EFFECT OF PRE TREATMENT ON SEED GERMINATION AND SHADE ON SEEDLING GROWTH AND YIELD OF *Mucuna pruriens* (L.) DC.

By

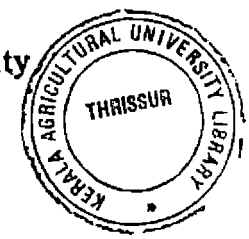
RAVINDRA, P. C.

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Science in Forestry

Faculty of Agriculture
Kerala Agricultural University



Department of Forest Management and Utilization

COLLEGE OF FORESTRY
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2007

DECLARATION

I hereby declare that this thesis entitled **"Effect of pre treatment on seed germination and shade on seedling growth and yield of *Mucuna pruriens* (L.) DC."** is a bonafide record of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society to me.

Vellanikkara
Date: 22/10/2007

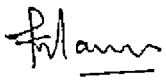
Ravindra, P.C
2005-17-104

Dr. K. Vidyasagaran
Assistant Professor (SS)
Department of Forest Management and Utilization,
College of Forestry,
Kerala Agricultural University,
Trichur, Kerala - 680656

CERTIFICATE

Certified that this thesis, entitled "**Effect of pre treatment on seed germination and shade on seedling growth and yield of *Mucuna pruriens* (L.) DC.**" is a record of research work done independently by **Ravindra.P.C. (2005-17-104)** under my guidance and supervision, it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara,



Dr. K. Vidyasagaran.
Chairman
Advisory Committee

CERTIFICATE

We, the undersigned members of advisory Committee of **Sri. Ravindra, P.C.** a candidate for the degree of **Master of Science in Forestry,** agree that this thesis entitled "**Effect of pre treatment on seed germination and shade on seedling growth and yield of *Mucuna pruriens* (L.) DC.**" may be submitted by **Sri. Ravindra, P.C.** in partial fulfilment of the requirement for the degree.

19/10/07

Dr. K. Vidyasagaran
Associate Professor,
Department of Forest Management and Utilization,
College of Forestry,
Kerala Agricultural University,
Trichur, Kerala
(Chairman)

Dr. K. Gopikumar
Professor & Head,
Dept. of Forest Management
and Utilisation,
College of Forestry, Vellanikkara
Trichur, Kerala
(Member)

19/10/07

Dr. Luckins.C.Babu
Associate Dean (Rtrd)
College of Forestry,
Vellanikkara.
Trichur, Kerala
(Member)

Mr. S. Gopakumar
Assistant Professor (SS)
Dept. of Forest management
and Utilisation
College of Forestry, Vellanikkara.
(Member)

19/10/07

External Examiner

GRATITUDE

At this moment of fulfilment, my heart is overwhelmed with gratitude and I wish these words could convey the feelings at present.

With great reverence and heartfelt gratitude, I would like to acknowledge the flawless guidance and propitious support of **Dr. K. Vidyasagaran,** *Associate Professor, Department of Forest Management and Utilization, College of Forestry and Chairman of My Advisory Committee. His critical suggestions and wholehearted encouragements, which made my endeavour bear fruits, is thankfully recollected. I once again express my deep respect and unfathomed obligation towards him.*

It is with great pleasure that I am extremely thankful to **Dr. K. Gopikumar,** *Associate Professor and Head, Department of Forest Management and Utilization, College of Forestry and member of my advisory committee for his valuable comments and personal support, timely help and warm concern received right from the inception of my research work.*

It is with great pleasure that I am extremely thankful to **Dr. Luckin C. Babu,** *Former Associate Dean, College of Forestry and member of my advisory committee for his sustained and valuable technical support, guidance and encouragement right from the inception of the work and providing splendid support.*

I am deeply indebted to **Mr. S. Gopakumar,** *Assistant Professor, Dept. Forest Mangement and Utilization for his encouragement and valuable advice though out the conduct of the study and critical evaluation of the manuscript.*

I like to extend my sincere thanks to **Dr. N.K. Vijayakumar,** *Associate Dean, College of Forestry, for the continuous support for the smooth conduct of experiment during my study period.*

It is my special thanks to **Dr.B. Mohankumar**, *Associate Professor and Head Dept. of Silviculture and Agro-forestry, College of Forestry and* **Dr. P. K. Asokan**, *Associate Professor and Head, Dept. of Tree physiology and Breeding, College of Forestry for their guidance.*

I am grateful to **Dr. K. Sudhakara**, *Associate Professor and* **Dr. T.K. Kunhamu**, *Assistant Professor, Dept. Silviculture and Agroforestry, college of forestry,* **Dr. E.V. Anoop**, *Assistant Professor,* **Dr. B. Ambikavarma** *Associate Professor, Dept of Wildlife,* **Dr. P.O. Nameer,** *Assistant Professor, Dept of Wildlife and other faculty members of College of forestry.*

Words cannot describe the co-operation extended by my friends in each and every part of my work and I am deeply grateful to Mr. Vinayakumar sahu, Mr. Sreenivasan, Mr. Navas, Mr. ArunGupta, Mr. Abiram, Mr. Eldo, Mr. Anisha kalkoor and Ms. Jiscy.

My sincere thanks to Mr. Puttaswamy, Ms. Rashmi, Mr. Khelen somom, Mr. Harsha, Mr. Divyam, Ms. Natalya, Mr. Rubin, Mr. Rohini, and other friends for their uninhibited and unforgettable help and encouragement.

The Co-operation rendered by Ms Seena, Mr. Anto, Mrs. Reshmi, Mrs. Lolitha, Mrs. Sharada, Mrs. Sali, Mrs Jini is greately acknowledged.

I am deeply indebted to my loving parents, brother and family members for their splendid moral support and blessings.

Finally, I bow my head before almighty for these blessings on me.

[RAVINDRA. P. C]

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Dedicated to My Parents

Chikke Gowda and Harini Gowda

Introduction

INTRODUCTION

India is eulogized as the meadow of medicinal plants with 8000 species of medicinal plants. Before the dawn of modern era, herbal drugs were the only source available to mankind the world over, for health care. The World Health Organization (WHO) estimated that 80 per cent of the population of developing countries still relies on traditional medicines, mostly plant drug, for their health care needs (Ghosh, 2000).

Advances in science have lead not only to the isolation of many active principles from these medicinal herbs in pure form, but also to the production of there synthetic analogues. However, due to high cost of production, difficulties involved in the synthesis, and due to side effects resulting from continual use, the emphasis is now back on traditional and indigenous medicinal plants, and their products in pure form.

In spite of increasing demand for medicinal plant products, the availability is in the negative trend. This is accounted by destruction of natural pockets of medicinal plants and non-availability of productive agricultural land. Word trade of medicinal plants is worth about 60 billion US $ per year, which is growing at the rate of seven percent per annum (Ghosh, 2000). About 90 per cent of the raw drug materials are obtained in Asia, Africa, and Latin America and the rest in USA and Europe.

India is a veritable emporium of medicinal plants and there is a vast potential for export of medicinal plants from India. The total ayurvedic and herbal products in India is around Rs. 2300 crores. At present, India export herbal material and medicine to the tune of Rs. 446 crores and recent estimate shows that it can be raised to 3000 crores (Ghosh, 2000).

People of Kerala have traditionally been using plant based medicine and at present total turn over of ayurvedic medicine and herbal products are in the tune of Rs. 200 crores in Kerala. Kerala Forest Research Institute (1993) conducted an extensive study and identified 300 plants found in Kerala forest, which had commercial use as medicinal plants.

Mucuna pruriens (L) DC. (=Syn. *M. prurita* Hook), commonly called as Cowhedge, is an annual, herbaceous climber belonging to Family *Fabaceae.* In Sanskrit, it is known as Atmagupta or Kapikacchuhlt. In Hindi, it is called as Gonca, Kaunc or Kivacc. Turachi Avare or Nasuginnikayi in Kannada, Nayikorna in Malayalam and Punaikkali in Tamil. It is one of the popular medicinals of India and constitutes more than 200 indigenous drug formulations. It is widespread over most of the subcontinent and found in bushes, hedges and dry–deciduous, low forests throughout the plains of India (Agharkar, 1991; Singh *et al.* 1996) All part of *Mucuna* posses valuable medicinal properties (Pandey, 1998; Pandey,1999; Caius,1989) and there is a heavy demand for *Mucuna* in Indian drug markets. After the discovery, that seed contain L-dopa, an anti-parkinson's disease drug, its demand in international market has increased many folds (Farooqi, 1999).

Generally seeds germinate readily when subjected to favourable condition of moisture and temperature but many species posses some degree of seed dormancy, which can be defined as the condition that prevents germination when ordinary requirement are met. It can be exogenous or seed coat dormancy. Most of the Fabaceae species possess seed coat dormancy. Hence pre-sowing treatments are essential for many species in nursery. An attempt is made to study the influence of different per-treatments on seed germination and seedling growth at nursery stage.

Growth is influenced by many environmental factors, among which amount of light plays an important role on productivity of crop. If a crop has to be included under plantation or in to agroforestry system, information on yield performance under different shade conditions are of paramount importance, hence an attempt is made to standardize the optimum level of shade required for *Mucuna pruriens.*

Wastelands statistics indicate that about 63.85 million hectares, which account for 20.17 per cent of the total geographical area (328.72 million hectares), exist as wastelands in India. *Mucuna pruriens* can be used for wasteland reclamation, as it is a nitrogen-fixing crop. Hence, the scope for cultivation of *Mucuna* is wide.

In Kerala, where home stead type of cultivation is predominant, it is difficult to introduce medicinal plants as pure crops, *Mucuna pruriens* can be easily introduced as an intercrop in plantations of rubber, oil palm and tree species. Besides being able to exploit available limited resources, this also helps to overcome the problems of land scarcity. It also provides additional income to farming community and increases the area under medicinal crop to meet the demand. Being a leguminous plant, it enriches the soil and thus helps in eliminating the use of inorganic fertilizers. Introduction of *Mucuna* acts as a cover crop in vegetative phase and helps in conservation of soil. After pods are harvested, the biomass can be incorporated to the soil as green manure.

The present study is aimed to standardise the pre-treatment methods to break seed dormancy and to increase yield of *Mucuna pruriens* (L.) DC. under different shade conditions.

Review of literature

REVIEW OF LITERATURE

The genus *Mucuna* consists of about one hundred species of annual and perennial legumes. *Mucuna* is self-pollinating and natural out-crossing is rare. The dozen or so cultivated species found in the tropics represent a fragment of the Asian cultigens (Duke, 1981).

2.1 The genus: *Mucuna*

General character of the genus can be described as twining plants with pinnately trifoliate leaves, which are unequal. Calyx campanulate: upper 2 lobes connate, lowest and longer. Corolla purple; standard folded, shorter than wings, auricled, wing adherent to keel; keel as long as wings, incurved at apex. Stamens 9 + 1; anther alternately long, basifixed and short, versatile. Ovary sessile, villous, few-many-ovuled. Pod turgid, often with stinging hairs.

2.2 The species: *Mucuna pruriens* (L.) DC.

Mucuna pruriens originated in southern China and eastern India. It is now found all over the world. In India it is found at the foothills of the Himalayas. Plains of West Bengal, Madhya Pradesh, Rajasthan, Gujarat, Karnataka, Kerala and Tamil Nadu (CSIR 1962).

Mucuna pruriens is a large half-woody twiner, with long slender cylindrical branches, at first covered with short reflexed hairs afterwards nearly smooth. Leaves alternate, pinnately trifoliate, on hairy petioles 6-12 inch long, stipules small, lanceolate; leaflets on short, thick, hairy stalk, with setaceous stipellae at their base, 6-8 inch long , the terminal one the smallest rhomboid-ovate, the lateral on broadly ovate, very unequal at base, the lower side being much expanded, all acute or acuminate, entire, membranous, green on both surfaces, nearly smooth above,

covered below with adpressed white hairs, especially abundant on the prominent veins.

Flowers are large, shortly stalked, in clusters of two or three together, in a pendulus, long stalked axillary raceme a foot or more in length, rachis and pedicels pilose, bracts half an inch long, lanceolate, densly hairy, falling before the flowering period. Calyx cup- shaped, silky externally, deeply cleft in a some what two- lipped manner, the two upper segment being perfectly united to form a signal triangular one, and the lower three lanceolate, subulate, the middle one the longest. Corolla papilionaceous standard broadly oval , acute, about 0.75 inch long, with a short claw, pale purplish, wings nearly 1.5 inch long, narrow, oblong, blunt, slightly falcate, dull dark purple tinged with pale yellowish-green. Keel- petals narrow, a little longer than the wings, nearly straight, except at the end, where they become hard and cartilaginous, and curve upwards, forming a prominent, stiff, greenish beak. Stamens 10, 9 combined by there filaments, the upper one distinct, fore part of the filament some what dilated, anthers small, soon falling, oblong. Ovary surrounded at the base by a small crenulate disk, shortly stalked, hairy, tapering in to the long slender style, stigma small, terminal. Legume nearly sessile, about 3 inches long by more than 0.5 inch broad, falcately curved at each end, some what compressed, slightly contracted between the seeds, dark brown, very densely covered with a thick felt of stiff, short, sharp, pale reddish hairs, which point back wards and are readily detached; when young the pods have a strongly marked rib down each valve, which is concealed by the hairs. Seeds 4 or 5, separated by cellular partitions, about ¼ of an inch long, ovoid, somewhat compressed, smooth, brownish, mottles with black, hilum large, oblong. (Bentley and Triman, 1983)

The pod or legumes which are somewhat compressed, vary in length from about 2 to 5 inches, and are commonly about 0.5 inch in breadth; they are densly covered with stiff brownish- red hairs. These hairs, which readily separated from pod,

constitute the official *cowhage;* It is also called as *cow-itch* when examined by a magnifying lens each hair is seen to consist of acutely pointed conical cell, which is slightly serrated towards its apex. When handled or incautiously touched, the hairs penetrate the skin, and produce an intolerable itching.

The plant is said to have antidiabetic properties. Seeds are astringent, nutritive and have shown hypoglycaemic activity in albino rats. They are also used as an aphrodisiac, as a nervine tonic, in scorpion stings, for leucorrhoea, spermatorrhoea and mensural disorders. Generally, the seed are given as a powder in doses of 30-40 g or in form of decoction.

Seeds contain a non-protein amino-acid L-DOPA (L - 3, 4 digydroxy phenylalanine) and alkaloids mucunine and mucunadine. It also contain glutathione, mulhingallic acid and a number of alkaloids including nicotine, prurienine, prurienidine and five bases designates as P,Q,R,S and Y. The seed-kernel oil contains sitosterol and lecithin. This crop is gaining commercial importance because L-DOPA at 60 g per day in 3-4 divided doses is used as anti-parkinsonias and hypertensive drug (Farooqi, 2001).

The roots are pungent, stimulant, diuretic, purgative and tonic. They are recommended for diseases of nervous system such as facial paralysis. An ointment made from the root is used for the treatment of elephantiasis. Besides, the root are prescribed in fever; powdered and made into a paste and applied to body in dropsy; a strong infusion mixed with honey is given for cholera also (Farooqi, 2001).

Clinical studies confirm the efficacy of the seeds in the management of spasms associated with Parkinson's disease for its high L-DOPA content, the precursor to the neurotransmitter dopamine. Ayurvedic classical text describes this herb as a powerful nervine tonic and aphrodisiac, applicable to the treatment of

disorders of the male or female reproductive system. *Mucuna pruriens* increases the production of HGH (Human Growth Hormone) and testosterone levels. This in turn increases the body's ability to build lean muscle and break down fat. Mucuna can be a very beneficial supplement for bodybuilders. The hairs or bristles of cowhage pods are employed as a vermifuge, and seem to act against the several species of worms, except the tape-worm. The pods are anthelmintic and the root powder, a laxative.

2.3 Nursery studies

2.3.1 Seed Dormancy and germination

Seed dormancy refers to a condition in which a viable seed prevented from germinating when supplied with the factors normally considered adequate for germination (Willan, 1985). Widely accepted dormancy classification is given by Nikolaeva (1977). Among the exogenous causes of dormancy types are physical, chemical and mechanical dormancy and among the endogenous are the morphological and physiological dormancy.

Seeds of most of the trees species in drier tropics have been reported to exibit exogenous dormancy which includes either physical dormancy, caused by hard seedcoats or pericarps with cutinized layers which are impermeable to water, or chemical dormancy caused by inhibiting chemicals present in the seed covering. Sometimes both occur simultaneously in the seed (Willan, 1985).

Veena and Gupta (2003) studied the efficacy of various pre-sowing treatments (scarification, hot water treatment, cold stratification and growth regulator) in breaking dormancy for 39 medicinal and aromatic plants from India. The treatments were given to seeds prior to germination. A seed germination of up to 80-95 per cent was obtained with sand paper scarification for *Abelmoschus moschatus, Abrus precatorius, Cardiospermum halicacabum, Cassia spp.*, and *Withania coagulans*; acid scarification for *Abrus precatorius*, *Argyreia nervosa*, *Bixa orellana*, *Helicteres*

isora and *Indigofera tinctoria*; cutting/piercing the seed coat for *Acacia concinna, Aegle marmelos, Caesalpinia spp., Mucuna pruriens* and *Rubia cordifolia*; pre-soaking of seeds for *Argemone mexicana, Randia dumetorum* and *Rauvolfia serpentina*; GA_3 [gibberellic acid] treatment for *Costus speciosus* and *Embelia ribes*; pre-chilling of seeds for *Asparagus officinalis, Bunium bulbocastanum, Centratherum anthelminticum, Plantago lanceolata* and *Saussurea spp.*; and 0.2 per cent KNO_3 treatment for *Costus speciosus* and *Ocimum sanctum [Ocimum tenuiflorum].*

Mature seeds unable to germinate when placed in favorable conditions are normally regarded to have primary dormancy. On the other hand, secondary dormancy is often induced by extremely high or low temperatures (Mayer and Poljacoff-Mayber, 1989).

Every species has its own germination pattern as the various environmental conditions affect the seeds differently. Young and Young (1989) reported that years with rains in early autumn usually favours legumes.

Seed imbibition is essential to reactivate stored metabolites and organelles and to initiate the early stages of germination. However, this critical step may be prevented by the presence of impermeable seedcoat which restrict the availability of water and gases to inner parts of the seed (Leadem, 1987). Water absorption measured in five southern pines confirmed that seedcoats restricted the amount of water moving into the seeds (Barnett, 1976).

Candido *et al.* (1981) identified impermeability of the seedcoat as the cause of dormancy in *Schizobium pasahybum* seeds. Seeds of most of the tropical leguminous species are dormant due to impermeability of seedcoat (Clemens *et al.* 1977). Hard

seed coat dormancy in *Mucuna pruriens* was reported by Yogeesha and Shivananda (2003).

Sajeevkumar *el al.* (1995) reported that chemical scarification by sulphuric acid gave the highest germination per cent in *Albizia procera and Albizia falkataria.* Nicking the round seeds with knife or iron file was suggested for higher germination per cent in *Albizia Saman, Paraserianthes falcataria, Albizia lebbek and Leucana leucocephala* (Anoop and Gopikumar, 1992).

Chee and Chiu (1997) studied germination and viability testing in seeds of the cover crops *Pueraria javanica* [P. phaseoloides], *Calopogonium caeruleum, C. mucunoides, Centrosema pubescens, Mucuna cochinchinensis* and *Desmodium ovalifolium.* They reported that making an incision on the seed coat increases germination by about 50 per cent of assumed germination. It is recommended that in viability testing, germination of a seed sample should be recorded on the basis of actual germination plus an assumed germination.

A number of treatments involve soaking seeds in water or other liquids. Wet treatments may combine the effects of softening hard seedcoat and leaching out chemical inhibitors (Willan, 1985). The proper relationship between the volume of water to the volume of seeds as well as the temperature requirement, duration of treatment, etc. vary from species to species and is determined by experiments (Bonner, 1974).

Some seeds which have little resistance to germination may respond well to soaking for 24 hours in water at ambient temperature (Kemp, 1975). Koffa (1983), Granfulah and El-Hadidy (1987) and many other workers observed that cold water treatment alone for 24 hours was ineffective in different legumes.

Hot water treatment has been tried in the case of Albizia seeds by several workers. Kumar and Purkayastha (1972) reported that hot water treatment is highly beneficial in *Albizia richardiana.* Valencia (1973) found that 20-30 minutes soaking in water at 38 ^{0}C gave optimum germination in *Albizia falcataria* seeds. The volume of water used was twice that of seed.

