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EVALUATION OF NEYKUMBALAM [*Benincasa hispida* (Thunb.) Cogn.] IN OIL PALM PLANTATIONS

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Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2003

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DECLARATION

I hereby declare that this thesis entitled "**Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations**" is a record of research work done independently by Ms. Devi Raveendran (2000-12-05) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Achan and Amma

ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and sincere thanks to:

Smt. P.C. Jessykutty, Assistant Professor, Department of Plantation Crops and Spices and Chairperson of my advisory committee for her valuable guidance, wholehearted co-operation and constant encouragement throughout the course of study. I am obliged to her for her affectionate advice, patience and everwilling help which rendered this endeavour a successful one.

Late Dr. G. Sreekandan Nair, former Professor and Head, Department of Horticulture for his keen interest inspiring encouragement, kind help and affection rendered throughout my course of study.

Dr. B.K. Jayachandran, Associate Professor and Head, Department of Plantation Crops and Spices for his timely help and valuable suggestions during the critical scrutiny of the manuscript.

Dr. B.R. Reghunath, Associate Professor, Department of Plantation Crops and Spices for his generous help and critical scrutiny of the manuscript.

Dr. V.K. Venugopal, Professor and Head, Department of Soil Science and Agricultural Chemistry for his valuable suggestions, critical comments and critical evaluation of the manuscript.

Dr. Philipose Joshua, Associate Professor and Head, Department of Processing Technology and Dr. Roy Stephen, Assistant Professor, Department of Plant Physiology for their help at various stages of the course of study.

Mr. C.E. Ajithkumar, Programmer, Department of Agricultural Statistics for the help rendered during the computer analysis of the data.

Kerala Agricultural University for granting me the Junior Research Fellowship.

Mr. Biju. P. of ARDRA for the timely and neat preparation of the manuscript.

Mr. Madhukumar, Aparna chechi and Kiran for their co-operation and warm company during my visits to Kulathupuzha.

Geetha chechi, Devi chechi and Rajamanickam for their immense help especially during chemical analysis.

My friends Renu, Ranjini, L. K. Mathew and my junior friends Sreeja, Hima, Roby, Bini and Shino for their help and support rendered to me during the work.

My friends M.S. and Rakhee for their constant encouragement, sincere help and moral support throughout the period of my study and investigation.

My in-laws for their encouragement and support.

My husband Vinod, for his unconditional love, constant inspiration and moral support which made this attempt a success.

My beloved Achan, Amma and Pinky for their undying love, moral support, constant encouragement, sincere efforts, prayers and blessings without which this study would have never been complete.

Above all, to God Almighty for all his help and blessings rendered through various hands, which helped me pursue this endeavour to completion.

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LIST OF ABBREVIATIONS

%	per cent
@	At the rate of
^0C	Degree Celsius
AGR	Absolute growth rate
Ca	Calcium
CGR	Crop growth rate
cm	Centimetre
DAS	Days after sowing
day^{-1}	Per day
et al.	And others
Fe	Iron
Fig.	Figure
g	Gram
ha^{-1}	Per hectare
HI	Harvest Index
K	Potassium
kg	Kilogram
LAI	Leaf area index
m	Metre
Mg	Magnesium
mm	Millimetre
N	Nitrogen
NAR	Net assimilation rate
NS	Not significant
P	Phosphorus
RGR	Relative growth rate
S	Sulphur

INTRODUCTION

1. INTRODUCTION

Plants have been a major source of medicine since time immemorial. They are the foundation of health care systems all over the world. They are widely utilized in the indigenous systems of medicine namely Ayurveda, Siddha and Unani. In Ayurveda, ashgourd fruit is considered as the best among climbers. The small fruited type referred to as 'neykumbalam' has wide demand for the manufacture of a variety of ayurvedic preparations like Kushmandarasayanam, Kushmandasavam, Kushmandakhritam etc.

Ashgourd is considered good for people suffering from nervousness and debility (Saimbhi, 1993). Ripe fruits are useful for treating tridoshas. insanity, epilepsy and other nervous disorders (Sanyal, 1984). Fruit paste can be used in case of cuts, burns and minor wounds. Tender stems are found good in liver troubles and muscular pain. Seed powder is antihelmintic (Agarwal, 1997).

The wild growing populations of important medicinal plant species are fast reducing due to over exploitation in their known habitats. With screening of more and more plants as source of drugs, it is apprehended to lose our heritage of medicinal plant wealth through uncontrolled and unscrupulous collection. This is augmented with the distribution of many of the forest areas for other developmental programmes. This has led to adulteration, substitution and high cost of genuine drugs. The need of the hour is the domestication of drug plants for conservation and cultivation for sustained supply to pharmaceutical industries.

In a thickly populated state like Kerala due to scarcity of cultivable land, the scope of cultivating medicinal plants as a pure crop is very much limited. However, there is ample scope for introducing them as intercrops in plantations of oil palm, coconut and rubber. Oil palm is the most rapidly expanding plantation crop in the tropics and now Technology

Mission on Oil seeds and Pulses has envisaged to develop small oil palm gardens in farmers' field. Raising of some intercrops will help the farmers to generate an additional income.

Organised intercropping is not being practised in oil palm plantations at present. Literature shows that intercropping on an experimental scale has been practised in some plantations in the initial years of their establishment. The plants tried are maize, cowpea, okra, yams and cassava. Intercropping trial conducted in oil palm at farmers field in Andhra Pradesh and Karnataka revealed that vegetables like cabbage, cauliflower, chillies, cucurbits and tomato can be successfully grown in the interspaces during the initial years (Anon., 1996). In Indonesia, patchouli had been recommended as a profitable intercrop in young oil palm plantations (Soepadyo and Tan, 1968). A study on the growth behaviour, yield and chemical constituents of intercropped ashgourd in the oil palm plantations can be helpful in the present context of scarcity of this crop for officinal uses. Further, the study will provide insight on the possibility of introducing the crop as intercrop in oil palm plantations.

Lack of authentic varieties in medicinal plants is a major lacuna that hinders quality standardisation of pharmaceutical preparations made out of them. Screening of existing genotypes and releasing authentic varieties of medicinal plants will certainly help in maintaining the uniformity of raw materials used in pharmaceutical industry leading to sustained quality of the products.

The present study is aimed at :

i) Study of growth behaviour and yield of *Benincasa hispida* in the interspaces of young and mature oil palm plantations and open conditions

ii) Screening of accessions for yield and chemical content and

iii) Exploring the feasibility of cultivating the crop as a promising intercrop in oil palm plantations.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Benincasa hispida is an important warm season cucurbit vegetable grown for its fruit used in confectionery and ayurvedic medicinal preparations (Indira and Peter, 1987). *Benincasa hispida* fruit is considered as the best among the climbers, in ayurveda.

The present study in *Benincasa hispida* comprises collection and screening of various ecotypes for yield, chemical content and medicinal property and evaluation of the performance as intercrop in oil palm plantation and as pure crop in open. In this chapter, literature on the above areas in ashgourd is reviewed. Wherever relevant literature in ashgourd is not available literature on similar aspects reported in other crops has been reviewed.

