5. | Needs technical support to take up plantations | : | Yes/no |
| 6. | Require market information | : | Yes/no |

X) Please specify your suggestions to increase the area and use of Pongemia as bio-fuel :

1.
2.
3.
4.
5.

Appendix III: Nutrient status in Cattle, Pig and poultry manure

| Source | Dry matter (%) | Nitrogen | Phosphorous | Potassium | Magnesium |
|---|---|---|---|---|---|
| Cattle manure | 0.04-0.23% | 0.24-0.65 % | 0.04-0.18% | 0.20-0.58% | 0.02-0.06% |
| Pig manure | 0.05-0.25% | 0.16-0.68% | 0.06-0.21% | 0.17-0.36 | 0.03-0.07% |
| Poultry manure | 0.23-0.68% | 0.96-2.3% | 0.24-1.2% | 0.38-1.16% | 0.12-0.22% |
| FYM | | 0.4-1.5 % | 0.3-0.9 % | 0.3-1.9 % | |
| Pongamia | | 3.69 % | 2.41 % | 2.42 % | |
| Press mud | | 1.25 % | 2 % | 0 % | |
| Vermi compost | | 1.94 % | 0.47 % | 0.70 % | |

Appendix IV: Nutrient status of Vermicompost

| | Nutrients | Per cent |
|---|---|---|
| 1. | Nitrogen | 0.5 - 1.5 |
| 2. | Phosphorous | 0.10 - 0.99 |
| 3. | Potassium | 0.40 – 1.20 |
| 4. | Sodium | 0.10 – 2.30 |
| 5. | Calcium and Magnesium | 22.7 – 70 mg |
| 6. | Copper | 2.0 – 9.5 ppm |
| 7. | Iron | 2.0 – 9.3 ppm |
| 8. | Zinc | 5.7 – 11.5 ppm |
| 9. | Sulphur | 128.0 – 584.0 ppm |

# STUDIES ON PROVENANCE, NURSERY MIXTURE AND PRE SOWING TREATMENTS ON SEED QUALITY AND CHARACTERIZATION IN PONGAMIA

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## ABSTRACT

Pongamia (*Pongamia pinnata* (L) pier.) locally known as honge. It is indigenous to India, belongs to family Leguminaceae and sub family Pappilionaceae.

In this study, 40 candidate plus trees were selected from 10 different agro climatic zones of Karnataka to study the effect of provenance on seed quality, nursery mixture , pre sowing treatments on seed quality and characterization in pongamia. Among different candidate plus trees tested zone-3 (Bijapur) was found superior for seed quality and zone-5 (Bangalore) was found superior for seedling parameters.

Among different nursery mixtures tested black soil + black sand + vermicompost found superior over other nursery mixtures for seed quality parameters.

Among hydro priming treatments seed soaking for 16 hours ($H_2$) found superior for seed quality and seedling parameters, among interaction seed soaking for 16 hours and seed treated with 0.2 % Bavistin found superior for seed quality and seedling parameters.

Each of 38 SDS- PAGE electrophorograms obtained for different Pongamia candidate plus trees contained (CPT's) 3 – 17 bands and distinctly different bands 2, 3, 4, 5, 6, 8, 16, 17 were common in candidate plus trees 1-19 and bands 1, 3, 5, 6, 9, 14, 16, 17 were common in candidate plus trees 20-38. It was interesting that bands 5, 6 were unique in CPT's 3, 4, 10, 11, 12, 19, 20, 21, 22, 29 and 30, CPT's 33 and 5 would be identified on the basis of absence of bands 1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 17. On the other hand, bands 1, 2 were missing in CPT's 8, 27 and 32.

Among twenty candidate plus trees tested for catalase, peroxidase, phosphates and amylase activity, maximum was noticed in CPT 31 (2428 units), CPT 23 (62.5 units) CPT 27 (12.9 mM) and CPT 20 (1.00mg) respectively.