Mechanical and chemical scarification was more effective in breaking seed dormancy due to hard seed coat (Stilinovic and Grabic, 1988). One of the simplest and most direct physical methods is to cut, drill or file a small hole in the coat of each seed before sowing (Goor and Barney, 1976). This method has been found appropriate for large leguminous seeds (Seeber and Agpaca, 1976). Onyekwelu (1990) found that rubbing seeds between two rough surfaces of sand paper for three minutes gave 100 per cent germination in *Tetrapleura tetraptera.*

The chemical most commonly used to break seedcoat dormancy is concentrated sulphuric acid (Willan, 1985). Rai (1978) reported that soaking in concentrated sulphuric acid for 10 minutes and subsequently washing and soaking in water for 18 hours significantly increased the germination of *Albizia falcataria* and *Albizia chinensis.* Soaking in concentrated sulphuric acid for 25-30 minutes followed by soaking in water for 24 hours was most beneficial in *Albizia richardiana.*

Seeds of *M. pruriens* with 8 per cent moisture content were subjected to the following pre-germination treatments: soaking in sulfuric acid for 5, 15, 20, 25, 45 or 90 minutes; 50°C hot water treatment for 30 or 60 minutes; 100°C hot water. The final germination was recorded after 14 days. The germination of seeds treated with sulphuric acid increased with the increase in the duration of soaking (86 per cent germination with soaking for 90 minutes). Seeds scarified by rubbing the dorsal

surface on hard rough cement surface or by using sand paper resulted in germination percentages of 86 and 88 per cent respectively. These treatments were effective in overcoming hard seed coat dormancy in *M. pruriens*. The rate of water absorption was faster at the hilum region compared to the other regions of the seed coat surface after scarification with sulfuric acid for 9 minutes. The seeds whose hilum region was in contact with moisture required only 6 hrs to attain 90 per cent moisture gain, whereas the seeds whose dorsal surface was in contact with moisture required more than 24 hrs to attain the same level of moisture gain (Yogeesha and Shivananda, 2003).

Priming with polyethylene glycol or scarification with concentrated sulphuric acid both significantly enhanced germination of *Mucuna flagellipes*. Priming at - 15 bars or scarification by soaking for 25 minutes in acid appeared to be the most advantageous (Asiegbu, *et al.* 2006).

2.4 Crop production and management

Mucuna pruriens can be grown on a wide range of soils. Preferred soil texture is sandy to sandy clay. Growth in clay soils may be hindered by water logged conditions (Kay, 1979). The optimum temperature for cultivation of crop is between 20°C to 30°C (Buckles, 1995). Sowing should be done with the onset of monsoon rains do that pods are harvested during January or February. The crop is sensitive to frost and hence frost prone areas should be avoided for cultivation (Chadha, 1995).

The land is ploughed two to three times to make a fine seed bed before sowing. A basal dose of 1.0 t ha $^{-1}$ of farm yard manure together with 80 Kg ha $^{-1}$ of phosphorous and 40 Kg ha $^{-1}$ of potassium is recommended (Chadha, 1995). Botton (1958) and Kay (1979) reported a seed rate of 11 to 22 Kg ha $^{-1}$ for row planting and 45 to 90 Kg ha $^{-1}$ when broadcasted. Chadha (1995) suggested a seed rate of 50 Kg ha^{-1}. Versteeg (1998) suggested a seed rate of 11 Kg ha $^{-1}$ for intercropping system.

According to Kay (1979), inter-row spacing of Mucuna grown for seed should be 1 to 2 m. When grown for green manure the rows should be 0.5 to 1.0 m apart. Versteeg (1998) found a spacing of 80×80 cm to give acceptable ground rows. Chadha (1995) reported a spacing of 60×60 cm over rows or ridges, the crop is given a top dressing of a mixture of 80 Kg of nitrogen per hectare, in two equal split doses at 30 and 60 days after sowing. Kay (1979) reported that application of superphosphate at doses ranging from 75 to 225 Kg ha $^{-1}$ favored the crop growth.

Allelopathy between *Mucuna pruriens* (velvet bean) and *Lactuca sativa* (lettuce) was studied under 3D-clinorotation. Growth of both roots and shoots of lettuce seedlings was suppressed by the presence of velvet bean. The degree of suppression was less on the clinostat compared to the normal static earth gravity. L-DOPA (L-3, 4-dihydroxyphenylalanine) is known to be a major substance in Allelopathy of velvet bean (Tomita-Yokotani, *et al.* 2003).

The crop can be raised as irrigated and rainfed crop. The rainfed crop is sown after the on set of monsoon (Chadha 1995). When spaced properly and growing normally, *Mucuna* hardly needs to be weeded (Versteeg, 1998). *Mucuna* can be intercropped with maize, wheat, oats, rice, banana, orange, sorghum, millet, cassava and other common crops (Becker and Tarawalli, 1998). Staking, or trellising, for support of veins is suggested for increasing seed yield [Humpherys and Reveros (1986) and Chadha (1995)].

The flowering starts 35 to 75 days after sowing. Mature Pods were harvested with the help of knife or sickles (Becker and Tarawali, 1998). Mucuna vegetation after harvest of pods can be used as green fodder, or processed as dry season hay (Buckles, 1995).

In general, *Mucuna* crop does not have much fungal or pest problem. It is susceptible to mosaic virus, vine rot disease and may have leaf spot attack towards maturity (Chadha, 1995). It is resistant to root knot nematodes (ECHO, 1998).

2.5 Yield and biomass production

Mucuna pruriens belongs to family *Fabaceae*. The life cycle ranges from 100 to 290 days. It is of an herbaceous twining nature with trifoliate and broadly ovate leaves. The flowers are produced in pendulous clusters and usually purple in colour. *Mucuna* grows vigorously producing suffuse vegetative matter or biomass. Leaf biomass of *Mucuna* ranges from 6 to 12 t ha $^{-1}$ of dry matter as reported by Chavez (1993).

According to Singh (1957), biomass is mainly a function of the vegetative growth by virtue of inherent genetic makeup of each legume. A maximum dry matter production of 4.5 t ha $^{-1}$ for vegetable cowpea (100 days) occurs when irrigation is given at 75 percent field capacity (Jyothi, 1995). Mercy (1981) reported a production of 14.1 t ha $^{-1}$ of velvetbean green fodder and 2.3 t ha $^{-1}$ of velvetbean dry matter.

Biomass yield (18.77 t ha $^{-1}$) of *M. pruriens* when grown under shaded condition is reported to be superior to biomass yield (16.83 t ha $^{-1}$) when the crop is grown under open condition. (Sunitha, 1996). Mini (1997) found that in summer vegetable cowpea, frequent light irrigation produces maximum dry matter at all stages.

Biomass yield of *Mucuna* varies directly with length of growing season and soil fertility conditions. High biomass accumulation (10 t ha $^{-1}$) was observed in areas

of longer growing season. Variety characteristics were also observed to influence the rate of dry matter production (IITA, 1997).

According to Becker and Johnson (1998), soil phosphate is an important factor in *Mucuna* biomass accumulation, as legumes require phosphorus for growth and nitrogen fixation. IITA (1998) reported a biomass yield of 2.3 t ha $^{-1}$ in *M. pruriens* grows at a site in Nigeria.

2.5.1 Plant length

Variation in plant length within legumes is purely a function of the genetic makeup (Bose, 1963). Mercy (1981) reported that *Mucuna* vines are longer and more aggressive than cowpea and horse gram, and produce more number of leaves which helps the crop for greater utilization of environmental resources. Veerupakshappa (1982) observed the negative association of plant length and number of seed per pod, in cowpea. An increase in plant length may increase transpirational loss of water due to increase in vegetative growth. This in turn may hinder reproductive growth and ultimately reduce the yield in legume crop (Anitha, 1989). A plant height of 3.7 m at three month stage was observed in vegetable cowpea by Jyothi (1995).

According to Mini (1997), plant length in vegetable cowpea is significantly influenced by frequency of irrigation. Geetha (1999) reported that nitrogen plays a key role in influencing the length of vines in vegetable cowpea.

2.5.2 Number of leaves

According to Nair (1966), the number of leaves per plant like in other growth parameters is purely a function of genetic makeup, under identical conditions of growth. An average of 79 leaves per plant at 75 DAS and 67 leaves per plant at 90 DAS (i.e. harvest stage) were observed in cowpea. The decrease in the number of

leaves is attributed to the phenomenon of 'leaf shedding' before harvest (Jyothi, 1995). Frequent light irrigation produced the highest number of leaves per plant in vegetable cowpea (Mini, 1997). Geetha (1999) reported significant influence of high levels of nitrogen on number of leaves per plant.

2.5.3 Root characters

A well developed root system is characteristic of increased yield in cowpea (Babalola, 1980). Kavitha (1982) reported a positive association of root length with yield in Blackgram. In contrast Anitha (1989) observed that greengram varieties with high root length and spread were low yielding due to increase of vegetative growth at the expense of reproductive growth. Rajan (1999) found that length of primary root showed a positive association with weight of nodules, plant length, number of seed per pod and 100 grain weight, and a negative association with number of pods.

2.5.4 Pod character

Mucuna pruriens possesses pods of around 9 to 13 cm length. They are covered by long stinging hairs containing alkaloids like *mucunine, mucunadine* and *mucunane.* This causes extremely painful and itchy rashes on contact with human skin. These hairs are beneficial to plants, they discourage seed predators, hence *Mucuna* pods are fairly free from insect attack (Buckles, 1995).

According to Nair (1966), pod length in cowpea mainly depends on genetic makeup of variety. He also reported that the higher the amount of nitrogen applied to the crop, more the vegetative growth and lesser the yield of pods. Jayarani (1993) observed a range of 6.93 to 26.57 numbers of pods per plant, and length of 8.65 cm to 26.58 cm pod length in grain cowpea.

Sajikumar (1995) reported a range of 12.33 to 26.34 pod clusters per plant, 23.89 to 78.78 total numbers of pods per plant, 11.95 to 27.86 g average weight of pods per plant and a range of 3.65 to 4.95 cm pod length in blackgram. According to Geetha (1999), the maximum yield of green pods and number of pods in cowpea, occur when nitrogen and potassium are given in doses of 20 Kg ha $^{-1}$ each.

2.5.5 Seed characters

In *Mucuna pruriens*, there are about 4 to 8 seeds per pod. The seeds are globular or reniform and usually black, white, creamy yellow or may be mottled. Hundred seed weight may vary from 25 to 110 g (Buckles, 1995). Rajendran (1979) reported in cowpea, a positive association of grain yield with height of plant, number of days to flowering, number of pod clusters per plant and number of seeds per pod. Mishra (1985) observed that the number of pods per plant, 1000 seed weight, number of seed per pod and length of reproductive period contributed directly to seed yield in Greengram.

According to Chikkadyavaiah (1985), in cowpea, seed yield is positively associated with number of branches per plant, number of pods per plant, number of seeds per pod and 100 seed weight. Kay (1979) summarized *Mucuna pruriens* seed yields as ranging from 700 to 1100 Kg ha $^{-1}$ in India, 1700 to 2200 Kg ha $^{-1}$ in USA and the lowest of 600 Kg ha $^{-1}$ in Australia. Jayarani (1993) reported a number of 8.5 to 14.5 seeds per pod in blackgram whereas Sajikumar (1995) reported a number of 4.75 to 6.65 seeds per pod, seed weight of 7.89 to 22.95 g per plant and 100 seed weight of 4.87 to 6.42 g.

Support or stalking generally recommended for improving quantity and quality of legume seed production (Humpherys and Riveros, 1986). According to Kachalreiss and Tarawali (1994) for each climbing legumes, seed yield can be

increased at least five times by trailing. Seed yield from a rainfed crop of *M. pruriens* without stalking was 1500 to 1750 Kg $^{-}$ha^{1}. Where stakes are provided, a yield of 3000 to 3750 kg ha^{-1} was observed, and from a well managed irrigated crop having the support of stakes, a seed yield of 5000 Kg ha^{-1} was obtained (Chadha, 1995).

2.5.6 Leaf area parameters and physiological parameters

Russell (1961) reported that an increase in total leaf area which results in higher leaf area index (LAI), had a profound effect on enhancing photosynthetic activity and hence, the yield of crop. Mercy (1981) observed the LAI of legume at three stages i.e. 45 days after sowing (DAS) and 90 DAS, to be around 3.34, 5.80 and 9.50 respectively. According to Maggie (1989), the LAI of cowpea increased at vegetative and flowering stages (0.85 and 1.50 respectively) and decreased at harvest (0.50) due to leaf shedding.

LAI is the primary factor that determines the rate of dry matter produced. It is found to lower during reproductive phase, as vegetative phase is reduced at this phase (Pearce and Mitchel, 1990). Sajikumar (1995) reported LAI in range of 1.95 to 8.19 at harvest, among genotypes of blackgram. High levels of nitrogen are found to significantly influence the LAI of cowpea (Geetha, 1999). The net assimilation rate (NAR) is one of the most important growth characteristics describing the net production efficiency of the assimilation apparatus. It reflects the net photosynthetic rate per unit leaf area for a given period. As the plant develops and the number of leaves increases, more of them get shaded and this results in decrease of photosynthetic rate, hence the NAR is lowered (Pearce and Mitchel, 1990).

Harvest index (HI) varies among legumes according to its genetic makeup. Different genotypes of cowpea displayed a range of 0.30 to 0.65 in value of the harvesting index (Maggie, 1989). The crop growth rate (CGR) can be considered as

the most meaningful growth analysis term. It is closely related to the LAI. Growth in plants is influenced by the period over which plants maintain their leaf area and its persistence in time (Pearce and Mitchel 1990).

Crop growth rate (CGR) of cowpea at four stages i.e. 30 DAS, 45 DAS, and 90 DAS was observed as 0.6, 0.7 and 0.6 respectively. The decline in CGR is attributed to leaf shedding (Jyothi, 1995).

Legumes can fix around 50 to 300 Kg ha^{-1} of nitrogen, resulting in the addition of nitrogen to agricultural soil than all other fertilizing practices combined (Venkataraman and Tilak, 1990). The encouraging results of three decades of cover legume research in tropics, has resulted in the promotion and increased use of legumes for the improvement of soil fertility (IITA, 1993). Hartwell and Pember (1911) credited an annual average gain of 65 Kg ha^{-1} of nitrogen to fields cultivated with legumes. Greaves and Jones (1950) reported that returning the legume crop to the soil after cultivation, significantly increased the soil nitrogen content. Sen and Rao (1953) quantified nitrogen fixed by legumes in the soil as 130 Kg ha^{-1} per year. According to Khan (1953), the quantity of nitrogen fixed varies with each legume and ranges from 15 to 70 Kg ha^{-1} generally. The amount of nitrogen fixed is the sum total of nitrogen derived from the atmosphere and nitrogen derived from the soil, and comprises around two thirds and one-thirds amount, respectively. Russel (1961) observed that all the nitrogen fixed is transferred to the plant tops and seeds; hence not much increase may be seen in the soil nitrogen.

Under Kerala conditions, loss of nitrogen in cultivated fields is very high due to high temperature and excessive rainfall. Hence growing legumes is a cheap source of maintaining soil fertility. Cowpea is observed to fix nitrogen to about 201.80 Kg ha^{-1}, *Sesbania aculeate* about 179.55 Kg ha^{-1}, *S. speciosa* about 23.95 Kg ha^{-1} and

Arachis hypogoea about 90.10 Kg ha^{-1} of soil nitrogen (Bose, 1963). *Mucuna* was tested extensively in Nigeria for soil fertility maintenance (Vine, 1953). Botton (1958) recommended it for Ivory Coast.

2.6 Nutrient studies

An estimate of 155 to 200 Kg ha^{-1} of nitrogen was found in leaves, pods and roots of well grown solo *Mucuna* without mineral fertilization. In general, *Mucuna* may fix anywhere between 70 to 130 Kg ha^{-1} of nitrogen. An analysis of the long term changes in soil properties showed an overall increase of 30 per cent in nitrogen content after ten year of growing *Mucuna* (Sanchez, !993).

According to Becker and Johnson (1998), nitrogen accumulation in *Mucuna* varied from 30 to 257 Kg/ha and nitrogen derived from atmosphere varied from 30 to 90 Kg ha^{-1}. These benefits were found to be significantly superior to other legumes crops like cowpea, Stylosanthes, Calapogonium and Centrosema. In Kerala *M. pruriens* was found to increase the soil nitrogen content by 60 Kg ha^{-1} (Sunitha, 1996).

Nodulation is the main index of symbiotic nitrogen fixing efficiency in legumes. Atmospheric nitrogen fixed by the legume returns to the soil through nodules sloughing or excretion of fixed nitrogen. The plant that records the maximum yield has significantly more number of nodules and weight at all stages of observation (Venkataram and Tilak, 1990). According to Bose (1963), legume with larger number of nodules fix higher amount of soil nitrogen; a good part of the nodules are returned in organic form, to soil nitrogen. *Sesbania aculeate* was observed to have 110.13 nodules at 60 DAS compared to *S. speciosa* (26.88), *Arachis hypogoea (39.62)* and *Vigna sinensis* (3.75).

Sunitha (1996) reported that the number of nodules per plant in *M. pruriens* was higher under shaded condition (113.5) than under open condition. Rajan (1999) recorded a range of 14.40 to 140.00 mg in nodule weight per plant, at 50 percent flowering in greengram.

The application of calcium acetate to soyabeans was observed to increase the nodulation by ten times (Scalan, 1928). Whyte and Trumble (1953) reported on the importance of calcium for nutrition of the legume plant, as well as nitrogen fixing bacteria. According to Fred and Graw (1942), phosphorous play a dynamic role in symbiotic nitrogen fixation, as it has a stimulatory effect on movement of rhizobia towards the root system. Sen and Rao (1953) reported on the marked response to application of phosphorous, on extent of nodulation and nitrogen fixation in legumes. Rajashree (1994) reported that high doses of both phosphorous and potassium increased nodulation in greengram.

2.7 Medicinal value

Mucuna pruriens is a plant of immense medicinal value, its properties are put to use in the treatment of a vast number of disorders. The seed can be used as a nervine tonic; Aiyar and Kolammal (1962), antidiabetic; Dhar and Dhawan (1968); Lal (1990), to reduce levels of cholesterol; Pant (1978), to enhance spermatogenesis; Mishra and Shukla (1984) and Manyam and Ramos (1999). They can serve as a very potent aphrodisiac; (Saksena and Dixit, 1987; Ananthakumar *et al.*1994 and Amin, 1996). The leaves are used in treatment of syphilis and sores; (Atal and Kapu, 1986), in reducing hypertension; (Mogra, 1987), in the treatment of cancer; (Panikkar and Pillai, 1988) and snakebite; (Houghton, 1994). The roots can be used as analgesic and emollient; (Aruna, 1998). The hairs present on the pods are a good vermifuge when administered along with honey (Wallis, 1985).

Yet the most outstanding use of *M. pruriens* is in the treatment of Parkinson's diseases. Parkinson's disease, a progressive neuro-degenerative disorder which causes degeneration and gradual loss of motor activity, is of world wide occurrence and life long presence. It is caused due to the reduction in level of dopamine; a neuro-transmitter produced naturally by the body. This affects the motor activities and functioning of nervous system resulting in jerky or spasmodic movements (Parikh and Manyan, 1999). Several scientists have reported on the healing power of *M. pruriens* seed in Parkinson's disease. This treatment is claimed to be safe from side effects, efficient and economical (Vaidya and Khan, 1978; Heidel, 1987; Dan, 1990; Taiyab and Khan, 1991; Kurien, 1995 and Altern, 1995).

2.8 *Mucuna pruriens* as inter crop and cover crop

One of the prominent alternatives to existing cropping systems is the introduction of leguminous intercrop in plantations (Balasubramaniyam, 1991). Several reports are available on successful intercropping of medicinal plants in plantations (Singh *et al.*, 1990 and Nair *et al.*, 1991). Legumes can potentially sustain gains in productivity in intensified system (Wagger, 1996).

Increase in cereals yield was contributed by soil improvement after *Mucuna* cultivation, due to fixation of nitrogen was reported by Lathwell (1991). According to Sanchez (1993) when *Mucuna* was intercropped with maize, the nitrogen released by *Mucuna* (70 to 115 Kg ha^{-1}) reached a peak about 30 days after slashing. High levels of nitrogen (60 to 70 Kg ha^{-1}) were found in the soil before slashing, indicating the active decomposition of litter biomass, caused by leaf shedding and consequent release of nitrogen. Van Noordwjk (1995) estimated that 83 percent of nitrogen contained in *Mucuna* crop was available to a subsequent maize crop.