2.1 COLLECTION AND CLASSIFICATION OF GERMPLASM OF *Benincasa hispida*

Simmonds (1976) reported that ashgourd is indigenous to Asian tropics. Ashgourd is probably a native of Malaysia. The cultivated forms may have originated in southeastern Asia (Peter, 1998).

Benincasa is a monotypic genus and the only cultivated species is *Benincasa hispida*. The chromosome number is 2n = 24 (Varghese, 1974; Seshadri, 1993). Small-fruited wild populations, classified as *Benincasa hispida* var. pruriens (Parkinson) Whistler, occur on several islands in the South Pacific (Whistler, 1990) and reported in Australia, Indonesia. Japan and southern China as well.

Morton (1971) described three cultivar types in wax gourd group on the basis of fruit character. These are :

- fruits nearly round and essentially hairless;
- fruits nearly round and hairy; and

- fruits oblong and hairy.

Walters and Walters (1989) proposed four major categories as cultivar group :

- unridged winter melon group;
- ridged winter melon group;
- fuzzy gourd group; and
- wax gourd group.

Mature fruits are called winter melons because they can be stored for as long as a year. The waxy coating serves to keep moisture in and insects and microorganisms out. They have a very high moisture content and are low in calories and carbohydrates (Morton, 1971). *Benincasa hispida* is also known as wax gourd, white pumpkin, chinese squash etc. (Seshadri, 1993). The name wax gourd refers to the thick waxy cuticle that typically develops on mature fruits. The specific epithet *hispida* refers to the hirsute pubescence on the foliage and immature fruits (Robinson and Decker, 1997).

2.2 CROP PRODUCTION AND MANAGEMENT

2.2.1 Soil and Climate

Ashgourd is both a summer as well as a rainy season crop. High temperature, good sunshine and dry winds are most suited for its production. A temperature of 75 to 80° F is reported to be best for its production (Srivastava and Sachan, 1969). Optimum temperature requirement is 24-30°C (Nath *et al.*, 1987). Ashgourd is grown throughout the plains of India upto an altitude of 1500 m (Robinson and Decker, 1997; Peter, 1998). Ashgourd may be produced successfully on practically all types of cultivated soils ranging from sandy to clay soils. Medium soils like loam with plenty of organic matter is the most suitable for its cultivation

(Srivastava and Sachan, 1969). Fertile, well drained soils of pH 5.5–6.4 are preferred (Robinson and Decker. 1997).

2.2.2 Cultural Practices

Benincasa hispida is a seed propagated crop. It is sown in pits taken at a spacing of 4.5 m x 2 m. Gopalakrishnan (1957) reported that medicinal ashgourd can be grown in pits of 2 x 2 x 2 feet size dug at a distance of six feet in the row and eight feet between row.

Krishnaswamy and Pandian (1991) suggested sowing pre-germinated seeds for earlier seedling emergence. Renugadevi (1992) reported that seed treatment with a slurry of captan @ 25 g per kg seed was best in maintaining seed viability upto 10 months in ashgourd.

Frequent hoeing and intercultural operations should be followed to promote the healthy growth of plants which results in heavy fruiting (Srivastava and Sachan, 1969). In ashgourd, total number of fruits were more in drip irrigation than basin irrigation (Andezhathu, 1989).

In ashgourd, the planting system significantly influence the fruit size and yield of plant. The individual fruit weight and circumference are more in pit system whereas production per unit area is more in trench system (Balan, 1998).

Ashgourd is ideal to be grown as intercrop in coconut garden in September – October (Hedge *et al*., 1991).

2.2.3 Pests and Diseases

Ashgourd is reported to be tolerant to pests and diseases. Gopalakrishnan (1959) reported that medicinal ashgourd is more resistant to pest and diseases. The waxy coating serves to keep the microorganisms out (Morton, 1971). Ashgourd is resistant to soil borne diseases (Robinson and Decker, 1997). Singh (1979) reported incidence of pumpkin mosaic virus and Roy *et al*. (1980) reported occurrence of *Penicillium* dry fruit rot in ashgourd.

2.2.4 Harvest and Yield

Flowering commences about sixty days after sowing and it takes 60 –75 days for the fruits to mature completely. Fruits are harvested when the fruit stalk show symptoms of drying up. On an average each vine bears 8 to 10 fruits (Gopalakrishnan, 1957).

2.3 INFLUENCE OF LIGHT ON GROWTH PARAMETERS

2.3.1 Plant Height

Allen (1975) noticed that soyabean grown under 70 per cent shade grew much taller than those in light. Tarila *et al.* (1977) reported that high intensity of light reduced plant height in cowpea. In *Mentha piperita* length of branches under 44 per cent day light was significantly greater than under 100 per cent day light (Virzo and Alfani, 1980). Positive influence of shade on plant height was reported on rice (Janardhan and Murty, 1980), groundnut (George, 1982), sweet potato (Bai, 1981), tomato (Kamaruddin, 1983), winged bean (Sorenson, 1984), cassava (Ramanujam *et al.*, 1984; Sreekumari *et al.*, 1988), broad bean (Xia, 1987), passion fruit (Menzel and Simpson, 1988), colocasia (Prameela, 1990) and cotton (Perumal and Rao, 1991). Pusphakumari and Sasidhar (1992) noticed increased vine length with increase in shade intensity in *Dioscorea alata* and *D. esculenta*. Greater shoot height was noticed in seven soyabean cultivars grown under shade in a coconut plantation (Babu and Nagarajan, 1993). Jung *et al.* (1994) reported that mains stem and branch length of pepper increased significantly under shaded condition. Increase in plant height was also reported in tomato due to increase in the period of shading (Nasiruddin *et al.*, 1995). In a field experiment to study response of blackgram to shade by Lakshmamma and Rao (1996) using 0, 33 or 66 per cent shade it was revealed that shading increased plant height. In arrow root, the plant height was higher under intercrop compared to open space grown crop (Maheswarappa, 1997). In pepper, length of primary and secondary branches increased with decrease in light intensity from 100 to

50 per cent (Devadas, 1997). Height increases in *Asparagus racemosus* grown as intercrop in coconut gardens has been reported from Kerala Agricultural University (KAU, 1999). Increased plant height was reported in different chilli species under shade by Sreelathakumary (2000).

Negative influence of shade on plant height was noticed in bird's foot, trefoil and alfalfa (Cooper, 1966) and red gram (George, 1982). Kulasegaram and Kathirvetpillai (1980) reported that height of tea plant was greater under 60 per cent sunlight and was least under 10 per cent as compared to 30 and 100 per cent.

2.3.2 Number of Branches

The number of branches is usually related to the height of the plant (George, 1981).

Deli and Tiessen (1969) reported that chilli plants produced more branches when exposed to low light intensity of 800 ft. candles than at 1600 ft. candles. In cowpea increased light intensity decreased the number of branches (Tarila *et al.*, 1977). Khosien (1977) noticed reduction in branching in bean plants due to high light intensity. Senanayake and Kirthisinghe (1983) reported better production of laterals in black pepper at 50 per cent light than at 75 and 25 per cent light.