According to Becker and Johnson (1998), use of *Mucuna* as dry season fallow increased upland rice yields by around 500 Kg ha^{-1}, which corresponds to a mineral fertilizer substitution of about 50 Kg ha^{-1} of nitrogen, as urea. The net increase in inorganic nitrogen resulting from mineralization, after cultivation of *Mucuna varied* from 60 to 165 Kg ha^{-1} (Flores, 1999).

In recent years, covercrops have received considerable importance as means to increase the productivity and sustainability of agricultural system. *Mucuna* is prominent among the covercrop studied and promoted (Bunch, 1990). *Mucuna* can achieve nearly 100 percent ground cover in two months if soil fertility is adequate. This ground cover can help to physically protect the soil from raindrop impact and soil erosion. This helps to maintain the physical and chemical properties of soil. *Mucuna* leaf litter as mulch protects the soil and increases organic matter content. It also moderates soil temperature, and alleviates soil compaction (Becker and Tarawalli, 1998; IITA, 1998). According to Peoples and Grey (1995) the mean nitrogen accumulation in leguminous cover crop is about 100 Kg/ha. *Mucuna bracteata* has been introduced as a cover crop in Rubber plantations. (KAU, 2004).

2.9 As a means to control weeds

Botton (1958) reported that *M. pruriens* was effective in controlling both nutgrass (*Cyprus rotundus)* and speargrass *(Imperata cylindrical*), two of the most obnoxious weeds in the tropics. This was in congruence with the finding of Poku (1985) and Thurston (1997). Continuous cropping of *M. pruriens* was found to reduce the weed population by 75 percent. The crop was also reported to possess allelopathic properties. The harmful substance was identified as L-DOPA which had a suppressing effect on *Astytasia intrusa, Paspalus conjugatus and Phaseolus vulgaris* (Fujii and Yasuda, 1991). In Costa Rica, Valverde and Rojas (1995) found that *Mucuna* reduced the biomass of itchgrass (*Rottboellia cochinchinesis*) by 75 to

95 per cent. Becker and Johnson (1998) observed that *Mucuna* completely controlled *Imperata cylindrica* and *Chromolaena odorata.*

2.9.1 As a mean to control nematodes

Reddy *et al.* (1986) reported that *Mucuna* was effective in reducing soil population of root knot nematodes. Caveness (1993) and Thurston (1997) reported on the suppression of root lesion nematodes like *Pratylenchus spp.* by *Mucuna.*

2.10 As a fodder and food crop

According to Botton (1958) and Buckles (1995), *Mucuna* has good forage and can be given along with other fodder, in fresh or dry form. *M. pruriens* grains have good potential as an animal feed. It contains upto 29 per cent protein (Buckles, 1995). *M. pruriens* bean are described as extremely good, fairly palatable, high protein feed for most of livestock (ECHO, 1998). *M. pruriens* is also considered as a human food legume (Kay, 1979). *Mucuna* seeds have been regularly consumed by tribal of Andhra Pradesh (Pant, 1992). According to Rajyalakshmi (1994), the seeds contain upto 29 per cent protein and traces of calcium, phosphorous, iron and niacin. As the seeds contain traces of anti-nutritional factors, they have to be treated by keeping them in boiling water for 40 minutes and discarding the water.

The seeds of *Mucuna* are roasted and ground, then used as a coffee substitute in Guatemala. Hence they are known by the name 'nescao' or 'nescofi'. Currently there is sale under commercial brand names like 'Nutricoffee' (ECHO, 1998). In Brazil, flour is prepared from both the seeds and roots of *M. pruriens. Mucuna* beans are a good choice as famine foods, as they are easy to cultivate and are produced abundantly (Flores, 1999).

Materials and Methods

MATERIALS AND METHODS

The present investigations were carried out at the tree nursery and the field in College of Forestry, Kerala Agricultural University, Vellanikkara, Trichur, Kerala, during the period 2005 to 2007. The details about the experiment site, materials used and methodology adopted are furnished below:

3.1 Location

The experimental site has an elevation of 40.3 m above sea level and located at 10° 13'N latitude and 76° 13' E longitude.

3.2 Climate

The study area experiences a warm humid climate, having mean annual rainfall of 2890 mm, most of which is received during the south west monsoon (June to August). The mean maximum temperature recorded at Vellanikkara varied from 28.4 ° C in June to 34.9 ° C in March. The mean minimum temperature varied from 21.9 ° C in July to 24.7 ° C in April.

3.3 Soil

The soil of the experimental site is an ultisol having a pH of 5 to 6, relatively rich in organic matter.

3.4 The species: *Mucuna pruriens* (L.) DC

Mucuna pruriens originated in southern China and eastern India. It is now found all over the world. In India it is found at the foothills of the Himalayas, plains of West Bengal. Madhya Pradesh. Rajasthan Gujarat. Karnataka, Kerala and TamilNadu (CSIR, 1962). The genus *Mucuna* consists of about one hundred species of annual and perennial legumes. *Mucuna* is self pollinating and natural out crossing is rare. The dozen or so cultivated species found in the tropics represent a fragment of the Asian cultigen's (Duke, 1981). The commonly cited species and relevant information on them is given in Table 1 (Kay, 1979).

Table 1. Common cultivated species of genus *Mucuna* (Kay, 1979)

Sl. No.	Species	Distribution	Flower colour	Seed colour	Pod length (cms)	Main use
1	*Mucuna pruriens*	India, Japan, Philippines, Africa, W. Indies, USA	Purple/ White	Black creamy yellow or motted	9-13	Medicinal plant, Human food crops, Cattle fodder
2	*M. deeringiana*	USA, S.America	Purple	Mottled	5-8	Cattle fodder, Green manurecrop
3	*M. aterrina*	Mauritius, Australia,Brazil, W.Indies	Purple/White	Black	9-13	Rotation crop, Cover crop
4	*M. utilis*	India, SE. Asia	Purple	Mottled	8-13	Green manure, fodder
5	*M. hassjoo*	Japan	Purple	Mottled	9-13	Fodder, Covercrop
6	*M. cochinchinensis*	Philippines, SE Asia	Purple	Grey, White or Mottled	8-13	Vegetable crop

3.5 Collection of seed

Seeds were collected from wild plant distribution in the campus of Kerala Agricultural University, Trichur. Pods were sun dried from which seeds were separated and graded based on size of seeds, uniform sized seeds were used for germination studies.

3.6 Seed treatments and sowing

Selected seeds were pre-treated before sowing in polybags and well prepared nursery bed. Polybags were filled with potting mixture of sand: soil: FYM (1:1:1). Seeds were treated with different per-sowing treatments details of which are furnished below.

T1: Cold water for 12 hours: selected 40 seeds were soaked in a container with cold water for 12 hours and sown in nursery bed and polybags.

T2: Cold water for 24 hours: selected 40 seeds were soaked in a container with cold water for 24 hours and sown in nursery bed and polybags

T3: Soaking seeds in hot water for 12 hours: selected 40 seeds were kept in hot water (100° C) for 2 minute and then soaked in cold water for 12 hours before sowing in poly bags and nursery bed (20 seeds each).

T4: Soaking seeds in hot water for 24 hours: selected 40 seeds were soaked in hot water (100° C) for 2 minute, then soaked in cold water for 24 hours and sown in poly bags and nursery bed (20 seeds each).

T5: Soaking seeds in Conc. H_2So_4 for 5 min. followed by 12 hours in cold water: selected 40 seeds were soaked in a container with Conc. H_2So_4. After 5 min they were washed in running water and soaked in cold water for 12 hours and seeds were sown in poly bags and nursery bed (20 seeds each).

T6: Soaking seeds in Conc. H_2So_4 for 10 min. followed by 12 hours in cold water: Selected 40 seeds were soaked in a container with Conc. H_2So_4. After 10 min, they were washed in running water and soaked in cold water for 12 hours and seeds were sown in poly bags and nursery bed (20 seeds each).

T7: Soaking seeds in Conc. H_2So_4 for 15 min. followed by 12 hours in cold water: Selected 40 seeds were soaked in a container with Conc. H_2So_4. After 15 min. they were washed in running water and soaked in cold water for 12 hours, and seeds were sown in poly bags and nursery bed (20 seeds each).

T8: Soaking seeds in Conc. H_2So_4 for 20 min. followed by 12 hours in cold water: Selected 40 seeds were soaked in a container with Conc. H_2So_4. After 20 min. they were washed in running water and soaked in water for 24 hours, and seeds were sown in poly bags and nursery bed (20 seeds each).

T9: Scarification by rubbing the dorsal surface of seeds against hard rough cement surface or by using sand paper: dorsal surface of the seeds were rubbed to hard cement surface without damaging the embryo and seeds were sown in poly bags and nursery bed (20 seeds each).

T10: Control: Untreated seeds were sown as control in poly bags and nursery bed (20 seeds each).

Pre-treated seeds were sown in CRD (Complete Randomized Design) with three replication. Daily observations were taken on germination of seed, from both polybags and nursery bed. Various growth parameters like height, collar diameter and number of leaves per plant were taken for five weeks. Then biomass (fresh weight and dry weight) of seedlings was estimated by destructive sampling.

3.7 Influence of shade on field:

After 5 weeks of sowing, selected seedlings were transplanted to different levels of shade condition, prepared by using shade net of 25 per cent, 50 per cent, 75 per cent and 0 per cent (open condition/ control).

In which

T_1 - Open or 0 per cent shade level

T_2 – 25 per cent shade level

T_3 – 50 per cent shade level

T_4 – 75 per cent shade level

Seedlings were planted in CRD with three replication, (30 seedlings under each shade condition/treatment). Proper plant caring procedure was carried out for its optimum growth. Irrigation was given during hot summer days. The following observations were recorded in the field

Days taken for inflorescence bud formation (Fortnightly)

Days taken for flower formation (Fortnightly)

Days taken for 50 per cent flowering (Fortnightly)

Days taken for pod formation and maturing of the pods (Fortnightly)

Number of flower per inflorescence (Fortnightly)

Number of matured pods (at the end of the study)

Number of seeds per pod (at the end of the study)

Pod characters (at the end of the study)

Biomass production (at the end of the study)

After bud initiation each inflorescence was tagged and further information at inflorescence level was recorded. Mature pods were harvested from plants keeping its identity, and sun dried. Dry weight was estimated after oven drying, to calculate yield.

For calculation of total biomass under different treatments, plants were harvested by cutting at the base and roots were uprooted to know root biomass. Above ground, biomass was separated into twigs and leaves. Both fresh weight and dry weight were estimated. Different components of biomass were summed up to get total biomass

Plate 1. General view of the experimental plot

Plate 2. *Mucuna pruriens* grown under 25 per cent shade level

Plate 3. ***Mucuna pruriens*** **grown under 50 per cent shade level**

Plate 4. ***Mucuna pruriens*** **grown open condition**

Plate 5. Tagging of inflorescence buds

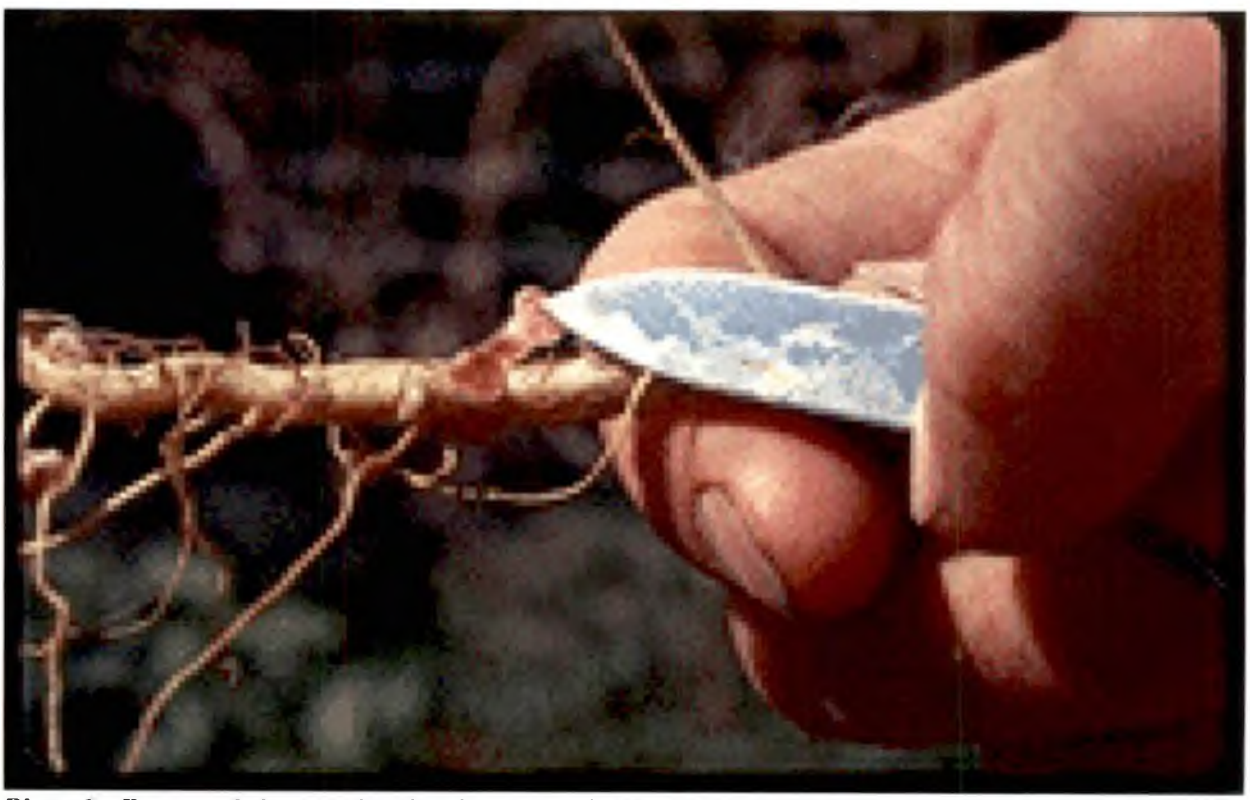

Plate 6: Root nodules production in roots of *Mucuna pruriens*

produced under different shade condition. Number of leaves at maturity was also counted.

Samples of leaf, twig and roots were collected for estimation of nitrogen, phosphorous and potassium content.

3.8 Phytochemical analysis

Triplicate samples of each biomass components were analyzed for nitrogen (N), phosphorous (P), and potassium (K). The oven dried samples were powdered and passed through sieves of size ranges from 5 mm to 2mm.

3.8.1 Nitrogen

Nitrogen content in dried samples was determined by digesting 0.1 g of the sample with 5 ml. of concentrated sulphuric acid in the presence of 3 g. of digestion mixture containing potassium sulphate and copper sulphate in 10:2 ratio. The digest was distilled using 40 per cent NaOH. The ammonium titrated was absorbed in 4 per cent boric acid which was then titrated with 0.1 N sulphuric acid using mixed indicator (Jackson, 1958).

3.8.2 Phosphorus

0.2 grams of the powdered sample was digested in triacid mixture (Nitric acid: sulphuric acid: perchloric acid in 10:1:3 ratio) and the digest was made up to 100 ml. A known quantity of aliquot was taken to determine the phosphorus content calorimetrically by the vanadomolybedo phosphoric yellow column method (Jackson, 1958).

3.8.3 Potassium

The triacid extract prepared earlier was used to estimate potassium content also. It was estimated in digital flame photometer (Jackson, 1958).

3.9 Statistical analysis:

The data obtained from the field were subjected to analysis of variance and significant effects were further analyzed using DMRT (Duncan multiple range test).

Since co-efficient of variation was very high in all most all variables, transformations were used depending on the nature of the data. Here in the present study two transformations were used viz. Square root and Arc sine.

Results

RESULTS

The present series of investigations were carried out in College of Forestry, Kerala Agricultural University, Vellanikkara, Trichur with the objective to know the effect of different pre treatment on seed germination and growth rate in nursery stage and yield of *Mucuna pruriens* under different shade condition. The results obtained are furnished below.

4.1 Nursery studies

4.1.1 Pre treatment and germination

In case of germination percentage, it varied among the two systems (Polybag and Nursery bed) significantly with higher mean for polybag condition. Significant difference was observed among the treatment for germination percentage. Scarification by rubbing the dorsal surface of seeds against hard rough cement surface gave highest mean (1.57). (Table 3 and Fig.1). Interaction was also analyzed and shown to be significant (Table 3).

4.1.2 Germination energy

There was no significant difference between two systems with respect to germination energy with little difference between means (Table 3) and interactions were also non significant but among different treatments significant variation was observed. (Table 3)

4.1.3 Growth parameters

4.1.3.1 Height

The observation on the rate of growth in height at weekly interval for five consecutive weeks was taken and data are furnished in Table 4. It is evident from Table 4 that variation in height is significant between two systems (polybags and nursery) and it is observed that variation within the system (between treatment) was also significant up to first week with T_9 (Scarification by rubbing the dorsal surface of seeds against hard rough cement surface or by using sand paper) attaining the highest followed by T_8

Table 2. Germination per cent obtained in polybag and nursery bed

Sl. No	Treatments	Germination per cent (Polybag)	Germination per cent (Nursery bed)
1	T_1 (Cold water for 12 hours)	30.00	18.33
2	T_2 (Cold water for 24 hours)	28.33	18.33
3	T_3 (Soaking seeds in hot water for 12 hours)	46.67	38.33
4	T_4 (Soaking seeds in hot water for 24 hours)	43.33	46.67
5	T_5 (Conc. H_2So_4 for 5 min. followed by 12 hours in cold water)	26.67	28.33
6	T_6 (Conc. H_2So_4 for 10 min. followed by 12 hours in cold water)	30.00	31.67
7	T_7 (Conc. H_2So_4 for 15 min. followed by 12 hours in cold water)	45.00	50.00
8	T_8 (Conc. H_2So_4 for 20 min. followed by 12 hours in cold water)	93.33	73.33
9	T_9 (Scarification by rubbing the dorsal surface of seeds against hard rough cement surface)	100.00	100.00
10	T_{10} (Control)	23.33	28.33

Table 3. Mean germination per cent and germination energy of various treatments

Sl. No.	Treatment	Germination percent			Germination energy.		
		Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	0.58 (30.00)	0.44 (18.33)	0.51^{ed} (24.16)	1.91 (3.67)	1.61 (2.67)	1.76^{e} (3.16)
2	T_2	0.56 (28.33)	0.44 (18.33)	0.50^{e} 23.33	1.63 (2.67)	1.61 (2.67)	1.61^{e} 2.66
3	T_3	0.75 (46.67)	0.66 (38.33)	0.70^{e} (42.5)	2.57 (6.67)	2.35 (5.67)	2.46^{c} (6.16)
4	T_4	0.72 (43.33)	0.75 (46.67)	0.73^{c} (45.0)	2.21 (5.00)	2.34 (5.67)	2.27^{cd} (5.33)
5	T_5	0.54 (26.67)	0.56 (28.33)	0.54^{ed} (27.5)	1.99 (4.00)	1.61 (2.67)	1.79^{ed} (3.33)
6	T_6	0.58 (30.00)	0.60 (31.67)	0.58^{d} (30.83)	1.91 (3.67)	2.02 (4.33)	1.96^{ed} (4.00)
7	T_7	0.74 (45.00)	0.79 (50.00)	0.76^{c} (47.5)	2.16 (4.67)	2.94 (8.67)	2.54^{c} (6.66)
8	T_8	1.31 (93.33)	1.03 (73.33)	1.17^{b} (83.33)	3.16 (10.00)	3.04 (9.33)	3.1^{b} (9.66)
9	T_9	1.57 (100.00)	1.57 (100.00)	$1..57^{a}$ (100.0)	4.36 (19.00)	4.28 (18.33)	4.32^{a} (18.66)
10	T_{10}	0.50 (23.33)	0.56 (28.33)	0.53^{ed} (25.83)	1.79 (3.33)	1.52 (2.33)	1.65^{e} (2.83)
MEAN		0.78 (46.66)	0.74 (43.33)		2.37 (6.26)	2.33 (6.23)	
F test			*			*	
CD			0.10			0.53	

Figures with similar letters as superscript do not differ significantly
Original means are given in parenthesis

* Significant at 5 per cent level

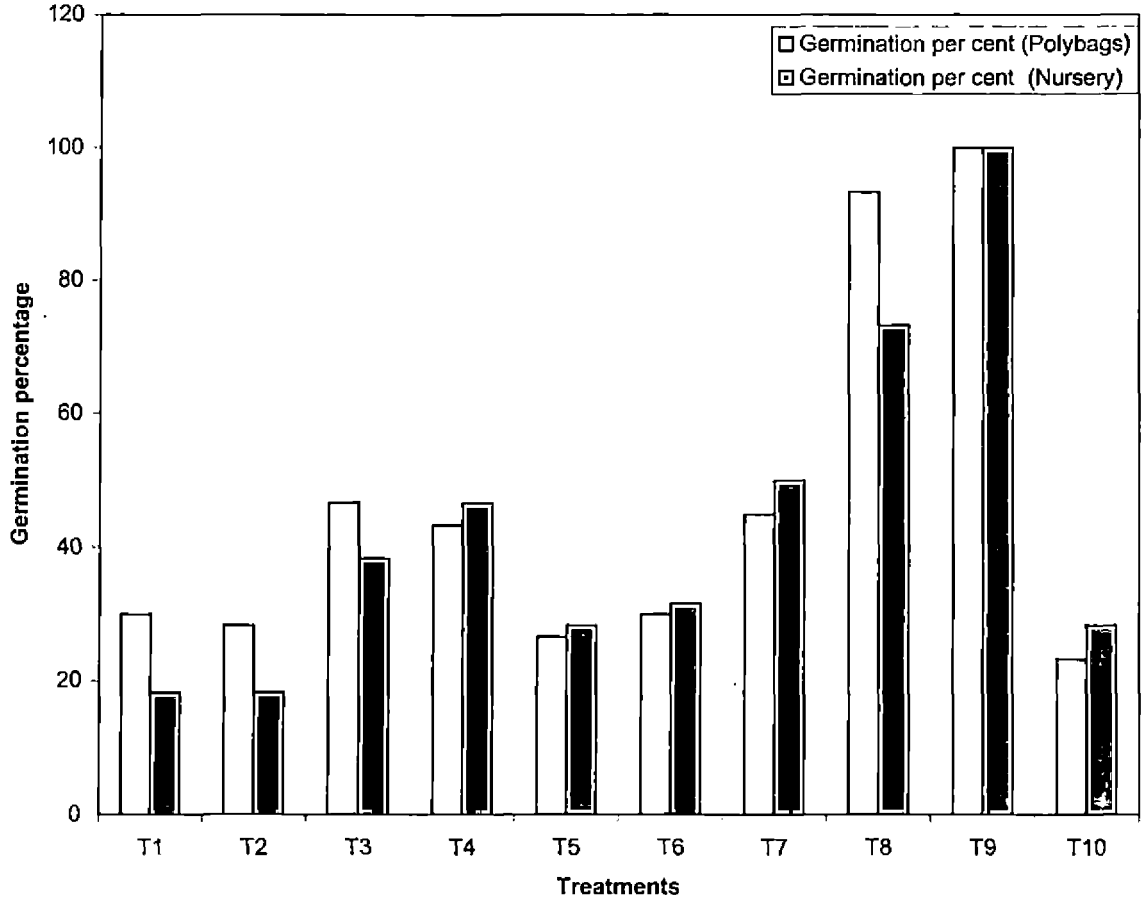

Fig.1. Germination percentage in polybag and nursery bed

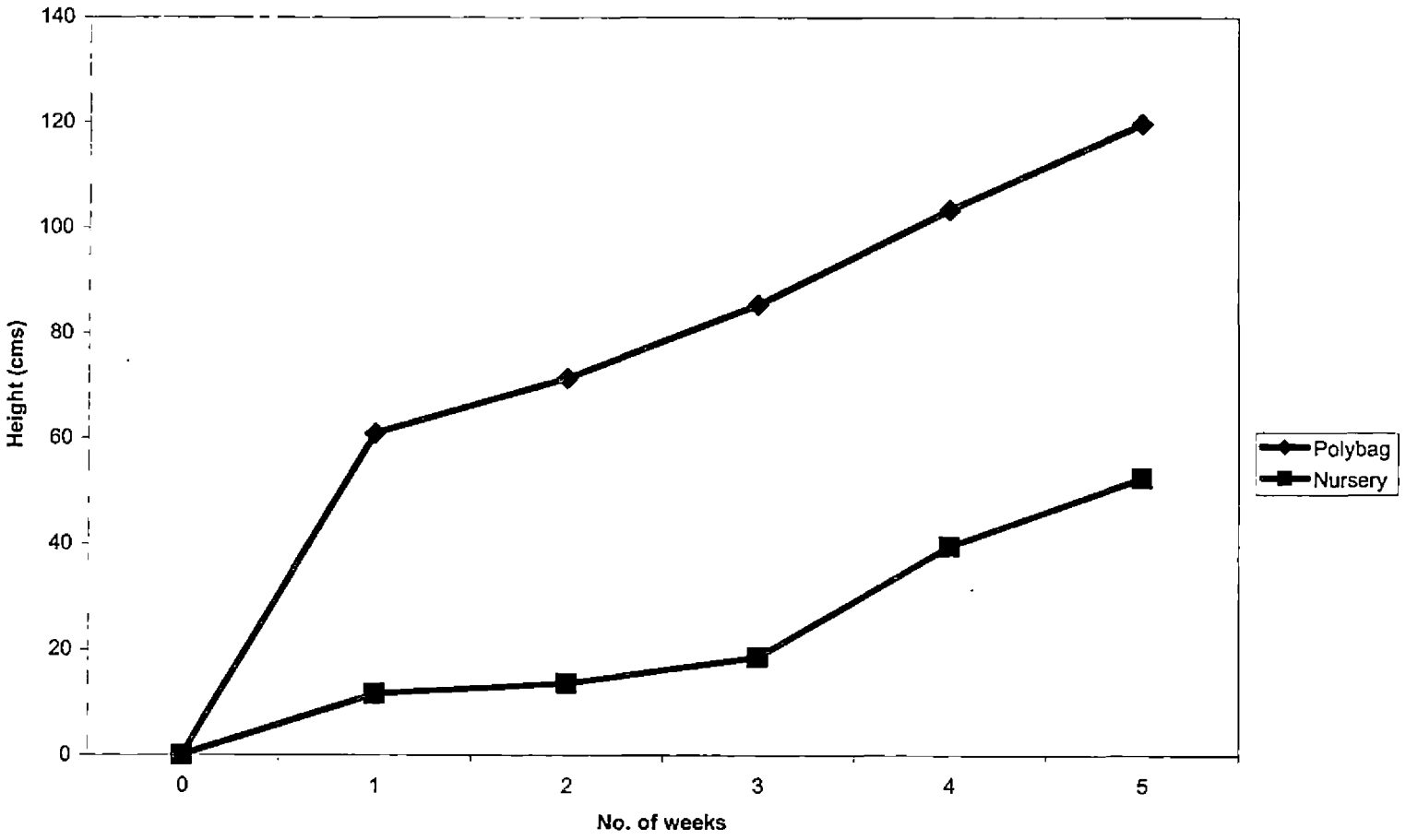

Fig. 2 Rate of growth (height) in polybag and nursery bed

(Soaking seeds in Conc. H_2So_4 for 20 min. followed by 12 hours in cold water) in both the system. The difference between two systems of sowing was high with 61.10 cm for polybag and 11.60 cm for nursery condition respectively (Table 4). Fig.2 shows rate of growth (height) in polybag and nursery bed. Variation in height at second week also followed the same trend as in first week with highest mean for T_9.

Even in the fifth week T_9 gave the highest mean length of 178.33 cm in poly bag and 61.33 cm in nursery bed, followed by T_8 (seeds treated in concentrated H_2So_4 for 20 min.) with 134.33 cm and 55.33 cm for polybags and nursery bed respectively. Untreated seeds (T_{10}) and seeds treated with cold water (T_1) were on par with respect to height at nursery stage. The interaction among different treatments irrespective of sowing system was shown to be significant. (Table 4)

4.1.3.2 Number of leaves

It is evident from the Table 5 that number of leaves under different treatment and two systems varied significantly with higher mean for polybag condition and seedlings obtained by scarified (T_9) which accounted for highest number of leaves. The least number of leaves was noticed in T_2 during the first week of observation.

T_9 accounted the highest number of leaves up to fifth week of observation, with significant difference among treatments as well as between the two systems which is evident by the data furnished in the Table 5 and Fig. 3.

4.1.3.3 Collar Diameter

The observation on collar diameter of seedlings grown in polybag and nursery bed condition showed considerable variation which is statistically proved to be significant with higher mean for seedlings in polybag for all the treatments.(Fig.4). T_9 and T_8 corresponded the highest collar diameter in both polybag and nursery bed without significant difference between them. T_1, T_5, T_8 and T_{10} gave on par results with respect to collar diameter (Table 6).

Table 4. Rate of growth of seedlings in height (cms.) at weekly interval after sowing in nursery stage

Sl. No	TR	1st Week			2nd Week			3rd Week			4th Week			5th Week		
		Polybag	Nursery bed	MEAN	Polybag	Nurserybed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	7.12 (51.33)	2.51 (6.67)	4.81^{e} 29.00	8.08 (65.67)	2.90 (8.67)	5.48^{ed} 37.16	8.91 (79.67)	3.68 (17.67)	6.29^{ed} (46.66)	9.87 (97.67)	5.88 (34.67)	7.87^{ed} (66.16)	10.33 (107.00)	6.90 (47.67)	8.61^{d} (77.33)
2	T_2	7.72 (59.67)	3.27 (10.67)	5.49^{cd} 35.16	8.34 (69.67)	3.56 (12.67)	5.94^{dc} 41.16	9.14 (83.67)	4.20 (13.67)	6.67^{dc} (50.66)	10.08 (101.67)	6.22 (38.67)	8.14^{cd} (70.16)	10.52 (110.67)	7.19 (51.67)	8.85^{cd} (81.16)
3	T_3	7.09 (50.33)	2.82 (8.00)	4.95^{ed} (29.16)	7.76 (60.33)	3.16 (10.00)	5.46^{ed} (35.16)	8.62 (74.33)	3.87 (15.00)	6.24^{ed} (44.66)	9.61 (92.33)	6.00 (36.00)	7.80^{ed} (64.16)	10.50 (110.33)	7.00 (49.00)	8.75^{d} (79.66)
4	T_4	7.19 (51.67)	3.31 (11.00)	5.25^{edc} (31.33)	7.85 (61.67)	3.60 (13.00)	5.72^{ced} (37.33)	8.70 (75.67)	4.24 (18.00)	6.47^{edc} (46.83)	9.68 (93.67)	6.24 (39.00)	7.96^{edc} (66.33)	10.57 (111.67)	7.21 (52.00)	8.88^{cd} (81.83)
5	T_5	8.00 (64.00)	3.31 (11.00)	5.65^{c} (37.50)	8.60 (74.00)	3.60 (13.00)	6.10^{c} (43.50)	9.38 (88.00)	4.24 (18.00)	6.80^{c} (53.00)	10.30 (106.00)	6.24 (39.00)	8.26^{c} (72.50)	11.14 (124.00)	7.21 (52.00)	9.17^{c} (88.00)
6	T_6	6.89 (47.67)	3.96 (15.67)	5.42^{cd} (31.66)	7.59 (57.67)	4.20 (17.67)	5.89^{cd} (37.66)	8.46 (71.67)	4.76 (22.67)	6.61^{de} (47.16)	9.47 (89.67)	6.61 (43.67)	8.03^{cde} (66.66)	10.37 (107.67)	7.53 (56.67)	8.95^{cd} (82.16)
7	T_7	6.92 (48.00)	3.21 (10.33)	5.06^{ed} (29.16)	7.61 (58.00)	3.51 (12.33)	5.56^{ed} (35.16)	8.48 (72.00)	4.16 (17.33)	6.32^{ed} (44.66)	9.49 (90.00)	6.19 (38.33)	7.83^{ed} (64.16)	10.39 (108.00)	7.16 (51.33)	8.77^{d} (79.66)
8	T_8	8.62 (74.33)	3.78 (14.33)	6.19^{b} (44.33)	9.18 (84.33)	4.04 (16.33)	6.60^{b} (50.33)	9.92 (98.33)	4.62 (21.33)	7.26^{b} (59.83)	10.78 (116.33)	6.51 (42.33)	8.64^{b} (79.33)	11.59 (134.33)	7.44 (55.33)	9.51^{b} (94.83)
9	T_9	10.87 (118.33)	4.51 (20.33)	7.68^{a} (69.33)	11.32 (128.33)	4.72 (22.33)	8.02^{a} (75.33)	11.93 (142.33)	5.23 (27.33)	8.57^{a} (84.83)	12.66 (160.33)	6.95 (48.33)	9.80^{a} (104.33)	13.35 (178.33)	7.83 (61.33)	10.59^{a} (119.83)
10	T_{10}	6.69 (45.67)	2.82 (8.00)	4.75^{e} (26.83)	7.41 (55.67)	3.16 (10.00)	5.28^{e} (32.83)	8.31 (69.67)	3.87 (15.00)	6.09^{e} (42.33)	9.34 (87.67)	6.00 (36.00)	7.66^{e} (61.83)	10.26 (105.67)	7.00 (49.00)	8.63^{d} (77.33)
Mean		7.71 (61.10)	3.35 (11.60)		8.38 (71.53)	3.65 (13.60)		9.18 (85.53)	4.29 (18.60)		10.13 (103.53)	6.28 (39.60)		10.90 (119.77)	7.25 (52.60)	
F test			*			*			*			*			*	
CD			0.74			0.65			0.57			0.49			0.45	

Figures with similar letters as superscript do not differ significantly
Original means are given in parenthesis

* Significant at 5 per cent level

Table 5. Variation in number of leaves at weekly interval in seedling stage

Sl. No	TR	1 st Week			2 nd Week			3 rd Week			4 th Week			5 th Week		
		Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	2.51 (6.33)	1.73 (3.00)	2.12 ^{dc} (4.66)	2.26 (8.33)	0.93 (4.00)	2.44 ^{dc} 6.16	3.51 (12.33)	2.65 (7.00)	3.07 ^{dc} (9.66)	4.47 (20.00)	3.61 (13.00)	4.03 ^{cb} (16.5)	5.10 (26.00)	4.12 (17.00)	4.61 ^{fed} (21.50)
2	T_2	2.07 (4.33)	1.73 (3.00)	1.90 ^{e} (3.66)	1.67 (8.33)	0.93 (4.00)	2.25 ^{e} (5.16)	3.21 (10.33)	2.65 (7.00)	2.92 ^{e} (8.66)	4.16 (17.33)	3.61 (13.00)	3.88 ^{e} (15.16)	4.93 (24.33)	4.12 (17.00)	4.52 ^{f} (20.66)
3	T_3	2.50 (6.33)	1.41 (2.00)	1.95^{ed} (4.16)	1.47 (6.33)	0.77 (3.00)	2.30 ^{ed} (5.66)	3.51 (12.33)	2.45 (6.00)	2.97 ^{ed} (9.16)	4.39 (19.33)	3.46 (12.00)	3.92 ^{ed} (15.66)	5.13 (26.33)	4.00 (16.00)	4.56 ^{ef} (21.16)
4	T_4	2.51 (6.33)	2.00 (4.00)	2.25 ^{cb} (5.16)	1.50 (7.67)	1.23 (5.00)	2.56 ^{cb} (6.66)	3.51 (12.33)	2.83 (8.00)	3.16 ^{cb} (10.16)	4.40 (19.33)	3.74 (14.00)	4.06 ^{cb} (16.66)	5.13 (26.33)	4.24 (18.00)	4.68 ^{dcb} (22.16)
5	T_5	2.38 (5.67)	2.24 (5.00)	2.30 ^{b} (5.33)	1.83 (8.33)	1.43 (6.00)	2.60 ^{b} (6.83)	3.41 (11.67)	3.00 (9.00)	3.20 ^{cb} (10.33)	4.32 (18.67)	3.87 (15.00)	4.09 ^{cb} (16.83)	5.07 (25.67)	4.36 (19.00)	4.71 ^{cb} (22.33)
6	T_6	1.73 (3.00)	2.65 (7.00)	2.18 ^{cb} (5.00)	1.40 (5.00)	1.43 (8.00)	2.53 ^{cb} (6.50)	3.00 (9.00)	3.32 (11.00)	3.15 ^{cb} (10.00)	4.00 (16.00)	4.12 (17.00)	4.06 ^{cb} (16.50)	4.80 (23.00)	4.58 (21.00)	4.68 ^{dcb} (22.00)
7	T_7	2.45 (6.00)	1.91 (3.67)	2.18 ^{cb} (4.83)	1.40 (8.00)	1.27 (4.67)	2.49 ^{cb} (6.33)	3.46 (12.00)	2.77 (7.67)	3.11 ^{cb} (9.83)	4.36 (19.00)	3.70 (13.67)	4.02 ^{cbd} (16.33)	5.10 (26.00)	4.20 (17.67)	4.65 ^{edcb} (21.83)
8	T_8	2.70 (7.33)	2.00 (4.00)	2.34 ^{b} (5.66)	1.98 (9.33)	1.33 (5.00)	2.64 ^{b} (7.16)	3.65 (13.33)	2.83 (8.00)	3.23 ^{b} (10.66)	4.51 (20.33)	3.74 (14.00)	4.12 ^{b} (17.16)	5.23 (27.33)	4.24 (18.00)	4.73 ^{b} (22.66)
9	T_9	4.16 (17.33)	2.71 (7.33)	3.43 ^{a} (12.33)	2.27 (19.33)	1.42 (8.33)	3.64 ^{a} (13.83)	4.83 (23.33)	3.37 (11.33)	4.09 ^{a} (17.33)	5.51 (30.33)	4.16 (17.33)	4.83 ^{a} (23.83)	6.11 (37.33)	4.62 (21.33)	5.36 ^{a} (29.33)
10	T_{10}	2.51 (6.33)	1.73 (3.00)	2.12 ^{dc} (4.66)	1.82 (8.33)	1.30 (4.00)	2.44 ^{dc} (6.16)	3.51 (12.33)	2.65 (7.00)	3.07 ^{dc} (9.66)	4.40 (19.33)	3.61 (13.00)	4.00 ^{dc} (16.16)	5.13 (26.33)	4.12 (17.00)	4.62 ^{edc} (21.66)
Mean		2.55 (6.90)	2.01 (4.20)		2.93 (8.90)	2.25 (5.20)		3.56 (12.9)	2.85 (8.2)		4.45 (19.97)	3.76 (14.20)		5.17 (26.87)	4.26 (18.20)	
F test			*			*			*			*			*	
CD			0.23			0.20			0.17			0.14			0.13	

Figures with similar letters as superscript do not differ significantly
Original means are given in parenthesis