High light has been reported to increase number of laterals in pepper (Mathai, 1983). Rylski and Spigelman (1986) reported that shading inhibited development of lateral shoots on the main stem in capsicum. Smitha (2002) reported that shading reduced number of primary branches in tomato.

2.3.3 Number of Leaves

Nair (1964) reported that the production as well as the retention of leaves will be more under shade than in the open, in peppermint. Senanayake and Kirthisinghe (1983) reported maximum number of leaves in black pepper under 50 per cent light compared to 75 and 25 per cent light. Aasha (1986) reported that the number of leaves in open condition will be less as compared to that under shade in begonia. The clove seedlings kept under shade produced more number of leaves than seedlings exposed to sun (Venkataraman and Govindappa, 1987). In arrow root, number of leaves was higher under inter crop compared to open space crop (Maheswarappa, 1997). In pepper, under shaded condition the production and retention of leaves was higher (Devadas and Chandini, 2000).

Prabhakar *et al.* (1979) obtained higher leaf number in plots of cassava where no inter crop was raised. In sweet potato leaf number declined in response to higher shade level (Laura *et al.*, 1986). Simbolon and Sutarno (1986) observed that *Amaranthus spp.* kept at medium shade produced more leaves than at high levels of shade. Xia (1987) found that *Vicia faba* plants subjected to 50 and 20 per cent shade exhibited 30 per cent reduction in the number of leaves per plant. In cassava, the leaf number decreased when grown under shade in coconut garden (Sreekumari *et al.*, 1988). Varghese (1989) observed a decrease in the number of leaves with shade in ginger and turmeric. Sunitha (1996) reported higher number of leaves in *Clitoria ternatea* under open condition when compared to shade condition. High light intensity has increased leaf number in betel vine (Shivasankara *et al.*, 2000).

2.4 INFLUENCE OF LIGHT ON FLOWERING CHARACTERS

Hong *et al.* (1986) reported that geranium flowered earlier at 50 per cent light than at 88 per cent light. Pepper (*Capsicum annum* L.) when grown under 50 per cent light flowered earlier than at 100 per cent light (Mathi and Bahadli, 1989). Early flowering was noticed in black pepper at 50 per cent light. Under full sunlight the vines took 94 days for flowering, while under 50 per cent light it took only 84.9 days (Devadas, 1997).

Tomato required longer time for flower bud differentiation at low light intensities (Watanabe, 1963). Lower light intensities retarded morphological development of flowers in tomato (Saito and Ito, 1967). Sagi *et al.* (1979) observed flower drop under low solar radiation intensity (SRI). Number of days from sowing to flowering and percentage of flower drop increased as the shade increased (Jeon and Chung, 1982). Hedge *et al.* (1991) reported production of more number of male flowers and late emergence of female flowers when ashgourd was intercropped in coconut garden. El-gizaway *et al.* (1993) observed delay in flowering in tomato as shading increased whereas the number of flowers per plant decreased under all shading rates compared with full sunlight. Nasiruddin *et al.* (1995) reported that shading delayed flowering in tomato but insignificantly only in partial shading in comparison with full exposure. Shading delayed flowering in chilli (Sreelathakumary, 2000) and tomato (Smitha, 2002).

2.5 INFLUENCE OF LIGHT ON PHYSIOLOGICAL PARAMETERS

2.5.1 Dry Matter Production

Photosynthetic efficiency and biomass production of crop plants are positively correlated with total leaf area of the plant (Russell, 1961). Monteith (1969) observed that the maximum amount of dry matter produced by a crop was strongly correlated with the amount of light intercepted by its foliage. High dry matter production under shade was noticed in *Xanthosoma sagittifolium* (Caeser, 1980) and cotton (Singh, 1986). In black pepper 50 per cent light enhanced dry matter production (Senanayake and Kirthisinghe, 1983; Seneviratne *et al.*, 1985). Venkataraman and Govindappa (1987) reported that coffee seedlings kept under shade produced more total dry matter compared to those exposed to sun. Prameela (1990) reported highest dry matter production at 25 per cent shade level in colocasia. In arrowroot, total dry matter production was higher under intercrop compared to open space grown crop

(Maheswarappa, 1997). In pepper, drymatter production was maximum (73.4g) under 50 per cent light and there was a drastic reduction in drymatter production under 100 per cent light (39.16g) (Devadas. 1997).

Kulasegaram and Kathirvetpillai (1980) reported that tea plants grown under high light intensity produced more dry matter. Dry matter production was high in cardamom clumps under medium and high light as compared to clumps under low light (Sulikeri, 1986). A reduction in dry matter production was noticed under low light condition in rice (Janardhan and Murthy, 1980; Singh *et al.*, 1988). A reduction in dry matter accumulation under shade noted on several crops such as *colocasia esculenta* (Caesar, 1986), peanut plants (Farnham *et al.*, 1986), rice (Vijayalekshmi *et al.*, 1987; Thankaraj and Sivasubramanian, 1992) and turmeric (Varghese, 1989; Louis, 2000). In sweet potato, deep shade (> 55 per cent) reduces dry matter production due to suppression of both initiation and growth of storage roots (Ravi and Indira, 1999).

Soyabean plants grown under 70 per cent shade did not show any reduction in drymatter (Erikson and Whitney, 1984).

2.5.2 Leaf Area Index (LAI)

Increase in total leaf area results in higher leaf area index (Russell, 1961). The optimum LAI depends not only on the arrangement of leaves within the canopy but also on the light intensity that the canopy receives. Growth will be slow in periods of low light intensity (Bleasdale, 1973).

Low leaf area index was observed at high light intensities in crops like cotton (Bhat and Ramanujam, 1975) and rice (Janardhan and Murthy, 1980; Singh *et al.*, 1988). High LAI had been reported under intercropping systems by several workers (Lin *et al.*, 1981; Reddy and Willey, 1981; Mandal *et al.*, 1986). Sorenson (1984) observed higher LAI with higher shade intensity in winged bean. In Satsuma mandarin orange reduced light intensity increased LAI (Ono and Iwagaki, 1987). High LAI was reported by Ravisankar and Muthuswamy (1988) when ginger was grown as an intercrop in six year old arecanut plantations. Joseph (1992) observed that LAI in ginger was significantly lower under open condition compared to shade levels in all growth stages. Yinghua and Jianzhen (1998) reported increased leaf area index in capsicum with increasing shade. Ginger plants grown under 20 and 40 per cent shade levels produced higher LAI at all growth stage when compared to open conditions (Sreekala, 1999). In pepper LAI increased when light intensity was reduced from 100 to 50 per cent (Devadas and Chandini, 2000).

Rice crops shaded during vegetative phase were smaller with a lower LAI (Yoshida and Parao, 1976). Bai (1981) reported decrease in LAI in sweet potato with increase in shade intensity. High light has been reported to increase LAI in pepper (Mathai, 1983). Total leaf area in cardamom increased as the light intensity increased (Sulikeri, 1986). High light intensity increased leaf area in betel vine (Shivasankara *et al.*, 2000). In *Clitoria ternatea*, LAI was more in open condition when compared to shaded condition (Reshmi, 2001).

Bai (1981) reported that leaf area indices of ginger, turmeric and coleus was not influenced by different intensities of shade.