Significant at 5 per cent level

Table 6. Variation in collar diameter (cms) at weekly interval in seedling stage

Sl. No		1 st Week (19/04/06)			2 nd Week (26/04/06)			3 rd Week (3/5/2006)			4 th Week (10/5/2006)			5 th (Week 17/5/2006)		
	TR	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	1.36 (1.86)	0.91 (0.83)	1.13 dcb 1.34	1.50 (2.26)	0.96 (0.93)	1.23 cb (1.59)	1.75 (3.06)	1.11 (1.23)	1.42 cb (2.14)	1.83 (3.36)	1.43 (2.03)	1.62 cb (2.69)	1.88 (3.56)	1.49 (2.23)	1.68 cb (2.89)
2	T_2	1.13 (1.27)	0.91 (0.83)	1.01 ef 1.05	1.29 (1.67)	0.96 (0.93)	1.12 ed (1.30)	1.57 (2.47)	1.11 (1.23)	1.34 ed (1.85)	1.66 (2.77)	1.43 (2.03)	1.54 ed (2.40)	1.72 (2.97)	1.49 (2.23)	1.60 ed (2.60)
3	T_3	1.03 (1.07)	0.82 (0.67)	0.92 f (0.86)	1.21 (1.47)	0.88 (0.77)	1.04 e (1.11)	1.50 (2.27)	1.03 (1.07)	1.26 e (1.66)	1.60 (2.57)	1.37 (1.87)	1.48 e (2.21)	1.66 (2.77)	1.44 (2.07)	1.55 e (2.41)
4	T_4	1.05 (1.10)	1.06 (1.13)	1.05 ed (1.11)	1.22 (1.50)	1.11 (1.23)	1.16 dc (1.36)	1.52 (2.30)	1.24 (1.53)	1.37 dc (1.91)	1.61 (2.60)	1.53 (2.33)	1.56 cd (2.46)	1.67 (2.80)	1.59 (2.53)	1.63 dc (2.66)
5	T_5	1.20 (1.43)	1.15 (1.33)	1.17 cba (1.38)	1.35 (1.83)	1.20 (1.43)	1.27 ba (1.63)	1.62 (2.63)	1.32 (1.73)	1.46 ba (2.18)	1.71 (2.93)	1.59 (2.53)	1.65 ba (2.73)	1.77 (3.13)	1.65 (2.73)	1.71 ba (2.93)
6	T_6	1.00 (1.00)	1.15 (1.33)	1.07 ed (1.16)	1.18 (1.40)	1.20 (1.43)	1.18 dcb (1.41)	1.48 (2.20)	1.32 (1.73)	1.39 cbd (1.96)	1.58 (2.50)	1.59 (2.53)	1.58 cbd (2.51)	1.64 (2.70)	1.65 (2.73)	1.64 dcb (2.71)
7	T_7	1.00 (1.00)	1.08 (1.17)	1.03 ed (1.08)	1.18 (1.40)	1.12 (1.27)	1.15 dc (1.33)	1.48 (2.20)	1.25 (1.57)	1.36 cd (1.88)	1.58 (2.50)	1.54 (2.37)	1.55 cd (2.43)	1.64 (2.70)	1.60 (2.57)	1.62 dc (2.63)
8	T_8	1.26 (1.58)	1.11 (1.23)	1.18 ba (1.40)	1.41 (1.98)	1.15 (1.33)	1.28 ba (1.65)	1.67 (2.78)	1.28 (1.63)	1.47 ab (2.20)	1.76 (3.08)	1.56 (2.43)	1.65 ab (2.75)	1.81 (3.28)	1.62 (2.63)	1.71 ba (2.95)
9	T_9	1.37 (1.87)	1.15 (1.32)	1.25 a (1.59)	1.50 (2.27)	1.19 (1.42)	1.34 a (1.84)	1.75 (3.07)	1.31 (1.72)	1.53 a (2.39)	1.83 (3.37)	1.59 (2.52)	1.71 a (2.94)	1.89 (3.57)	1.65 (2.72)	1.76 a (3.14)
10	T_{10}	1.19 (1.42)	1.09 (1.20)	1.14 dcb (1.31)	1.35 (1.82)	1.14 (1.30)	1.24 cb (1.56)	1.62 (2.62)	1.26 (1.60)	1.44 cb (2.14)	1.71 (2.92)	1.55 (2.40)	1.62 cb (2.60)	1.77 (3.12)	1.61 (2.60)	1.68 cb (2.86)
Mean		1.16 (1.36)	1.04 (0.11)		1.32 (1.76)	1.09 (1.21)		1.60 (2.56)	1.22 (1.51)		1.69 (2.86)	1.52 (2.31)		1.75 (3.06)	1.58 (2.51)	
F test			*			*			*			*			*	
CD			0.14			0.13			0.10			0.09			0.09	

Figures with similar letters as superscript do not differ significantly
Original means are given in parenthesis

* Significant at 5 per cent level

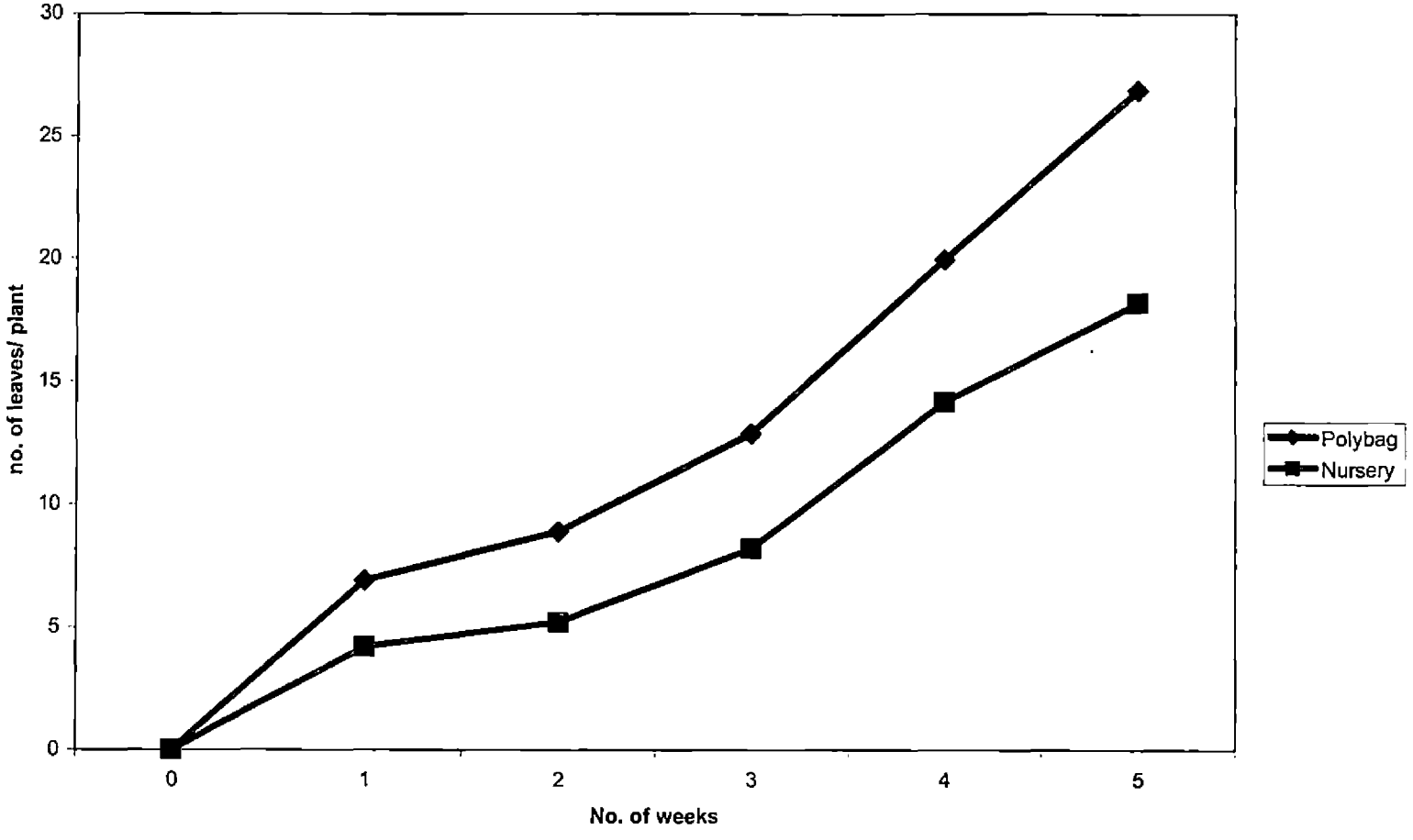

Fig. 3. Variation in number of leaves at weekly interval in seedling stage

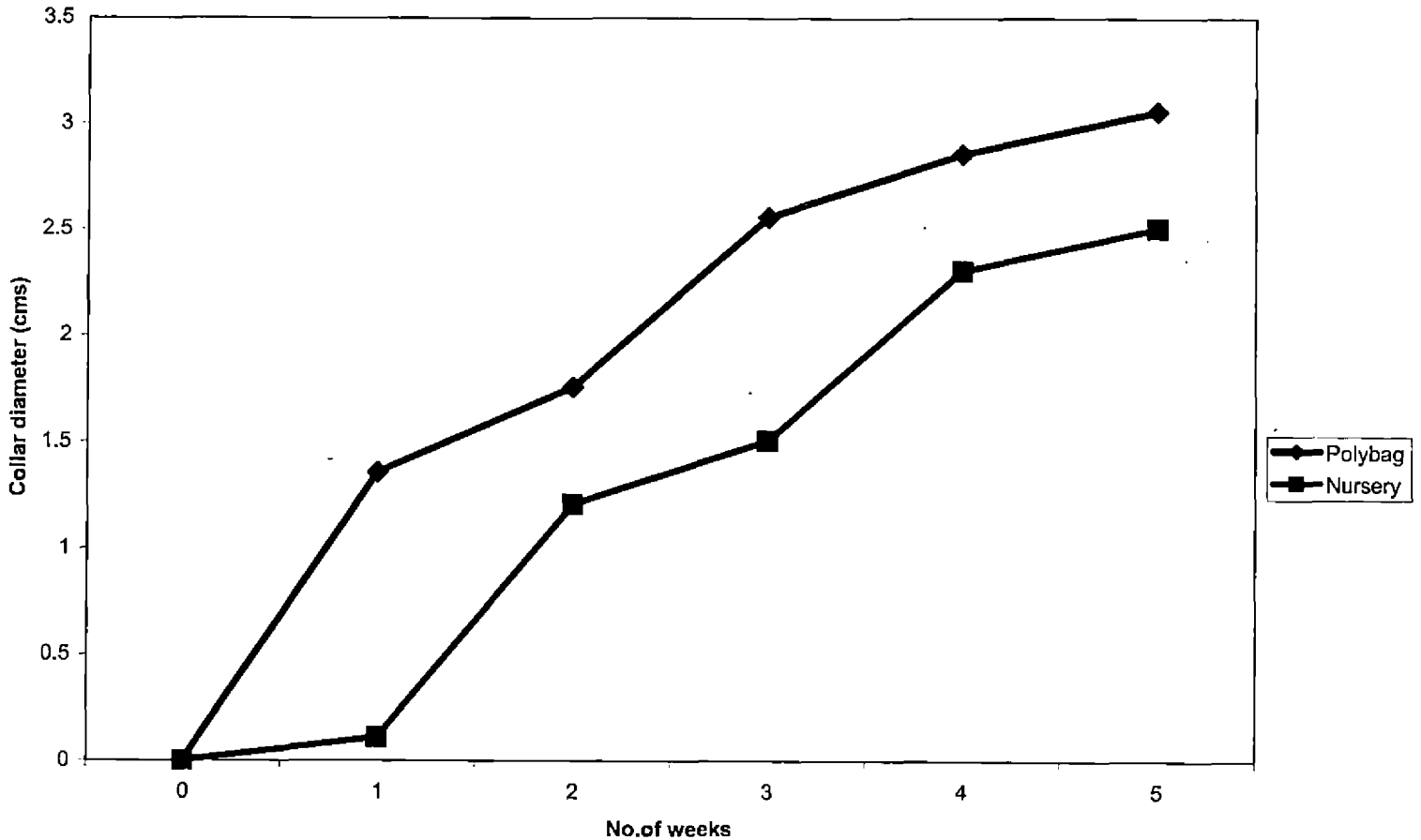

Fig.4. Variation in collar diameter at weekly interval in seedling stage

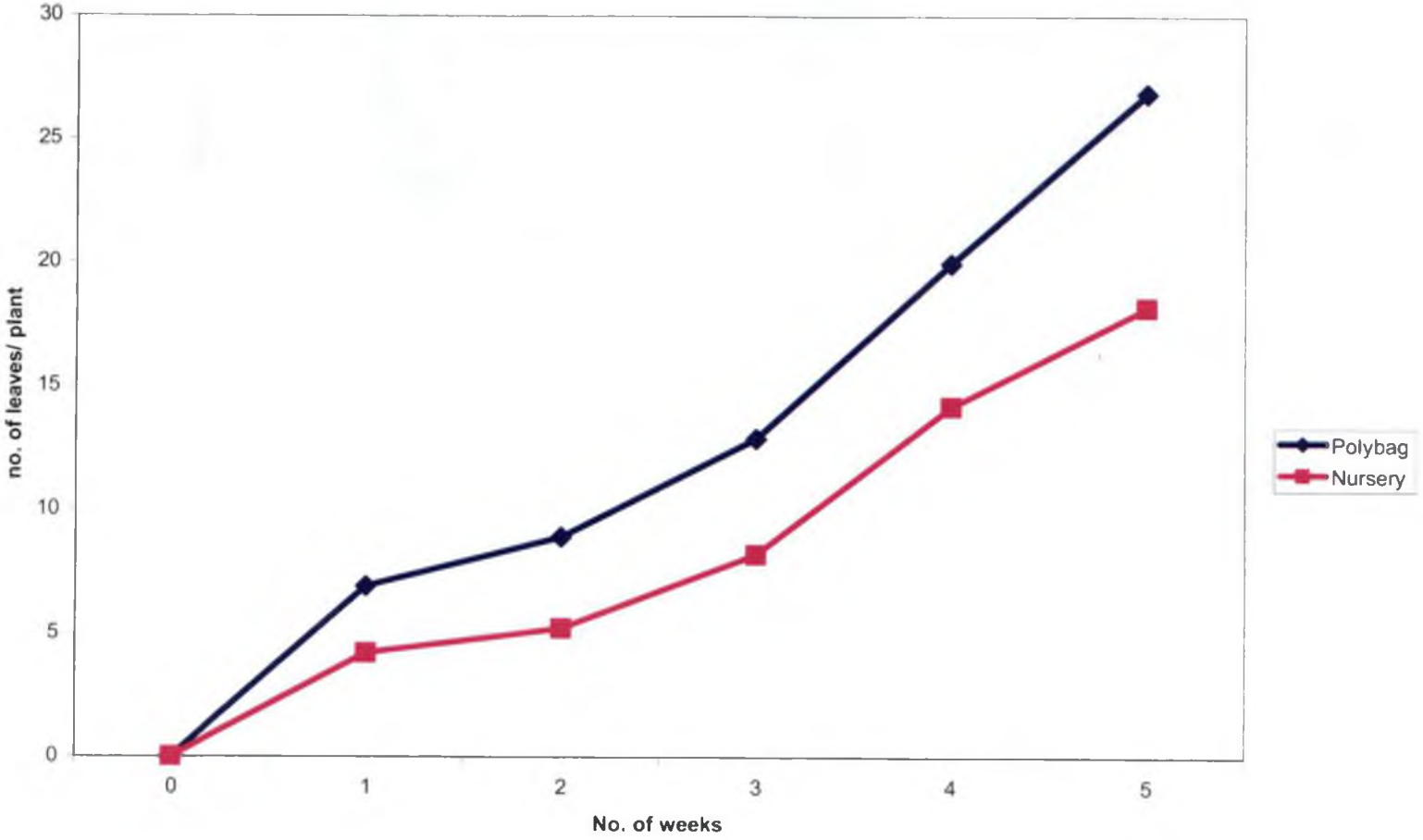

Fig. 3. Variation in number of leaves at weekly interval in seedling stage

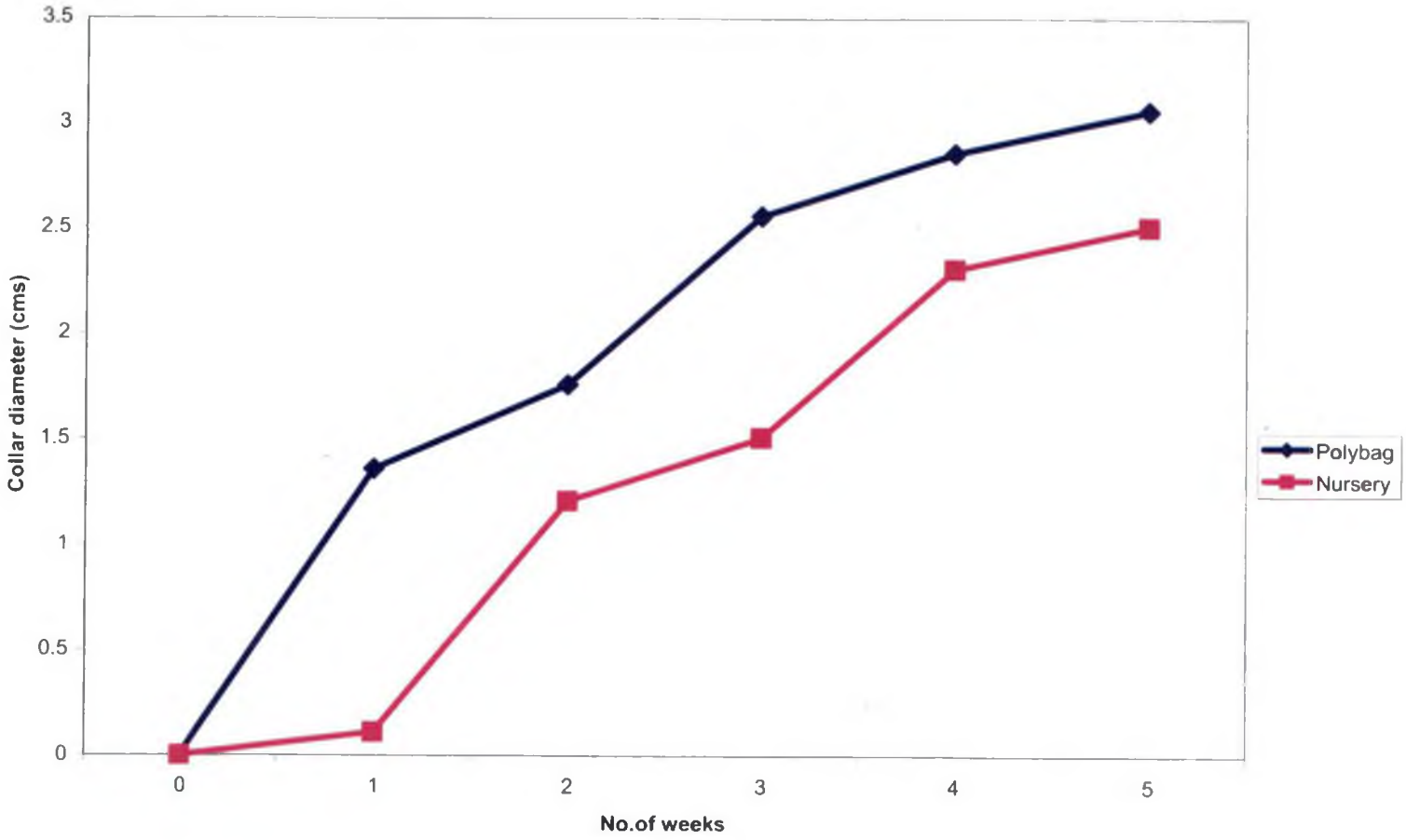

Fig.4. Variation in collar diameter at weekly interval in seedling stage

4.2 Nursery biomass

The study was undertaken to know the effect different per treatments and growing seedlings in polybags and nursery bed on total biomass produced. After five week of sowing, plants were uprooted to know the shoot length, root length, fresh and dry weight of the seedlings.

4.2.1 Shoot length

There was a significant variation among two systems as well as between different pre-treatments Total mean shoot length in polybag condition was 122.93 cm where as for nursery condition it was 105.7 cm with significant difference between them.

In case of seedlings under different per-treatments, highest root length was observed in T_9 in both polybag and nursery bed with 194.00 cm and 173.67 cm respectively and seedlings under untreated seedlings gave the lowest shoot length in both system with 122.93 and 105.57 cm respectively (Table 7). The results of DMRT analysis reviewed that shoot length under T_9 was superior to other treatment, followed by T_8. T_4 and T_2 were having same effect on shoot length (Table 7).

4.2.2 Number of leaves

There exists a significant variation among different condition, i.e., polybag and nursery bed and between different treatments. At the end of five week of nursery study, T_9 gave maximum mean number of leaves of 42.00 and 31.67 respectively for polybag and nursery bed, followed by T_8 with mean number of leaves of 37.33 and 30.00 for polybag and nursery bed respectively. The least no. of leaves was seen in cold water treatment (T_1) in polybag and untreated seeds (T_{10}) in nursery bed (Table 7).

4.2.3 Root length

Data tabulated in Table 7 show the variation of root length under different treatments in polybag and nursery conditions. Significant difference in root length was observed among different system with higher mean of 27.33 cm for polybag and 21.10 cm for nursery bed. Highest root growth was under T_9 followed by T_8 and T_7, least

Table: 7 Mean shoot length root length, leaf length and leaf breadth in nursery stage

Sl. No	TR	Shoot length (cms)			Root length (cms)			No of leaf			Leaf length (cms)			Leaf breadth (cms)		
		Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	9.88 (97.67)	8.98 (80.67)	9.43 ^{f} (89.16)	3.79 (14.33)	3.51 (12.33)	3.64 ^{g} (13.33)	4.20 (17.67)	3.79 (14.33)	3.99 ^{i} (16.00)	2.97 (8.83)	3.12 (9.73)	3.04 ^{c} (9.28)	2.74 (7.50)	2.78 (7.73)	2.75 ^{c} (7.61)
2	T_2	10.21 (104.33)	9.33 (87.00)	9.77 ^{e} (95.66)	4.69 (22.00)	4.32 (18.67)	4.50 ^{e} (20.33)	5.29 (28.00)	4.69 (25.00)	5.14 ^{e} (26.50)	2.79 (7.80)	3.05 (9.30)	2.92 ^{e} (8.55)	2.74 (7.50)	2.77 (7.67)	2.75 ^{c} (7.58)
3	T_3	11.93 (142.33)	11.09 (123.00)	11.51 ^{c} (132.66)	5.23 (27.33)	5.00 (25.00)	5.11 ^{d} (26.16)	5.77 (33.33)	5.23 (29.00)	5.57 ^{c} (31.16)	2.99 (8.97)	3.03 (9.17)	3.01 ^{cd} (9.06)	2.87 (8.27)	2.89 (8.33)	2.88 ^{b} (8.30)
4	T_4	10.00 (100.00)	9.27 (86.00)	9.63 ^{e} (93.00)	4.72 (22.33)	4.24 (18.00)	4.48 ^{e} (20.16)	5.07 (25.67)	4.72 (23.67)	4.96 ^{f} (24.66)	2.92 (8.50)	2.92 (8.50)	2.91 ^{e} (8.50)	2.73 (7.43)	2.71 (7.37)	2.71 ^{c} (7.40)
5	T_5	11.03 (121.67)	10.33 (106.67)	10.67 ^{d} (114.16)	4.80 (23.00)	4.04 (16.33)	4.41 ^{e} (19.66)	5.63 (31.67)	4.80 (28.33)	5.47 ^{e} (30.00)	2.92 (8.53)	2.89 (8.37)	2.90 ^{e} (8.45)	2.72 (7.40)	2.73 (7.47)	2.72 ^{c} (7.43)
6	T_6	9.27 (86.00)	8.14 (66.33)	8.70 ^{g} (76.16)	4.28 (18.33)	3.65 (13.33)	3.96 ^{f} (15.83)	4.93 (24.33)	4.28 (22.33)	4.82 ^{g} (23.33)	2.92 (8.53)	2.90 (8.43)	2.91 ^{e} (8.48)	2.71 (7.33)	2.69 (7.27)	2.70 ^{c} (7.30)
7	T_7	11.93 (142.33)	11.16 (124.67)	11.54 ^{c} (133.5)	5.60 (31.33)	5.13 (26.33)	7.36 ^{c} (28.83)	5.54 (30.67)	5.60 (22.67)	5.14 ^{e} (26.66)	3.03 (9.17)	3.05 (9.30)	3.03 ^{c} (9.23)	2.86 (8.17)	2.89 (8.37)	2.87 ^{b} (8.26)
8	T_8	12.44 (154.67)	11.89 (141.33)	12.16 ^{b} (148.00)	6.90 (47.67)	6.19 (38.33)	6.54 ^{b} (43.00)	6.11 (37.33)	6.90 (30.00)	5.79 ^{b} (33.66)	3.41 (11.63)	3.44 (11.83)	3.42 ^{b} (11.73)	3.25 (10.57)	3.14 (9.83)	3.19 ^{a} (10.20)
9	T_9	13.93 (194.00)	13.18 (173.67)	13.55 ^{a} (183.83)	7.26 (52.67)	6.58 (43.33)	6.91 ^{a} (48.00)	6.48 (42.00)	7.26 (31.67)	6.05 ^{a} (36.83)	3.56 (12.67)	3.60 (13.00)	3.58 ^{a} (12.83)	3.25 (10.57)	3.26 (10.67)	3.25 ^{a} (10.61)
10	T_{10}	9.29 (86.33)	8.14 (66.33)	8.71 ^{g} (76.33)	4.28 (18.33)	3.05 (9.33)	3.66 ^{g} (13.83)	4.04 (16.33)	4.28 (18.33)	4.16 ^{h} (17.33)	2.89 (8.37)	2.98 (8.90)	2.93 ^{ed} (8.63)	2.79 (7.77)	2.71 (7.33)	2.74 ^{c} (7.55)
Mean		10.99 (122.93)	10.15 (105.57)		5.15 (27.73)	4.57 (22.10)		5.31 (28.70)	4.92 (24.53)		3.10 (9.65)	3.04 (9.30)		2.86 (8.25)	2.86 (8.20)	
F test			*			*			*			*			*	
CD			0.20			0.18			0.14			0.12			0.12	

Figures with similar letters as superscript do not differ significantly

Original means are given in parenthesis

* Significant at 5 per cent level

growth of root was seen in T_1 and T_{10} (3.66 and 3.64 cm) which are on par with each other. The interaction for root length between two systems was showed significant.

4.2.4 Fresh weight and dry weight

A perusal of data furnished in Table 8 indicated both fresh weight and dry weight was highest in T_9 for both condition with significant variation between polybag and nursery grown seedlings. Variation among seedlings grown in different per treatment was also showed to be significant. Dry weight and fresh weight in polybag was with higher mean than nursery condition. Fresh and dry weight in T_9 was maximum followed by T_8, where as T_3, T_5 and T_7 were on par with respect to fresh weight and T_1 and T_{10} did not show variation for fresh weight production.

In case of dry matter production (nursery stage) under different conditions was significant (Table 8) in which T_9 had more dry matter production in both polybag and nursery with 29.23 gms and 25.34 gms respectively. It is followed by T_8 and T_3. Whereas T_5, T_6 and T_{10} were showed to be on par with each other in dry matter production.

4.3 Effect of shade on reproductive characters.

The study was conducted to know the effect of shade on yield of *Mucuna pruriens* under four different shade levels was given viz, T_1 - open (0%), T_2 - 25 per cent, T_3 - 50 per cent and T_4 - 75 per cent. The salient results are as follows:

4.3.1 Inflorescence initiation:

The effect of shade levels on duration taken for the formation of flower, pod and maturity of the pod (Plate 7-8) was shown to be significant (Table 9). The highest number of days for inflorescence bud initiation was taken by the seedlings grown under 75 per cent (T_4) shade level, followed by 50 per cent (T_3), 25 per cent (T_2) and least number of days for inflorescence bud initiation was in case of open condition with 153.3 mean days (Fig.5). There was a significant variation in duration between all the treatments.

Table 8. Fresh and dry weight of seedlings grown in polybag and nursery condition

Sl. No	Treatments	Fresh weight (gms)			Dry weight (gms)		
		Polybag	Nursery bed	MEAN	Polybag	Nursery bed	MEAN
1	T_1	4.85 (23.50)	4.36 (19.00)	4.60 ^{f} (21.25)	3.44 (11.80)	2.91 (8.48)	3.17 ^{h} (10.13)
2	T_2	5.37 (28.86)	4.69 (21.97)	5.02 ^{e} (25.41)	3.83 (14.67)	3.36 (11.31)	3.59 ^{f} (12.98)
3	T_3	6.06 (36.81)	5.82 (33.90)	5.94 ^{c} (35.35)	4.42 (19.53)	4.22 (17.82)	4.32 ^{c} (18.68)
4	T_4	4.77 (22.84)	4.46 (19.93)	4.61 ^{f} (21.38)	3.54 (12.50)	3.21 (10.32)	3.37 ^{g} (11.41)
5	T_5	5.96 (35.48)	5.71 (32.63)	5.83 ^{c} (34.05)	4.13 (17.03)	3.75 (14.04)	3.93 ^{e} (15.53)
6	T_6	5.58 (31.14)	5.38 (28.97)	5.48 ^{d} (30.05)	4.02 (16.13)	3.99 (15.90)	4.00 ^{e} (16.01)
7	T_7	6.37 (40.67)	5.61 (31.43)	5.98 ^{c} (36.05)	4.38 (19.20)	3.92 (15.36)	4.15 ^{d} (17.28)
8	T_8	7.10 (50.35)	6.78 (46.00)	6.93 ^{b} (48.16)	5.02 (25.23)	4.67 (21.81)	4.84 ^{b} (23.51)
9	T_9	7.61 (58.13)	7.00 (48.93)	7.30 ^{a} (53.53)	5.41 (29.23)	5.03 (25.34)	5.22 ^{a} (27.28)
10	T_{10}	4.87 (23.77)	4.26 (18.17)	4.50 ^{f} (20.96)	3.96 (15.83)	3.97 (15.73)	3.96 ^{e} (15.78)
Mean		5.85 (35.15)	5.41 (30.09)		4.21 (18.12)	3.90 (15.61)	
CD		0.27			0.20		
F test		*			*		

Figures with similar letters as superscript do not differ significantly
Original means are given in parenthesis

* Significant at 5 per cent level

Plate 7. Different stages of reproductive phase

4.3. 2 Days taken for flowering

Duration for flower initiation significantly differed among shade levels. Lowest duration was seen for open condition (158.33 days) and highest for 75 per cent shade level (226.66 days) (Table 9).

Total number of buds (Plate 4) in the inflorescence was observed and time taken for 50 per cent of the bud to form flowers was noted and it is taken as duration for 50 per cent flowering in which there was a faster formation of flowers from bud in T_1 when compared to all other shade levels i.e. 172 days for open condition, 184.33 for T_2, 216 for T_3 and 238.33 the highest for T_4 (Table 9 and Fig.5).was observed.

4.3.3 Pod formation

Time taken for the formation (Plate 7-6) of pods by the seedlings under different shade levels varied significantly which is evident in Table 9. Least number of days was taken by seedlings drawn in open condition followed by 25 per cent (198), 50 per cent (233.33) and the highest for 75 per cent (254.33).

Same trend as pod formation was seen with respect to maturity, 205.66 for 0 per cent level and 265.66 for 75 per cent with significant variation. (Table 9 and Fig.5). The effect of shade on number of flower buds per inflorescence was proved to be statistically significant among open and 25 per cent shade levels, where as in seedlings under 50 per cent and 75 per cent were on par with each other. Highest number of buds in single inflorescence was seen in T_1 (Table 10).

Conversion of buds into flower in different shade condition varied significantly with highest number of conversion seen in open condition and all other treatments were with same effect for the trait.

Number of flowers converting into fruits (pod) under different shade also differed among T_1 and T_2 but similar effect was seen under T_3 and T_4. Highest number of pod formation per inflorescence was seen in open condition, 25 per cent shade level. Number

Table 9. Number of days taken for the production of reproductive structures under different shade levels

Sl. No	Treatments	Inflorescence initiation (days)	Flowering (days)	50% flowering (days)	Pod formation (days)	Maturity of pods(days)
1	T_1	12.38 [d] (153.30)	12.58 [d] (158.33)	13.11 [d] (172.00)	13.32 [d] (177.67)	14.34 [d] (205.66)
2	T_2	12.09 [c] (166.66)	13.26 [c] (176)	13.57 [c] (184.33)	14.07 [c] (198.00)	15.05 [c] (226.66)
3	T_3	13.9 [b] (193.33)	14.51 [b] (210.66)	14.71 [b] (216.66)	15.27 [b] (233.33)	16.09 [b] (259.00)
4	T_4	14.48 [a] (210.00)	15.05 [a] (226.66)	15.43 [a] (238.33)	15.94 [a] (254.33)	16.29 [a] (265.66)
F test		*	*	*	*	*

Figures with similar letters as superscript do not differ significantly
* Significant at 5 per cent level
Original means are given in parenthesis

Table 10. Effect of shade on flower and pod formation

Sl. No	Treatments	Number of flower buds per inflorescence	Number of flowers per inflorescence	Number of pods per inflorescence	Number of seeds per pod	Number of pods per plant	Number of leaf per plant
1	T_1	5.79 [a] (33.66)	4.96 [a] (24.66)	3.54 [a] (12.66)	3.1 [a] (9.66)	5.32 [a] (28.33)	24.21 [a] (586.66)
2	T_2	5.31 [b] (28.33)	4.23 [b] (18.00)	2.94 [b] (8.66)	3.05 [a] (9.33)	4.96 [b] (24.66)	20.59 [b] (424.66)
3	T_3	4.57 [c] (21.00)	4.15 [b] (17.33)	2.3 [c] (5.33)	2.64 [b] (7.00)	4.07 [c] (16.66)	17.36 [c] (302.33)
4	T_4	4.31 [c] (18.66)	3.78 [b] (14.33)	1.9 [c] (3.66)	2.44 [b] (6.00)	3.6 [d] (13.00)	12.1 [d] (146.66)
F test		*	*	*	*	*	*

Figures with similar letters as superscript do not differ significantly
* Significant at 5 per cent level
Original means are given in parenthesis

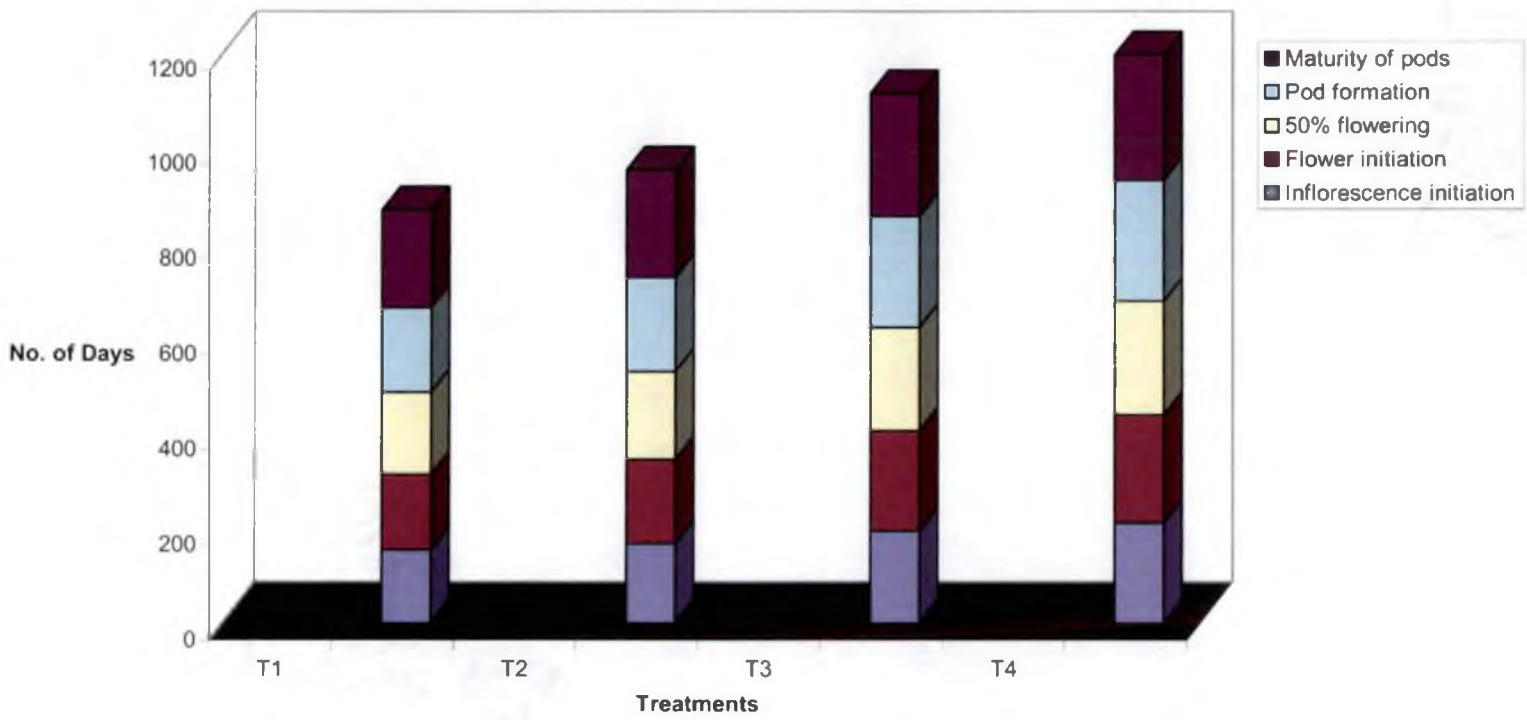

Fig.5. Duration for production of reproductive structures under different shade levels

of seeds per pod was evaluated in which open and 25 per cent shade level gave results which are similar but there was a significant variation between T1 and T3, T1 and T_4, T_2 and T_3 and T_2 and T_4 but in seedlings under 75 per cent and 50 per cent, there was no variation with respect to trait.

Number of pods per plants was evaluated in which seedlings under different shade varied with respect to number of pods and it is shown to be significant statistically.

4.3. 4 Number of leaves per plant

Highest number of leaf production was noticed in open condition followed by 25 per cent and 50 per cent shade conditions. Least number of leaves per plant was observed in 75 per cent shaded plants. All the treatments were significantly varied for number of leaf production.

4.3. 5 Effect of shade on pod character

Influence of shade on pod characters like length, girth, number of pods, fresh weight and dry weight were studied which is depicted in Table 11.

With respect to pod length there was no significant difference between seedlings grown under T_1 and T_2. Similarly there was no difference between T_3 and T_4 but there was significant variation between T_1 and T_3, T_1 and T_4, T_2 and T_3, T_2 and T_4. Variation with respect to pod girth followed similarly as in case of pod length that is there was no difference between T_1 and T_2, T_3 and T_4 (Table 11).

In case of fresh weight and dry weight under different shade levels followed the similar pattern, in which there was significant difference between pods in open condition and other treatments but it is evident from the Table 11 that there is no variation among pods in T_2, T_3, and T_4 with respect to both the trait (fresh weight and dry weight).

There was a significant difference among treatments for number of pods per plant with higher mean for T_1 (28.33) followed by T_2 (24.66) and T_3 (16.66). Least number of pods per plant was noticed in 75 per cent shade (13.00) (Table 11).

Table 11. Effect of shade levels on pod characters

Sl. No	Treatments	Pod length (cms)	Pod fresh weight (gms)	Pod dry weight (gms)	Pod girth (cms)	No of pods/ plant
1	T_1	3.03 [a] (9.20)	4.95 [a] (24.56)	3.88 [a] (15.16)	1.95 [a] (3.83)	5.32 [a] (28.33)
2	T_2	2.99 [a] (8.96)	4.48 [b] (20.13)	3.21 [b] (10.33)	1.93 [a] (3.73)	4.96 [b] (24.66)
3	T_3	2.56 [b] (6.60)	4.29 [b] (18.50)	2.94 [b] (8.66)	1.71 [b] (2.93)	4.07 [c] (16.66)
4	T_4	2.46 [b] (6.06)	4.25 [b] (18.06)	2.89 [b] (8.36)	1.69 [b] (2.86)	3.6 [d] (13.00)
F test		*	*	*	*	*

Figures with similar letters as superscript do not differ significantly
* Significant at 5 per cent level
Original means are given in parenthesis

4.4 Effect of shade on biomass

4.4.1 Leaf biomass

With respect to leaf biomass it was observed that significant variation exist among treatments with highest leaf biomass of 714.66 in open condition. In case of 25 per cent shade level leaf biomass was 580.66 gms followed by 393.66 gms and 283.38 gms in 50 per cent shade and 75 per cent shade respectively (Fig.6 and Plate 1 to 4).

4.4.2 Twig weight

Highest twig biomass was observed in open condition followed by 25 per cent, 50 per cent and 75 per cent. All the treatments varied significantly, which is evident from the data furnished in Table 12 (Plate 1 to 4).

4.4.3 Root weight and root length

Root biomass is observed from the Table 11 that highest root biomass and dry weight was accumulated in highest shaded seedlings that is 75 per cent shade followed by 50 per cent, and 25 per cent and least root biomass production was in open condition. Variation between T_3 and T_4 differed significantly. Similar the case with T_1 and T_2. Root length followed similar pattern as root weight (Table 12).

4.4.4 Seed weight/yield

It is evident from the data furnished in Table 12 that there was significant variation among different treatments with respect to seed yield. Highest mean was seen in open condition followed by 25 per cent shade and 50 per cent. Lowest seed yield per plant was seen in 75 per cent shaded level.