2.5.3 Net Assimilation Rate (NAR)

Blackman and Wilson (1951), Newton (1963) and Coombe (1966) reported a positive correlation between NAR and irradiance. The NAR of chickpea deceased with decrease in light intensities (Pandey *et al.*, 1980). Ramadasan and Satheesan (1980) observed highest NAR with turmeric cultivars grown in open condition compared to shade. Reduced NAR was also noticed in shade plants of cucumber (Smith *et al.*, 1984). Ramanujam and Jose (1984) observed reduced NAR of cassava grown under shade compared to those plants under normal light. A low rate of NAR under shade was also reported in sweet potato (Bai, 1981; Laura *et al.*, 1986). Low light reduced NAR in rice (Janardhan and Murthy, 1980; Singh *et al.*, 1988). Pushpakumari and Sasidhar (1992) noticed that shade decreased NAR in *Dioscorea alata*. NAR of soyabean was decreased under intercropping situation (Chandel *et al.*, 1993). Jung *et al.* (1994) reported that shaded plants of pepper had lower NAR. Sreelathakumary (2000) noticed that shade decreased NAR in capsicum. A low rate of NAR under shade was reported in *Clitoria ternatea* (Reshmi, 2001).

2.5.4 Crop Growth Rate (CGR)

Ramadasan and Satheesan (1980) reported highest crop growth rate in turmeric cultivars grown in open condition compared to shaded condition. Crop growth rate of cassava grown under shade was reduced significantly when compared to those plants grown under normal light (Ramanujan and Jose, 1984). In *Dioscorea alata* shade significantly reduced CGR (Pushpakumari and Sasidhar, 1992).

2.5.5 Relative Growth Rate (RGR)

Murata (1961) reported that the relative growth rate (RGR) of leaf area was practically free from the influence of solar radiation as long as the level of radiation was higher than the one third of the full incident radiation.

Jadhav (1987) reported a positive correlation of RGR with shade in rice.

In rice, RGR was reduced under low light condition (Janardhan and Murthy, 1980; Singh *et al.*, 1988). Shaded plants of pepper has lower RGR during flowering and early fruit development stages compared to exposed plants (Jung *et al.*, 1994).

Shade levels 60 and 80 per cent recorded low values of RGR in ginger plants during all stages except between 30-90 DAP (Sreekala, 1999).

2.5.6 Harvest Index

Shading of *D. stramonium* led to a greater decrease in seed production and, consequently, in the harvest index than in the other species examined (Benvenuti, *et al.*, 1994).

A moderate light intensity (60 lx) resulted in the highest biomass production and harvest index (2.137) in *Urginea indica* (Pal and Gupta, 1991).

2.6 INFLUENCE OF LIGHT ON YIELD AND FRUIT CHARACTERS

Positive influence of shade on yield was reported in many crops. In Chinese cabbage, lettuce and spinach the highest fresh weight was at 35 per cent shade, beyond which the performance was poor than those in full sunlight (Moon and Payo, 1981). Smith *et al.* (1984) found that tomato yields were the best under 15 per cent shade than open condition. El-Aidy (1986) found higher yield in tomato plants grown under shade than those in open field. Hedge *et al.* (1991) reported that among the different vegetable crops tried in coconut garden, snake gourd, amaranthus and brinjal in Kharif, bottle gourd, ridge gourd and coccinea in rabi and amaranthus, brinjal and coccinea in summer were found highly productive and economical. Yinghua and Jianzhen (1998) reported highest yield in pepper under 30 per cent shade.

According to Curme (1962) fruit set and yield of tomato was positively influenced by increased levels of incident sunlight. Sagi *et al.* (1979) observed reduced fruit set under low solar radiation intensity. The cardamom clumps under medium light and high light weighed significantly more as compared to clumps grown under low light (Sulikeri, 1986). Fruit set, days to harvest, number and weight of fruits per plant, weight and diameter of fruits of tomato was significantly influenced by shading (Sharma and Tiwari, 1993). In cocoa, under light limited environment pod yield was low (Field and Mooney, 1983; Hirose, 1988;

Nair *et al.*, 1996). Shade studies on tropical crops viz. colocasia, coleus, cowpea, brinjal, amaranthus, cluster bean, bhindi and sweet potato were conducted in Kerala Agricultural University under 0, 25, 50 and 75 per cent shade levels (Nair, 1991). In all these crops, the yield was the highest under open (0% shade) and declined with increasing shade levels. Jung *et al.* (1994) reported that pepper plants set fewer, smaller fruits in proportion to the degree of shading. Shukla *et al.* (1997) reported the effect of subabul canopy on yield of vegetables like chilli, brinjal, cauliflower and okra. Yield of all vegetables were significantly lower when grown under shaded conditions than in open.

No significant reduction in yield was noticed in different chilli species under mild shade of 25 per cent while dense shade of 50 and 75 per cent reduced the yield considerably (Sreelathakumary, 2000).

2.7 INFLUENCE OF LIGHT ON BIOCHEMICAL CHARACTERS

Kraybill (1922) observed higher content of nitrogen in shaded apple trees. Murray (1954) observed accumulation of potassium with increasing shade in cocoa. According to Maliphant (1959) in cocoa, shading increased nitrogen content of leaf but phosphorus content was decreased. Murray (1961) found greater accumulation of phosphorus in banana with increasing shade. Myhr and Saebo (1969) found that potassium content was doubled by shading of some grass species to 10 to 15 per cent of the intensity of natural light. Phosphorus, calcium and magnesium contents also increased under shading. In spinach, Cantiliffe (1972) observed that the concentration of potassium in tissue increased with reduction in light intensity. The potassium content of grass species when grown under 80-90 per cent shade was nearly double than that grown under open (Rodriguez *et al.*, 1973). Radha (1979) observed that shading increased magnesium content of leaves at all stages of growth and nitrogen at later stages of growth. In *Mentha piperita* under shaded conditions leaves contained significantly higher levels of nitrogen and potassium than leaves of sun plants (Virzo and Alfani, 1980). Bai (1981) observed an increase in the contents of nitrogen, phosphorus and potassium in coleus, colocasia, sweet potato, turmeric and ginger with increase in shade. Kulasegaram and Kathirvetpillai (1985) reported that shaded tea plants had higher percentage of nutrients except magnesium. High phosphorus content in capsules of cardamom was observed under low light and it decreased as the light intensity increased (Sulikeri, 1980). The nitrogen content in the leaf increased as shade increased upto 25 per cent and then showed declining trend with further increase in shade levels, while phosphorus and potassium were higher under 75 per cent shade in clocimum (Pillai, 1990). Prameela (1990) recorded highest nitrogen, phosphorus and potassium contents under 25 per cent shade in colocasia.

Gopinathan (1981) noted higher percentage of nitrogen, phosphorus and potassium in plants grown under direct sunlight than in the shaded plants. In cocoa, under light limited environments leaf nitrogen content was low (Field and Mooney, 1983; Hirose, 1988; Nair *et al.*, 1996).