4.4.5 Total biomass

Data furnished in Table 12 indicated that in *Mucuna pruriens*, there was significant effect of shade on total biomass production. At the end of this study, maximum biomass was produced by the seedlings grown in T_1 (open condition) followed

Table 12. Effect of shade levels on biomass production and seed yield per plant

Sl. No	Treatments	Leaf weight (gms)	Twig weight (gms)	Root weight (gms)	Root length (Cms)	Seed weight (gms)	Total biomass (gms)
1	T_1	26.72 [a] (714.66)	48.75 [a] (2376.60)	9.84 [c] (97.00)	8.48 [c] (72.00)	22.50 [a] (506.40)	59.97 [a] (3597.66)
2	T_2	24.09 [b] (580.66)	40.29 [b] (1623.7)	12.29 [b] (151.30)	9.74 [b] (95.00)	18.31 [b] (335.34)	51.87 [b] (2691.00)
3	T_3	19.84 [c] (393.66)	25.84 [c] (667.66)	13.66 [a] (186.70)	11.81 [a] (139.66)	9.34 [c] (187.30)	38.63 [c] (1492.66)
4	T_4	16.83 [d] (283.38)	19.95 [d] (398.33)	14.38 [a] (207.00)	12.03 [a] (145.33)	8.66 [d] (74.95)	31.04 [d] (963.66)
F test		*	*	*	*	*	*

Figures with similar letters as superscript do not differ significantly
* Significant at 5 per cent level
Original means are given in parenthesis

Fig.6. Effect of shade on allocation of biomass

by T_2 (25%) and T_3 (50%). The lowest total biomass of 963.66 gms per plant was observed in seedlings grown in 75 per cent shade level (Fig.6).

4.5 Effect of shade on nutrient content

4.5.1 Nitrogen

The effect of shade on nitrogen content in leaf, twig, and root is given in Table 13. The seedlings grown in 75 per cent shade recorded the maximum concentration of nitrogen for all the parts followed by seedlings grown in T_3 for leaf and twig whereas for roots concentration of nitrogen under 75 per cent shade and 50 per cent shade were on par with each other (Table 13; Fig.7). Concentration of nitrogen in plants of open and 25 per cent shade levels were non-significant.

4.5.2 Phosphorus

There was significant variation between treatments with regard to phosphorus concentration. In case of leaf phosphorus content, highest concentration was seen in seedlings grown under 25 per cent shade followed by seedlings in open condition. Where as phosphorus concentration in leaves of 50 per cent and 75 percent treatment was onpar with each other (Fig. 8).

P content in twigs also varied among shade levels, with highest and least in 25 per cent and 50 percent respectively.

In root, maximum concentration was in open condition and 25 per cent without significant difference between them. Lower in case of plants under 50 and 75 per cent shade levels (Table 13).

4.5.3 Potassium

There was significant variation in potassium content in various parts of the plants under different shade levels. In case of leaf, highest potassium content concentration was in 75 per cent shade followed by 50 per cent (Fig.9) and there was no variation in leaf potassium content in plants of T_1 and T_2. (Table 13)

Root potassium content under various treatments differed significantly between treatments in which concentration of potassium under 50 per cent and 75 per cent was similar and higher than other two treatments. T_1 and T_2 grown plants, potassium concentration in roots were on par with each other (Table 13).

Among various nutrients nitrogen constituted the highest followed by potassium and phosphorous respectively in all treatments for leaves. Similar trend was noticed for twigs and root for all treatments (Table 13).

Table 13. Effect of shade levels on nutrient content in different parts of plant

Sl. No	Treatments	Nitrogen %			Phosphorous %			Potassium %		
		Leaf	Twig	Root	Leaf	Twig	Root	Leaf	Twig	Root
1	T_1	1.37 ^{c} (1.90)	1.03 ^{b} (1.07)	0.74 ^{b} (0.552)	0.55 ^{b} (0.31)	0.36 ^{b} (0.13)	0.30 ^{a} (0.09)	1.14 ^{c} (1.32)	0.70 ^{b} (0.49)	0.62 ^{b} (0.38)
2	T_2	1.37 ^{c} (1.90)	0.84 ^{c} (0.709)	0.74 ^{b} (0.552)	0.61 ^{a} (0.38)	0.40 ^{a} (0.16)	0.30 ^{a} (0.09)	1.14 ^{c} (1.32)	0.70 ^{b} (0.49)	0.62 ^{b} (0.38)
3	T_3	1.5 ^{b} (2.30)	0.98 ^{b} (0.98)	0.84 ^{a} (0.7)	0.49 ^{c} (0.25)	0.3 ^{c} (0.10)	0.27 ^{b} (0.07)	1.40 ^{b} (1.98)	0.70 ^{b} (0.68)	0.70 ^{a} (0.49)
4	T_4	1.7 ^{a} (2.90)	1.02 ^{a} (1.11)	0.84 ^{a} (0.7)	0.49 ^{c} (0.25)	0.36 ^{b} (0.13)	0.27 ^{b} (0.07)	1.42 ^{a} (2.01)	0.88 ^{a} (0.77)	0.70 ^{a} (0.49)
F test		*	*	*	*	*	*	*	*	*

Figures with similar letters as superscript do not differ significantly
* Significant at 5 per cent level
Original means are given in parenthesis

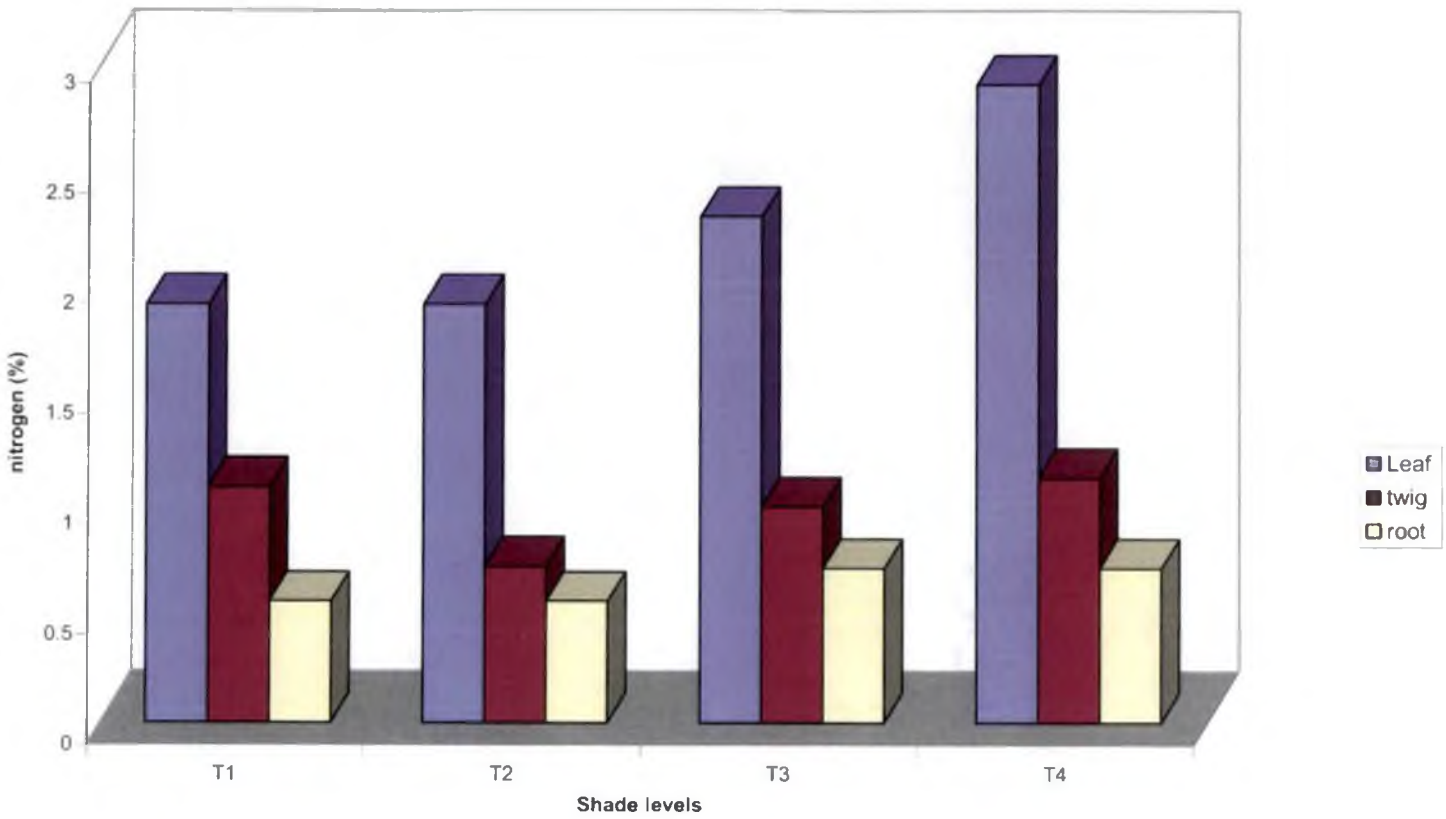

Fig.7. Effect of shade on nitrogen content

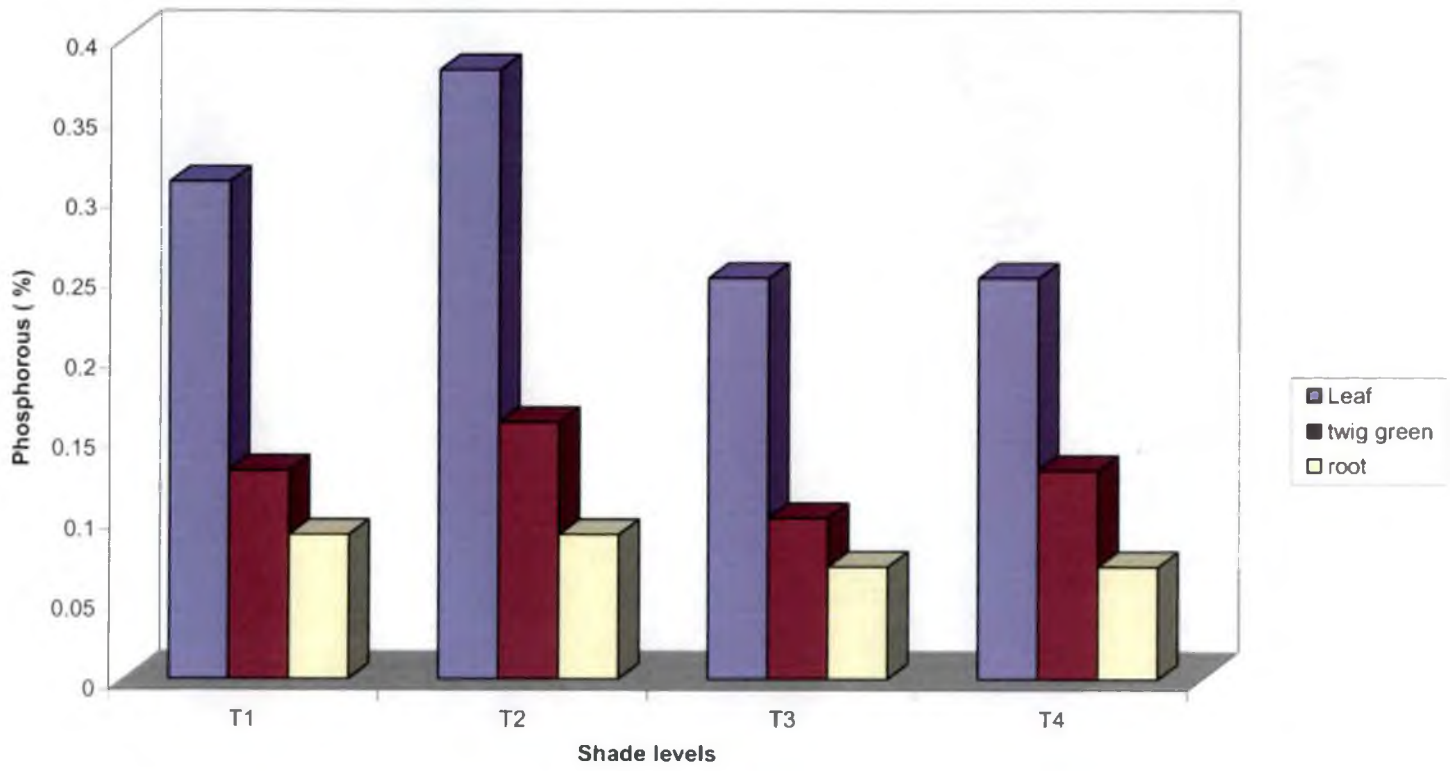

Fig.8 Effect of shade on Phosphorous concentration

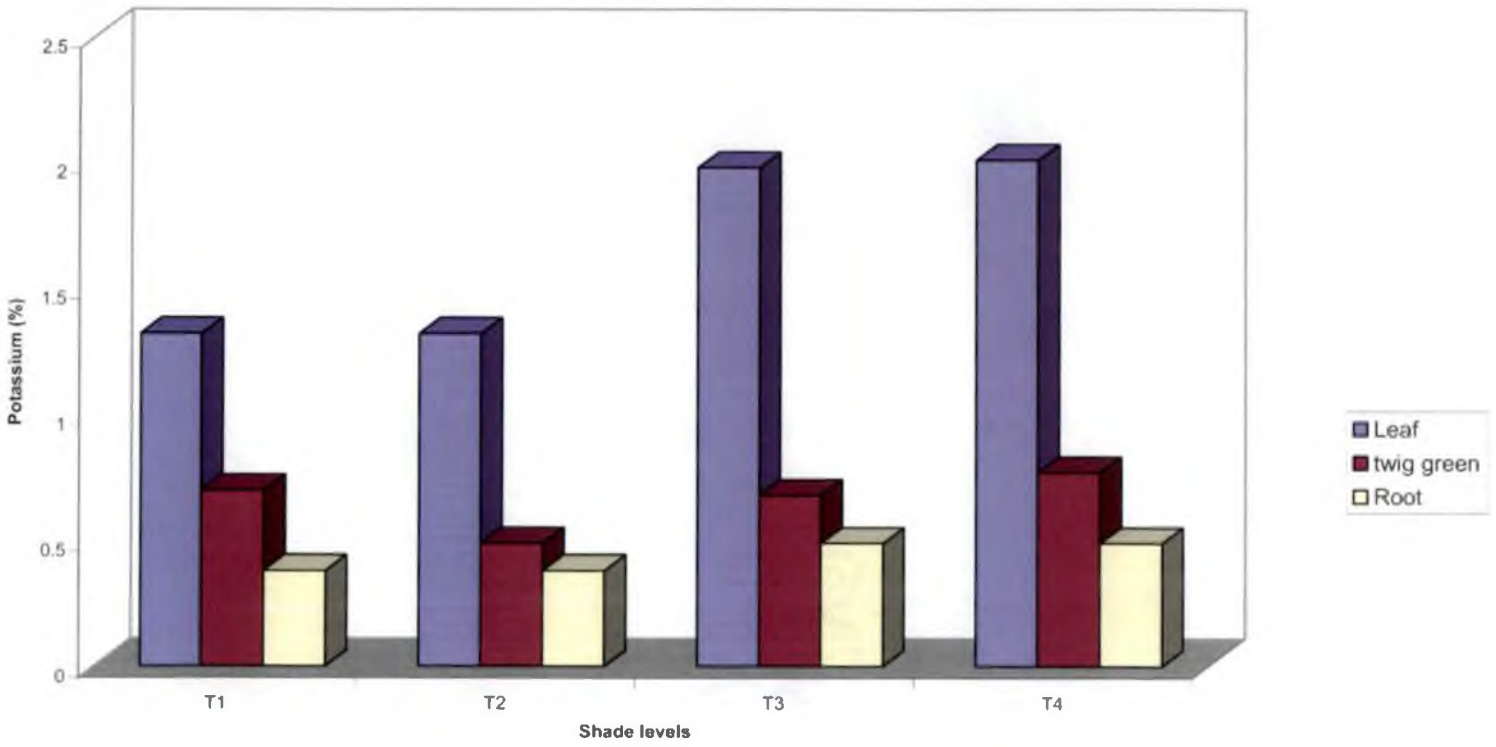

Fig.9 Effect of shade on potassium concentration

Discussion

DISCUSSION

5.1 Nursery studies

Seeds of various species fail to germinate when placed even under conditions like adequate water supply. Most of the legumes species are reported to exhibit some amount of dormancy (Adeola and Dada, 1986). Presence of dormancy leads to delayed and staggered germination. In the past years there has been an attempt to reveal the mechanisms controlling germination of seeds, Hence the present study was conducted to know the information about the effect of pre-sowing treatment on germination and seedling growth of *Mucuna pruriens* (L.)DC.

5.1.1 Pre treatment and germination

The highest germination per cent was in case of T_9 (Scarification by rubbing the dorsal surface of seeds against hard rough cement surface or by using sand paper) in both the condition of polybag and nursery bed. This method has been found appropriate for large leguminous seeds (Seeber and Agpaca, 1976). Saud and Bhorali (1998) evaluated seventeen indigenous cultivars of *Lablab purpureus* for different quantitative and qualitative characters in which for increased germination scarification was recommended. Similar results was obtained by Onyekwelu (1990) in *Tetrapleura tetraptera* after rubbing seeds between two rough surfaces of sand paper for three minutes which gave 100 per cent germination.

Seeds germination up to 80-95 per cent was obtained with sand paper scarification for *Abelmoschus moschatus, Abrus precatorius, Cardiospermum halicacabum, Cassia spp.,* and *Withania coagulans*; acid scarification for *Abrus precatorius, Argyreia nervosa, Bixa orellana, Helicteres isora* and *Indigofera tinctoria*; cutting/piercing the seed coat for *Acacia concinna, Aegle marmelos,*

Caesalpinia spp., Mucuna pruriens and *Rubia cordifolia*; presoaking of seeds for *Argemone mexicana, Randia dumetorum* and *Rauvolfia serpentina* (Veena, 2003)

In the present study, soaking seeds in Conc. H_2So_4 for 20 min. followed by 12 hours in cold water gave 93 per cent germination (Willan, 1985). Yogeesha and Shivananda (2003) in *Mucuna pruriens* (L.)DC. found that the germination of seeds treated with sulphuric acid increased with the increase in the duration of soaking (86% germination with soaking for 90 minutes). Rai (1978) reported significant increase in the germination of *Albizia falcate* and *Albizia chinensis* and *Albizia richardiana*. Priming with polyethylene glycol or scarification with concentrated sulphuric acid both significantly enhanced germination of *Mucuna flagellipes* (Asiegbu, 2006).

The result in the present study may be attributed to the increased absorption of moisture when hard seed coat is removed by mechanical or chemical scarification. Stilinovic and Grabic (1988) concluded that increased germination is due to more effectiveness in breaking seed dormancy due to hard seed coat. This method has been found appropriate for large leguminous seeds (Seeber and Agpaca, 1976).

5.1.2 Growth parameters

Different growth parameters like height of seedlings, number of leaves and collar diameter were highest in case of seedlings obtained from mechanically scarified seeds (T_9) in both the cases of sowing system (polybag and nursery bed). This is in accordance with findings obtained by various workers (Bose, 1963; Eidman, 1988; Joshi and Kelkar, 1970; Langdon, 1974 and Mercy, 1981). It is proved that seed germination influences the early seedling growth, hence the findings obtained in the present study (high growth parameters in T_9) may be attributed to early seed germination or higher germination energy in T_9.

5.2 Nursery biomass

Biomass parameters like shoot and root weight were analysed and it was higher in treatments which germinated faster (T_9). A study was carried out by Gopikumar and Mahato (1993) to study the germination percentage and biometric parameters of 10 species. They noticed that the seed with good germination per cent had better shoot and root growth, in the study *Ceiba pentandra* with 86 per cent germination had good root growth and shoot growth compared, in the present study also, this difference can be attributed to benefit by early seed germination.

As the seed coat is removed by rubbing against hard surface, it increased the uptake of moisture (water) by the embryo for better growth. Seed germination at the better beginning of the favorable season gives the maximum length of time for establishment for any plant species (Baskin and Baskin, 1972) In general seedlings obtained from the first week germinates recorded the maximum height, more number of leaves, high collar diameter and total biomass. Vasquez and Salazar (1999) reveled similar results in teak.

5.3 Effect of shade on reproductive parameters

Light is one of the inevitable and most dominant factors affecting the plant growth and life activities. Role of light in photo assimilation forms the basis of plant growth and development. Light availability is known to be the dominant resource limiting plant growth, as is evident from the work done on various commercial crops. It is a well established fact that plant species behave differently to the effect of light and shade.

As *Mucuna pruriens* (L.)DC. can be used as a potential cover crop and for rehabilitation of degraded sites, it can be selected based on its acclimatization potential to different light levels. Light availability is an important factor in making a plant community and it is an important factor to be considered for commercial exploitation of useful species. Number of research is going on to understand the effect of various intensities of light or shade on the growth and productivity of many plants. However systematic works on *Mucuna Pruriens* which has multiple uses is very scanty. Hence the present study was taken up to ascertain the effect of varying intensity of light.

The salient findings of the studies are discussed here under:

5.3.1 Inflorescence initiation:

Duration for bud initiation is of due importance as it affects the total yield per plant, in the present experiment least number of days taken for bud initiation was in open condition, this is in compromise with results obtained in cow pea by Gourley (1998). Variability in many of the economic characters in *Lablab purpureus* had been observed by many workers like Nayar (1982), Biju (2000), Singh *et al.* (2004) and Singh and Singh (2006).

5.3.2 Days for flowering

In full sunlight flower initiation took lowest number of days. Duggar (1993) unveiled that process of flower bud differentiation and initiation is effected by intensity of light, and stated that plants exposed to partial shaded condition delayed process of flowering considerably. In cowpea 50 per cent and 75 per cent shad lowered the production of flower (Kaname and Tagi, 1970). Fretz and Dunham (1971) reported reduction of flowering in *Ilex opacal* in shade when compared to open condition.

The intensity of light effects flowering in two ways; effect of bud sprouting is related mainly to red: far red ratio while the effect on flower development is related mainly to photon flux density (Fretz & Dunham, 1971).

Significant differences among the genotypes for the characters such as plant height, plant spread, number of primary branches, leaf length, leaf width, pedicel length, days to1st flowering, days to 50 per cent flowering, pod setting per cent, pod length, pod girth, pod thickness, pod weight, number of seeds pod per pod, number of pods plant^{-1}, yield plot^{-1}, 100 seed weight, shelling per cent, crude fibre and crude protein had been observed by many workers like Nayar (1982), Biju (2000), Singh *et al.* (2004) and Singh and Singh (2006) in *Lablab purpureus* (hyacinth bean).

5.3.3 Pod yield

Pod yield was positively correlated with light intensity in the present study. which is also recorded by Sunitha (1996) in *Mucuna pruriens* in evaluation of some leguminous medicinal plant, in which the yield of pod in terms of fresh weight and dry weight was higher in open condition, and among other plants *Mucuna pruriens* gave highest pod yield. (Nayar, 1982; Biju, 2000; Singh *et al.* 2004; Singh and Singh, 2006).

5.3.4 Effect of shade on biomass

Number of leaves and its weight was highest in 0 % shade level in the present study, this is in confirmation with Sunith (1996) in which *Mucuna pruriens* produced maximum leaves under open condition.

Higher biomass accumulation was in full sunlight out of all other treatments, Sunitha (1996) studied on different herbaceous leguminous medicinal plant species in which biomass yield is significantly superior under open condition in *Abrus*

precatorius, Clitoria ternatea, Crotalaria verrucosa and *Atylosia scarabaeodes* than under shade.

Twig biomass was highest in open condition when compared with other treatments. Effect on shade levels on shoot growth varies with the nature of species. In *Azadirachta indica* highest shoot growth was recorded under full sunlight as reported by Vimal (1993).

Data related to root growth parameter, viz, length and height showed negative relation with sunlight. Root yield was more in 75 per cent shaded condition in which light intensity was inversely proportional to root biomass; this is in agreement with Sunitha (1996) where root biomass was superior under shade for *Mucuna pruriens*.

Maximum development of shoots was in full shaded condition results were obtained by Barment (1989) in *Pinus* species. The higher root growth, when grown under full shaded conditions may be due to higher allocation of biomass due to stress or limiting light (Reich *et al.* 1998). Lyapora and Palashev (1982) in *Tilia tomentose* and Pathak *et al.* (1983) in *Lucaena leucocephala* have observed higher biomass when grown under shaded condition.

Total biomass was highest in open condition in *Mucuna pruriens* in the present study. However, in *Hibiscus syriacus* more biomass were obtained when grown under shaded condition. (Yoo and Kim, 1997). Here high biomass in open condition may be due to high growth rate in open condition and availability of light increased the photosynthetic production and total biomass.

5.4 Effect of shade on nutrient content

In the species, the treatments were seen to exert significant effect on nitrogen, phosphorus and potassium. Nitrogen content was found to be maximum when grown under 75 per cent shade. The pattern of nitrogen allotment to tissues is in agreement with the reports made on *Dicanthium aristatum* by Cruz (1997). The higher concentration of N under shade is presumed due to adapt of certain plant species to improve the CO_2 assimilation rates.

Phosphorous concentration was highest in plants grown in lower shade levels (25%). Lower shade levels were reported to result in more phosphorus accumulation in the leaf of *Dicanthium aristtaum* (Cruz, 1997). This in conformity with the result of present study.

Potassium content was highest plants grown in 75 per cent shade level. Similar results were obtained by Lee *et al.* (1996) for various species grown under different shade condition. Thomas (1996) reported higher nutrient uptake associated higher stock levels (Shaded condition) of *Ailanthus triphysa* in Ginger.

Summary

SUMMARY

The present study on "Effect of pre-treatment on seed germination and shade on seedling growth and yield of *Mucuna pruriens* (L.) DC." was carried out in the Tree Nursery, College of Forestry, Vellanikkara, during 2005 – 2007.

The programme envisaged evaluating different pre treatments for better germination to know the variation of germination percent, germination energy and growth rate in two system of sowing (nursery bed and polybag) and to evaluate the yield parameters under different shade levels. The salient findings of the experiments are summarized here under.

1. Germination percentage varied among the two systems (Polybag and Nursery bed) significantly with higher mean for polybag condition.

2. Significant difference was observed among the treatment for germination percentage. Scarification by rubbing the dorsal surface of seeds against hard rough cement surface gave highest germination.

3. The Rate of growth in height differed significantly among two systems viz polybags and nursery, and it was observed that variation between treatment was also significant. Seedlings obtained by scarification attained the highest mean followed by seedlings treated with Conc. H_2So_4 for 20 min.

4. Seedlings obtained by scarification accounted the highest number of leaves up to fifth week of observation, with significant difference among treatments and between the polybags and nursery bed.

5. After five week of sowing, plants were uprooted to know the shoot length, root length, fresh and dry weight of the seedlings. All traits differed significantly between polybag and nursery condition. The highest shoot length, root length, fresh weight and dry weight were in seedlings obtained by scarification by rubbing the dorsal surface of seeds against hard rough cement surface.

6. The effect of shade levels on duration taken for inflorescence bud initiation reveled that, The highest number of days was taken by the seedlings grown under 75 per cent shade level, followed by 50 per cent, 25 per cent and least number of days for inflorescence bud initiation was in case of open condition There was a significant variation in duration between all the treatments.

7. Duration for the flower initiation significantly differed among shade levels with lowest duration for open condition and highest for 75 per cent shade level.

8. Least number of days was taken by seedlings grown in open condition for the formation of pods followed by 25 per cent and highest for 75 per cent shade level.

9. Effect of shade on biomass was significant. Leaf biomass was highest in open condition (714.66gms) and least in case of 75 per cent shade (283.38 gms). Twig weight was also highest in open condition followed by 25 per cent, 50 per cent and 75 per cent. All the treatments varied significantly. Highest root biomass was accumulated in seedlings grown under 75 per cent shade followed by 50 per cent, and 25 per cent. Least root biomass production was in open condition.

10. Seed yield was significantly varied among different shade levels. Highest mean was seen in open condition followed by 25 per cent shade and 50 per cent. Lowest seed yield per plant was seen in 75 per cent shaded level.

11. Total biomass was significantly affected by shade. At the end of the study, maximum biomass was produced by the plants grown in full sunlight, followed by T_2 (25%) and T_3 (50%). The lowest total biomass per plant was observed in seedlings grown in 75 per cent shade level.

12. Shade had significant effect on nitrogen content. The seedlings grown in 75 per cent shade recorded the maximum concentration of nitrogen for all the parts, under 75 per cent shade and 50 per cent shade were on par with each other. Concentration of nitrogen in seedlings grown in open and 25 per cent were non-significant.

13. There was significant variation between treatments with respect to phosphorus concentration. In case of leaf and twigs, the highest concentration was in plants grown under 25 per cent shade. In root, higher concentration was in open condition.

14. Potassium content significantly varied under different shade levels. In case of leaf potassium content highest concentration was in 75 per cent shade. There was no variation in leaf potassium content in plants of open and 20 per cent shade levels.

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* Original not seen

Appendices

Appendix- i

Weather data of Vellanikkara (2006 September to 2007 April)

Element	Year 2006				Year 2007			
	September	October	November	December	January	February	March	April
Relative humidity (%)	84	79	72	57	54	55	63	69
Rain fall(mm)	522.2	323.7	79	0	0	0	0	61
Rainy days	17	11	5	0	0	0	0	4
Sunshine hours	3.9	4.8	6.5	7.8	8.7	9.8	8.2	7.7
Maximum temperature(^{0}C)	29.6	31.0	31.7	31.5	32.5	34.0	36.0	35.7
Minimum temperature(^{0}C)	23.0	23.0	23.7	23.6	22.0	22.2	24.4	25.0

Appendix- ii

ANOVA Table for germination and growth rate in nursery stage.

Tests of Between-Subjects Effects Dependent Variable: Germination percentage					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.707(a)	19	.353	83.823	.000
Intercept	34.901	1	34.901	8288.073	.000
polybag	.029	1	.029	6.992	.012
Nursery bed	6.514	9	.724	171.882	.000
polybag * Nursery bed	.163	9	.018	4.301	.001
Error	.168	40	.004		
Total	41.776	60			
Corrected Total	6.875	59			
a R Squared = .975 (Adjusted R Squared = .964)					

Tests of Between-Subjects Effects Dependent Variable: Germination energy					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	39.428(a)	19	2.075	20.256	.000
Intercept	331.474	1	331.474	3235.522	.000
polybag	.020	1	.020	.196	.660
Nursery bed	37.903	9	4.211	41.108	.000
polybag * Nursery bed	1.505	9	.167	1.633	.139
Error	4.098	40	.102		
Total	375.000	60			
Corrected Total	43.526	59			
a R Squared = .906 (Adjusted R Squared = .861)					

Appendix- ii (cont.)

Tests of Between-Subjects Effects Dependent Variable: Nursery Biomass Shoot length					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	148.974(a)	19	7.841	511.614	.000
Intercept	6705.413	1	6705.413	437534.272	.000
polybag	10.576	1	10.576	690.080	.000
Nursery bed	137.927	9	15.325	999.983	.000
polybag * Nursery bed	.471	9	.052	3.415	.003
Error	.613	40	.015		
Total	6855.000	60			
Corrected Total	149.587	59			
a R Squared = .996 (Adjusted R Squared = .994)					

Tests of Between-Subjects Effects Dependent Variable: Root Length					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	75.588(a)	19	3.978	333.628	.000
Intercept	1418.935	1	1418.935	118993.800	.000
polybag	5.084	1	5.084	426.326	.000
Nursery bed	69.365	9	7.707	646.340	.000
polybag * Nursery bed	1.139	9	.127	10.615	.000
Error	.477	40	.012		
Total	1495.000	60			
Corrected Total	76.065	59			
a R Squared = .994 (Adjusted R Squared = .991)					

Appendix- ii (cont.)

Tests of Between-Subjects Effects Dependent Variable: Number of Leaf					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	27.311(a)	19	1.437	203.030	.000
Intercept	1569.406	1	1569.406	221674.968	.000
polybag	2.204	1	2.204	311.274	.000
Nursery bed	23.747	9	2.639	372.691	.000
polybag * Nursery bed	1.360	9	.151	21.343	.000
Error	.283	40	.007		
Total	1597.000	60			
Corrected Total	27.594	59			
a R Squared = .990 (Adjusted R Squared = .985)					

Tests of Between-Subjects Effects Dependent Variable: Leaf length					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	3.196(a)	19	.168	33.377	.000
Intercept	565.203	1	565.203	112154.776	.000
polybag	.050	1	.050	9.872	.003
Nursery bed	3.044	9	.338	67.122	.000
polybag * Nursery bed	.102	9	.011	2.244	.039
Error	.202	40	.005		
Total	568.600	60			
Corrected Total	3.397	59			
a R Squared = .941 (Adjusted R Squared = .912)					

Appendix- ii (cont.)

Tests of Between-Subjects Effects
Dependent Variable:
Leaf Width

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.229(a)	19	.117	21.532	.000
Intercept	491.153	1	491.153	90144.407	.000
polybag	.001	1	.001	.149	.701
Nursery bed	2.193	9	.244	44.727	.000
polybag * Nursery bed	.035	9	.004	.713	.694
Error	.218	40	.005		
Total	493.600	60			
Corrected Total	2.447	59			

a R Squared = .911 (Adjusted R Squared = .869)

Tests of Between-Subjects Effects
Dependent Variable:
Fresh Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	53.845(a)	19	2.834	105.449	.000
Intercept	1902.484	1	1902.484	70789.737	.000
polybag	3.004	1	3.004	111.781	.000
Nursery bed	50.244	9	5.583	207.725	.000
polybag * Nursery bed	.597	9	.066	2.469	.024
Error	1.075	40	.027		
Total	1957.404	60			
Corrected Total	54.920	59			

a R Squared = .980 (Adjusted R Squared = .971)

Appendix- ii (cont.)

Tests of Between-Subjects Effects
Dependent Variable:
Dry Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23.143(a)	19	1.218	79.336	.000
Intercept	988.050	1	988.050	64354.011	.000
polybag	1.452	1	1.452	94.542	.000
Nursery bed	21.251	9	2.361	153.791	.000
polybag * Nursery bed	.441	9	.049	3.191	.005
Error	.614	40	.015		
Total	1011.808	60			
Corrected Total	23.758	59			

a R Squared = .974 (Adjusted R Squared = .962)

Appendix- iii

ANOVA for different traits observed under shade treatments

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
No of days for Inflorescence bud initiation	Between Groups	8.145	3	2.715	42.190	.000
	Within Groups	.515	8	.064		
	Total	8.659	11			
No of Days for first flowering	Between Groups	11.524	3	3.841	78.756	.000
	Within Groups	.390	8	.049		
	Total	11.914	11			
No of Flowers buds per inflorescence	Between Groups	4.144	3	1.381	23.493	.000
	Within Groups	.470	8	.059		
	Total	4.615	11			
No of Flowers / inflorescence	Between Groups	2.180	3	.727	12.083	.002
	Within Groups	.481	8	.060		
	Total	2.662	11			
No of Days for 50% flowering	Between Groups	10.107	3	3.369	159.719	.000
	Within Groups	.169	8	.021		
	Total	10.275	11			
No of Days for pod formation	Between Groups	12.463	3	4.154	221.873	.000
	Within Groups	.150	8	.019		
	Total	12.613	11			

Appendix- iii (Cont.)

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
No of Days for maturity of pods	Between Groups	7.565	3	2.522	252.733	.000
	Within Groups	.080	8	.010		
	Total	7.645	11			
No of Pods / inflorescence	Between Groups	4.703	3	1.568	26.292	.000
	Within Groups	.477	8	.060		
	Total	5.180	11			
Pod Length	Between Groups	.763	3	.254	63.013	.000
	Within Groups	.032	8	.004		
	Total	.795	11			
Pod Fresh Weight	Between Groups	.922	3	.307	15.232	.001
	Within Groups	.161	8	.020		
	Total	1.083	11			
Pod Dry Weight	Between Groups	1.881	3	.627	23.016	.000
	Within Groups	.218	8	.027		
	Total	2.099	11			

Appendix- iii (Cont.)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
No Of Seeds / Pod	Between Groups	.921	3	.307	22.959	.000
	Within Groups	.107	8	.013		
	Total	1.028	11			
Pod Girth	Between Groups	.178	3	.059	13.198	.002
	Within Groups	.036	8	.004		
	Total	.214	11			
No Of Pods/ Plant	Between Groups	5.618	3	1.873	93.521	.000
	Within Groups	.160	8	.020		
	Total	5.778	11			
No Of Leaf / Plant	Between Groups	237.837	3	79.279	147.257	.000
	Within Groups	4.307	8	.538		
	Total	242.144	11			
Leaf Weight	Between Groups	272.211	3	90.737	176.997	.000
	Within Groups	4.101	8	.513		
	Total	276.312	11			

Appendix- iii (Cont.)

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Twig Weight	Between Groups	1429.436	3	476.479	100.357	.000
	Within Groups	37.983	8	4.748		
	Total	1467.418	11			
Root Weight	Between Groups	35.686	3	11.895	31.406	.000
	Within Groups	3.030	8	.379		
	Total	38.716	11			
Root Length	Between Groups	26.068	3	8.689	23.170	.000
	Within Groups	3.000	8	.375		
	Total	29.068	11			
Total Biomass	Between Groups	1602.033	3	534.011	135.580	.000
	Within Groups	31.510	8	3.939		
	Total	1633.543	11			

Appendix- iv
ANOVA for Nutrient concentration under shade treatments

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
N% in Leaf	Between Groups	.216	3	.072	85.009	.000
	Within Groups	.007	8	.001		
	Total	.223	11			
N% in Twig	Between Groups	.075	3	.025	157.703	.000
	Within Groups	.001	8	.000		
	Total	.076	11			
N% in Root	Between Groups	.028	3	.009	20.190	.000
	Within Groups	.004	8	.000		
	Total	.032	11			

Appendix- iv. (Cont..)

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
P % in Leaf	Between Groups	.029	3	.010	85.009	.000
	Within Groups	.001	8	.000		
	Total	.030	11			
P % In Twig	Between Groups	.010	3	.003	157.703	.000
	Within Groups	.000	8	.000		
	Total	.010	11			
P % in Root	Between Groups	.004	3	.001	20.190	.000
	Within Groups	.000	8	.000		
	Total	.004	11			

Appendix- iv. (Cont..)

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
K % in Leaf	Between Groups	.152	3	.051	85.009	.000
	Within Groups	.005	8	.001		
	Total	.156	11			
K % in Twig	Between Groups	.052	3	.017	157.703	.000
	Within Groups	.001	8	.000		
	Total	.053	11			
K % in Root	Between Groups	.020	3	.007	20.190	.000
	Within Groups	.003	8	.000		
	Total	.022	11			

Abstract

EFFECT OF PRE TREATMENT ON SEED GERMINATION AND SHADE ON SEEDLING GROWTH AND YIELD OF *Mucuna pruriens* (L.) DC.

By

RAVINDRA, P. C.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Science in Forestry

Faculty of Agriculture
Kerala Agricultural University

Department of Forest Management and Utilization

COLLEGE OF FORESTRY
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2007

ABSTRACT

The present study entitled "Effect of pre-treatment on seed germination and shade on seedling growth and yield of *Mucuna pruriens* (l.) DC." was carried out in College of Forestry, Kerala Agricultural University, Vellanikkara, Trichur during the period of 2005-2007.

In the first phase, graded and selected seeds were subjected to 10 different pre-treatment methods and sown in two conditions viz, polybag and nursery bed. In both the cases scarification on dorsal surface gave highest germination per cent and germination energy. Various biometric parameters like height, collar diameter and number of leaves in various treatments under polybag and nursery bed conditions were observed. Biomass produced at nursery stage was also estimated; it is evident from the study that seedlings produced from scarification treatments was most superior for all traits in both polybag and nursery bed.

In the second phase, to evaluate yield under different shade situations, selected seedlings were planted out in 25 per cent, 50 per cent, 75 per cent and open situations. Various reproductive characters, yield parameters, and nutrient status were studied, in which early flowering, more number of flower bud production, and higher pod formation was observed in full light situation. The Highest seed yield and biomass production was observed when grown under open condition followed by 25 per cent and least was in 75 per cent or highest shade condition.

The nutrient accumulation under different shade was estimated. Nitrogen concentration in leaf and twig was more in case of full shade followed by seedlings grown in 50 per cent shade, whereas for roots concentration of nitrogen under 75 per cent and 50 per cent shade was observed to be non-significant. In case of leaf

phosphorus content, highest concentration was seen in seedlings grown under 25 per cent shade followed by seedlings in open condition. Phosphorus content in twigs was highest in 25 per cent and least in 50 per cent. In root, maximum concentration of phosphorous was observed in open condition. Highest potassium content was in 75 per cent shade followed by 50 per cent, and there was no variation in leaf potassium content in plants grown under open condition and 25 per cent shade level. Root potassium content under 50 per cent and 75 per cent was similar and higher than other two treatments.