2.8 ROLE OF NUTRIENTS (N, P, K)

2.8.1 Nitrogen

According to Singh (1957), readily available soil nitrogen induced excessive vegetative growth. Enhanced production of female flowers with increased nitrogen supply was observed in cucurbits by a number of workers (Brantley and Warren, 1958; 1960; Pustgarvi, 1961). On the other hand Pandey and Singh (1973) found that nitrogen at 50 or 100 kg ha^{-1} increased pistillate and staminate flowers, number of fruits as well as yield without affecting the ratio of female to male flowers in bottle gourd. Sundarajan and Muthukrishnan (1975) obtained higher yield in Co-2 pumpkin by the application of 40 kg N ha^{-1}. Nitrogen nutrition is important in watermelon production and highest yield was reported with 1·00 kg N ha^{-1} (Bhosale *et al.*, 1978). Singh *et al.* (1983) obtained maximum number of fruits and maximum diameter of fruits in round melon at 75 kg N ha^{-1}. Thomas (1984) reported increased leaf area index and dry matter production with N upto 60 kg ha^{-1} in bittergourd. Hedge (1987) observed the same in watermelon upto 120 kg N ha^{-1}. Haris (1989) reported that in bittergourd grown in coconut garden yield increased linearly with nitrogen levels. Prasanna (1994) reported that in ashgourd number of fruits per vine was the highest when 100 kg ha^{-1} of nitrogen was applied. Application of 100 kg nitrogen significantly increased the early fruit maturity in muskmelon (Singh *et al.*, 1995).

2.8.2 Phosphorus

Bishop *et al.* (1969) showed that in cucumber, phosphorus played a major role in yield increase than nitrogen and potash. McCollum and Miller (1971) observed maximum dry matter production at 48 kg P_2O_5 ha^{-1} in pickling cucumber. Randhawa *et al.* (1981) reported optimum plant growth in muskmelon with 37.5 kg P_2O_5 ha^{-1}. Singh *et al.* (1983) obtained maximum number of fruits in round melon at 30 kg P_2O_5 ha^{-1}. Thomas (1984) reported that 30 kg P_2O_5 ha^{-1} increased mean number of fruits produced per plant and mean length and weight of fruits. Application of 60 kg P_2O_5 ha^{-1} increased fruit yield by 75 per cent in muskmelon (Prabhakar, 1985). Sathish and Arora (1988) noticed that in sponge gourd 20 kg ha^{-1} P gave maximum number of fruits. In ashgourd number of fruits per vine and vine length was maximum when 100 kg ha^{-1} of P_2O_5 was applied (Prasanna, 1994).

2.8.3 Potassium

McCollum and Miller (1971) reported that maximum dry matter production in pickling cucumber at 91 kg K_2O ha^{-1}. Application of 80 kg K_2O ha^{-1} produced higher yield in Co-2 pumpkin (Sundarajan and Muthukrishnan, 1975). Penny *et al.* (1976) observed a markedly poor growth of cucumber in potassium deficient condition. Csermi *et al.* (1990) obtained best results in seed crop of cucumber with 180 kg ha^{-1} of K. Prasanna (1994) reported highest number of fruits in ashgourd when

50 kg ha^{-1} of potassium was applied. Application of 60 kg K significantly increased the early fruit maturity in muskmelon (Singh *et al.*, 1995).

2.9 CHEMICAL CONSTITUENTS IN *Benincasa hispida*

Plants synthesise organic compounds during their metabolic processes when they grow. The nature and amount of these chemical substances vary according to the agro-climatic conditions and growth stage of the plant (Chopra *et al.*, 1958). The active principles may be present in plant parts like cortical region, bark, stem, leaves, flowers, fruits, seeds etc. The main group of phytoconstituents of therapeutic significance are classified as carbohydrates, glycosides, tannins and phenolic compounds, lipids, volatile oils, resin and resin combinations and alkaloids (Handa and Kapoor, 1999).

Waxgourd contain 0.5g glucose and 0.5 g fructose per 100g edible portion, but no sucrose (Wills *et al.*, 1984). Major compounds in ashgourd include E-2 hexenal, n-hexanal and n-hexyl formate (Wu *et al.*, 1987). The fruits contain water 96%, protein 0.4%, fat 0.1%, carbohydrates 3.2%, mineral matter 0.3%, vitamin B1 21 I.U. In addition the fruits also contain Ca, P, Na, Mg, Fe, K, S and starch in minute quantities (Nesamony, 1988).

Amino acids including ∝-amino butyric acid, serine; proteinase, proteins, vitamin B1, vitamin C; glucose, mannitol, rhamnose; n-triacontanol; lupeol, β-sitoserol (fruits); isomultiflorenol acetate (fruit-wax); arachidic, linoleic, linolenic, oleic, palmitic, stearic acids; cucurbitacin B, β-sitoserol (seeds); arginine, aspartic and glutamic acids, lysine (flowers); carotene; citric, malic and oxalic acids; GABA; fructose; sucrose. amino acids including ∝-alanine, glycine and serine (leaves); E-2 hexenal, n-hexanal, n-hexyl formate, 2,5–dimethyl pyrazine, 2-6 dimethyl pyrazine, 2-methyl pyrazine, 2-ethyl-5-methyl pyrazine, 2,3,5– trimethyl pyrazine from the plant (Chatterjee and Prakashi, 1997). Asolkar *et al.* (2000)

reported that fruits contain n-triacontanol, mannitol, several amino acids, glucose, rhamnose, lupeol and β -sitosterol.

2.10 ECONOMIC IMPORTANCE OF *Benincasa hispida*

2.10.1 *Benincasa* as Medicine

Great variability in fruit size were reported by several workers (George, 1981; Randhawa *et al.*, 1983; Hamid *et al.*, 1989; Menon, 1998; Mandal *et al.*, 2002). The small fruited type with thick rind, waxy coat and long keeping quality commonly referred to as neykumbalam is the medicinally important one. The shreddings of the hard pulp of neykumbalam is used for the preparation of ayurvedic medicines like kushmandalehyam, kusmandarasayanam and kushmandakhritham and so this variety is locally known as vaidhya kumbhalom meaning thereby, medicinal ashgourd (Gopalakrishnan, 1957).

Ashgourd is considered good for people suffering from nervousness and debility (Nadakarni, 1927). According to unani system of medicine, sweet meat has medicinal property of imparting energy to heart and brain and also acts as laxative (Sidappa and Sastry, 1959). Peels and seeds of ashgourd boiled in coconut oil is used to promote luxurious growth of hair, to prevent dandruff, dryness of scalp, burning in the eyes and lack of sleep (Majeed, 1969). The fruit is considered tonic, nutritive and diuretic (Dymock *et al.*, 1976; Chopra *et al.*, 1996). Decoction of fruit is laxative, styptic and given for respiratory troubles and internal haemorrhages (CSIR, 1986). Ripe fruits are useful for tridoshas and insanity and also improves intellect. The alkaline fruit juice is useful to reduce hyperacidity (Santhakumar, 1991). Kushmanda is a rejuvenating drug capable of improving intellect and physical strength. Seeds are vermifuge and are useful in difficult urination and bladder stones (Sivarajan and Balachandran, 1994). The paste made of ashgourd fruit can be used in case of burns, guts and minor wounds (Mathewkutty, 1996). Kushmanda lehya, an ayurvedic medicine prepared from pericarp is used for diabetes, piles and dyspepsia. It is used in tumours as dimulant, cooling in fever, remedy in facial cruptioms, seed powder for appendicitis and as antihelmintic (Agarwal, 1997). Fruit juice is applied to haemorrhagic diseases, insanity and epilepsy. It is an effective antidote against mercurial and alcoholic poisoning (Chatterjee and Prakashi, 1997). Seed kernel is used against skin eruption and is one of the ingredients in drug preparation for appendicitis (Asolkar *et al.*, 2000). Fruit powder helps in increasing blood count and used in treating anaemia (Supreeja, 2002).

2.10.2 *Benincasa* as Food

Benincasa is a warm season cucurbitaceous vegetable grown for its fruits. The vegetable is a rich source of vitamins A, B, C, proteins, carbohydrates and minerals (Saimbhi, 1993; Seshadri, 1993). They may be eaten raw but more often are cooked or pickled. The ripe fruit is used for preparing a sweet meat or petha in north India (Supreeja, 2002). Candy is prepared from petha by drying it after draining free of syrup (Anon., 1956).

Tender stems of ashgourd are rich in vitamin B_1 and B_{12} (Agarwal, 1997) and young leaves, vine tips and flower buds are boiled and eaten as greens (Robinson and Decker, 1997).

2.10.3 Other Uses

The dry fruit rind serve as containers and utensils and an elegant serving bowl for soup (Robinson and Decker, 1997).

An enzyme extracted from ashgourd juice was successfully used in place of calf rennet in the production of cheddar cheese. The crop has value as potential fodder crop (Peter *et al.*, 1991).

The fruit wax is used to make candles and as a vehicle for carrying poison for homicide (Robinson and Decker, 1997).

2.11 INTERCROPPING

2.11.1 Intercropping in Plantations

Intercropping as applied to plantation crops refers to growing annuals in the interspaces of main crop. The major objectives in intercropping is to produce an additional crop without affecting too much the yield of base crop, to obtain higher economic returns, to optimize the use of natural resources including light, water and nutrients (Donald, 1963) and to stabilize the yield. The desirability of raising annuals or perennials in the inter spaces of coconut and the advantages arising out of such practices were earlier recognized by Nelliat (1973). The desirable characters of crops to be grown under or between tree crop have been described by Allen (1955) and Hartley (1977). According to Bai and Nair (1982) the ability of crops to come up under shade varied between species. Even cultivars within a crop differ in their productivity under intercropping (Ntari, 1989).

Intercropping in coconut gardens can substantially increase the overall productivity of land according to Liyange *et al.* (1984). It is a source of subsidiary or additional income from coconut plantations (Pillai, 1985). Intercropping is popular because of many advantages like increased productivity per unit area, better use of available resources (land, labour, time, light, water and nutrients), reduction in damage caused by pests, diseases and weed and socio economic factors (Vandermeer, 1989).

Like coconut, oil palm is generally grown as a mono-crop planted at a wide spacing of 10 m x 10 m which leaves a lot of space for intercropping (Rethinam, 1993). Oil palm remains committed to the land for decades with long gestation period, so it is advisable to practice intercropping for getting additional and staggered income. Also it help in the proper maintenance of the plantation and increase the overall yield from the plantation (Rao, 1982). Intercropping is carried out in oil palm plantation in the initial four to five years with Hawain papaya in Costa Rica and with black pepper and passion fruit in Brazil, with soyabean in Ecuador and with cotton in Guatemala (Varghese, 1993). Successful intercropping of arecanut in oil palm plantation is done (Abraham, 1994). Successful intercropping of sunflower, sugarcane, mulberry, tobacco, turnip, tomato, jasmine and vanilla is done in oil palm plantation. Intercropping trials revealed that vegetables like cabbage, cauliflower chillies, cucurbits and tomato can be successfully grown in oil palm plantation during initial years (Anon., 1996).

2.11.2 Intercropping of Medicinal Plants

Many workers (Lahiri, 1972; Singh *et al.*, 1990; Rajithan, 1997) reported successful intercropping of medicinal crops. In earlier studies, performance of some aromatic plants have been found suitable in the plantation of poplar, eucalyptus and subabool (Singh *et al.*, 1985). Studies at Rubber Research Institute of India, Kottayam, Kerala revealed that certain shade tolerant medicinal plants can be cultivated as intercrops in the rubber plantations during the unproductive period. More than 24 species have been reported as potential intercrops (RRII, 1989). Jha and Gupta (1991) studied intercropping of medicinal plants with poplar and their phenology. Out of the sixty four plants tried, thirteen were most suitable for intercropping with *Populus deltoides*.

Nair *et al.* (1991) reported the possibility of growing thirteen medicinal and aromatic plants as intercrops in 8-20 year old coconut plantations when no other inter crops are usually recommended. There is tremendous scope of intercropping of patchouli which is shade loving plant with papaya (Radhakrishnan *et al.*, 1991b). Viswanathan *et al.* (1992) reported successful cultivation of patchouli as intercrop in coconut gardens with palms of uniform age (13 years).

Joshi (1992) has tried to call attention to the inclusion of medicinal plants in afforestation programme for different areas of Gujarat state.

Cataloguing of medicinal plants grown in rubber plantation of Vellanikkara was carried out (Raghavan, 1992; Ramabhadran, 1993). Sunitha (1996) reported the feasibility of growing leguminous medicinal plant species as intercrops in coconut garden. At Rubber Research Institute of India, Kottayam, Kerala, four commercially important medicinal plants were identified based on their growth performance under different light legimes for growing as intercrops in rubber plantations (Neerakkal, 1998). The economic benefit of intercropping tea with *Ginkgo biloba*, a Chinese medicinal plant was reported by Lei (1998). Rathore *et al*. (1999) reported growing of isabagol (*Plantago ovata*) with sugarcane crop. Ram *et al.* (1999) reported that patchouli can be successfully intercropped with papaya with improvement in oil yield by 76 per cent and oil quality by 8.11 per cent over its sole crop. *Tagetes minuta* can be successfully grown under eight year old poplar plantation (Chauhan, 2000). A partial budget of cultivation of five selected medicinal plants indicated that a net profit of about Rs. 5000 per annum per acre was obtainable on intercropping these plants in coconut gardens (Suneetha and Chandrakanth, 2003).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study entitled 'Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations' was conducted at the oil palm plantations of the Oil Palm India Ltd., Kulathupuzha, Kollam district, Kerala during the period 2001-2002.

The details of the materials used and methods adopted for the study are presented in this chapter.

The work was carried out in four phases *viz.*,

1. Collection of accessions of *Benincasa hispida*
2. Germination studies
3. Cultural trial of selected accessions as intercrop in oil palm plantation and as pure crop in open
4. Biochemical analysis

3.1 PHASE I : COLLECTION OF ACCESSIONS OF *Benincasa hispida*

Seeds of twenty different accessions of *Benincasa hispida* were collected from different parts of Kerala. The accessions were duly registered in the Medicinal and Aromatic Plant accession register of the Department of Plantation Crops and Spices, College of Agriculture, Vellayani and accession numbers were allotted.

3.2 PHASE II : GERMINATION STUDIES

Details of twenty accessions of *Benincasa hispida* collected for the study are presented in Table 1.

The viability of seeds collected was estimated as described below. Twenty seeds of each accession were surface sterilized using 0.1 per cent mercuric chloride for one minute and then washed thrice with distilled water. They were then placed on moistened filter paper in petri dishes.

Table 1. Details of *Benincasa hispida* accessions collected for the study

Sl. No.	Accession No.	Accession	Date of collection	Source/place of collection
1	MP–123	Thiruvananthapuram local–1	15–06–01	Venganoor, Thiruvananthapuram
2	MP–124	Idukki local–1	23–06–01	Chungam, Idukki
3	MP–125	Kozhikode local–1	06–08–01	Vatakara, Kozhikode
4	MP–126	Kottayam local–1	11–08–01	Pala, Kottayam
5	MP–127	Kollam local–1	17–11–01	Kottarakkara, Kollam
6	MP–128	Kottayam local–2	22–11–01	Pala, Kottayam
7	MP–129	Thrissur local–1	22–11–01	Vellanikkara, Thrissur
8	MP–130	Thiruvananthapuram local–2	28–11–01	Vattiyoorkavu, Thiruvananthapuram
9	MP–131	Idukki local–2	29–11–01	Thodupuzha, Idukki
10	MP–132	Kottayam local–3	30–11–01	Pala, Kottayam
11	MP–133	Thiruvananthapuram local–3	02–12–01	Nedumangad, Thiruvananthapuram
12	MP–134	Idukki local–3	14–12–01	Koruthodu, Idukki
13	MP–135	Thiruvananthapuram local–4	04–01–02	Valiyasala, Thiruvananthapuram
14	MP–136	Kollam local–2	12–01–02	Nilamel, Kollam
15	MP–137	Thiruvananthapuram local–5	18–01–02	Karakulam, Thiruvananthapuram
16	MP–138	Pathanamthitta local–1	22–03–02	Pathanamthitta
17	MP–139	Kollam local–3	24–03–02	Chadayamangalam, Kollam
18	MP–140	Kollam local–4	17–04–02	Anchalamoodu, Kollam
19	MP–141	Palakkad local–1	20–04–02	Kanimangalam, Palakkad
20	MP–142	Thiruvananthapuram local–6	29–04–02	Kulathoor, Thiruvananthapuram

Seeds were considered to have germinated when the radicle emerged out of seed coat. Seed germination count was taken and germination percentage of each accession was worked out. The number of days taken for 50 per cent germination in each accession was also recorded.

3.3 PHASE III : CULTURAL TRIAL OF ACCESSIONS AS INTERCROP IN OIL PALM PLANTATION AND AS PURE CROP IN OPEN

3.3.1 Experiment Site

Table 2. Geographical and weather parameters of the site selected for study

Location	Oil Palm India Ltd., Kulathupuzha
Latitude	9° 5' N
Longitude	76° 8' E
Altitude	100–300 cm above mean sea level
Temperature	21.7°C - 29.4°C

Table 3. Average rainfall per month during the cropping period (mm)

Month	2000-01	2001-02	2002-03
September	9.39	9.83	8.98
October	9.57	9.27	9.92
November	11.98	12.86	14.76
December	10.61	8.60	-
January	10.60	1.10	-
February	1.30	1.12	-
March	6.90	12.60	-
April	8.70	14.60	-
May	13.20	7.31	-
June	9.11	8.26	-
July	12.49	9.45	-
August	10.36	7.75	-

The soil is deep well drained, clayey loam. Topography is undulating in nature. Palms in the plantation are spaced at 9 m in triangular planting system. The variety of oil palm is Tenera (Dura x Pisifera).

Three sets of experiments were conducted for the study, one under oil palms of age group below five years (young), one under oil palms of age group above eleven years (mature) and one under open condition.

3.3.2 Experimental Design and Layout

The experiment was laid out in split plot design with 2 replications. Shade levels were assigned to the main plot and accessions to the subplots. The details of the layout were as follows.

Number of main plots = 3

Number of sub plots = 20

Replications = 2

The layout plan is shown in Fig.1

3.3.3 Treatments

Main plot – 3 (shade level)

Sub plot – 20 (accessions)

3.3.3.1 Shade levels

S_1: Under oil palms above eleven years (mature)

S_2: Under oil palms below five years (young)

S_3: Under open condition

3.3.3.2 Accessions

A_1: MP-123

A_2: MP-124

A_3: MP-125

A_4: MP-126

A_5: MP-127

Fig. 1 Layout of the experiment

Rep. I

T_4	T_7	T_{18}	T_{17}
T_{12}	T_{14}	T_{11}	T_5
T_9	T_{20}	T_6	T_{13}
T_1	T_8	T_{15}	T_2
T_{16}	T_3	T_{10}	T_{19}

T_{37}	T_{24}	T_{22}	T_{32}
T_{26}	T_{33}	T_{34}	T_{21}
T_{30}	T_{29}	T_{28}	T_{25}
T_{40}	T_{23}	T_{31}	T_{39}
T_{35}	T_{36}	T_{27}	T_{38}

T_{55}	T_{41}	T_{46}	T_{52}
T_{42}	T_{45}	T_{44}	T_{57}
T_{47}	T_{60}	T_{51}	T_{54}
T_{49}	T_{53}	T_{43}	T_{50}
T_{58}	T_{48}	T_{59}	T_{56}

Rep. II

T_{13}	T_{20}	T_5	T_{16}
T_1	T_4	T_{18}	T_2
T_6	T_7	T_{10}	T_{14}
T_8	T_{19}	T_3	T_9
T_{17}	T_{12}	T_{11}	T_{15}

T_{25}	T_{24}	T_{32}	T_{38}
T_{33}	T_{29}	T_{26}	T_{34}
T_{30}	T_{21}	T_{39}	T_{23}
T_{22}	T_{35}	T_{27}	T_{36}
T_{37}	T_{28}	T_{31}	T_{40}

T_{58}	T_{45}	T_{43}	T_{53}
T_{47}	T_{54}	T_{52}	T_{48}
T_{51}	T_{50}	T_{55}	T_{60}
T_{41}	T_{44}	T_{49}	T_{42}
T_{56}	T_{57}	T_{46}	T_{59}

A_6: MP-128

A_7: MP-129

A_8: MP-130

A_9: MP-131

A_{10}: MP-132

A_{11}: MP-133

A_{12}: MP-134

A_{13}: MP-135

A_{14}: MP-136

A_{15}: MP-137

A_{16}: MP-138

A_{17}: MP-139

A_{18}: MP-140

A_{19}: MP-141

A_{20}: MP-142

Treatment combinations

S_1A_1: T_1	S_2A_1: T_{21}	S_3A_1: T_{41}
S_1A_2: T_2	S_2A_2: T_{22}	S_3A_2: T_{42}
S_1A_3: T_3	S_2A_3: T_{23}	S_3A_3: T_{43}
S_1A_4: T_4	S_2A_4: T_{24}	S_3A_4: T_{44}
S_1A_5: T_5	S_2A_5: T_{25}	S_3A_5: T_{45}
S_1A_6: T_6	S_2A_6: T_{26}	S_3A_6: T_{46}
S_1A_7: T_7	S_2A_7: T_{27}	S_3A_7: T_{47}
S_1A_8: T_8	S_2A_8: T_{28}	S_3A_8: T_{48}
S_1A_9: T_9	S_2A_9: T_{29}	S_3A_9: T_{49}
S_1A_{10}: T_{10}	S_2A_{10}: T_{30}	S_3A_{10}: T_{50}
S_1A_{11}: T_{11}	S_2A_{11}: T_{31}	S_3A_{11}: T_{51}

S_1A_{12}: T_{12}	S_2A_{12}: T_{32}	S_3A_{12}: T_{52}
S_1A_{13}: T_{13}	S_2A_{13}: T_{33}	S_3A_{13}: T_{53}
S_1A_{14}: T_{14}	S_2A_{14}: T_{34}	S_3A_{14}: T_{54}
S_1A_{15}: T_{15}	S_2A_{15}: T_{35}	S_3A_{15}: T_{55}
S_1A_{16}: T_{16}	S_2A_{16}: T_{36}	S_3A_{16}: T_{56}
S_1A_{17}: T_{17}	S_2A_{17}: T_{37}	S_3A_{17}: T_{57}
S_1A_{18}: T_{18}	S_2A_{18}: T_{38}	S_3A_{18}: T_{58}
S_1A_{19}: T_{19}	S_2A_{19}: T_{39}	S_3A_{19}: T_{59}
S_1A_{20}: T_{20}	S_2A_{20}: T_{40}	S_3A_{20}: T_{60}

3.3.4 Field Preparation and Sowing

The land was thoroughly prepared by digging and levelling. Manure was applied as per the Package of Practices Recommendations of Kerala Agricultural University (KAU, 2002). Seeds were sown in pits of 60 cm diametre and 35 - 45 cm depth taken at spacing of 4.5 m x 2.0 m. Chemical fertilizers and plant protection chemicals were not applied as the plants were intended for use in ayurvedic pharmaceutical industry.

3.3.5 Growth Parameters

The following biometrical observations were taken at four growth stages, *viz*., pre–flowering stage (35 DAS), flowering stage (70 DAS), fruiting (105 DAS) and harvest stage (140 DAS).

3.3.5.1 Days to 50 per cent Germination

Number of days taken for 50 per cent seed germination was counted and recorded.

3.3.5.2 Vine Length

Length of the vine from the base of the plant to the terminal bud was measured at the time of final harvest and recorded in metre.

3.3.5.3 Branches Plant^{-1}

The number of primary branches of each plant was counted at the time of final harvest and recorded.

3.3.5.4 Leaves Plant^{-1}

The number of leaves of each plant was counted and recorded.

3.3.5.5 Leaf Characters

The shape of leaf lobes in each accessions were noted.

3.3.6 Flowering Characters

3.3.6.1 Days to First Male Flower

Number of days taken from sowing to the bloom of first male flower was recorded.

3.3.6.2 Days to First Female Flower

Number of days taken from sowing to the bloom of first female flower was recorded.

3.3.6.3 Node to First Male Flower

Number of nodes from the base of the plant to the node where the first male flower appeared was recorded.

3.3.6.4 Node to First Female Flower

Number of nodes from the base of the plant to the node where the first female flower appeared was recorded.

3.3.7 Physiological Parameters

3.3.7.1 Dry Matter Production (DMP)

Observational plants of each accession were uprooted, first dried in shade and then dried in hot air oven at 70°C. Dry weight of each plant was recorded and average value was taken as dry matter yield per plant and expressed in gram.

3.3.7.2 Leaf Area Index (LAI)

Leaf area was measured using non–destructive method (Radhakrishnan *et al.*, 1991a) and LAI was worked out as per the method suggested by William (1946).

A = K (L x B)

A : Leaf area/leaf

K : Leaf area constant = 0.828

L : Maximum leaf length

B : Maximum leaf breadth

$$\text{LAI} = \frac{\text{Total leaf area of the plant } (m^2)}{\text{Area of land covered by the plant } (m^2)}$$

3.3.7.3 Net Assimilation Rate (NAR) (g m^{-2} day^{-1})

The method proposed by William (1946) was employed for calculating NAR on leaf dry weight basis.

$$\text{NAR} = \frac{(W_2 - W_1)(\log_e W_2 - \log_e W_1)}{(T_2 - T_1)(L_2 - L_1)}$$

where,

W_1, W_2 : dry weights of whole plants in g at time T_1 and T_2 respectively

L_1, L_2 : leaf area of the plant in m^2 at time T_1 and T_2 respectively

$T_2 - T_1$: time interval in days

3.3.7.4 Crop Growth Rate (CGR) (g m^{-2} day^{-1})

The CGR was calculated using the formula of Watson (1958).

$$\text{CGR} = \frac{(W_2 - W_1)}{P\,(T_2 - T_1)}$$

where,

W_1, W_2 : whole plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: time interval in days

P : ground area in m^2 on which W_1 and W_2 are estimated

3.3.7.5 Absolute Growth Rate (AGR) (g day^{-1})

The AGR was determined using the formula given by Watson (1958).

$$AGR = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

where,

W_1, W_2 : plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: time interval in days

3.3.7.6 Relative Growth Rate (RGR) (g day^{-1})

The RGR was determined as per the formula given by William (1946).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{(T_2 - T_1)}$$

where,

W_1, W_2 : plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: time interval in days

3.3.7.7 Harvest Index (HI)

Harvest index was calculated at final harvest as follows.

$$HI = \frac{Yecon}{Ybiol}$$

where, Yecon : total dry weight of fruits
Ybiol : total dry weight of plant

3.3.8 Yield and Fruit Characters

3.3.8.1 Fruits Plant^{-1}

The total number of fruits produced per plant was counted and recorded.

3.3.8.2 Fruit Length

The length of five fruits at random harvested from each plant was recorded, the average worked out and expressed in centimetres.

3.3.8.3 Fruit Diameter

After cutting the fruits into two halves diameter at the middle of the fruits including the rind was measured and expressed in centimetres.

3.3.8.4 Mean Fruit Weight

The sum of the weight of five fruits selected at random from each plant was taken and their average value was expressed in kilograms.

3.3.8.5 Fruit Yield

Fruit yield per plant was computed as the sum total of the weight of all the fruits in that plant and expressed in kilograms.

3.3.8.6 Rind Thickness

The difference between the fruit diameter and flesh thickness was calculated and expressed in millimetres.

3.3.8.7 Flesh Thickness

Each fruit was cut at the middle, the thickness of flesh measured and recorded in centimetres.

3.3.8.8 Seeds per Fruit

The seeds from five fruits were counted, average worked out and recorded.

3.4 PHASE IV: BIOCHEMICAL ANALYSIS

The mature fruits after removing the rind were made into a pulp in a homogeniser, filtered and made upto known volume. Aliquots from this were used for the analysis of the characters as detailed below.

Table 4a. Analytical methods followed in plant analysis

	Method	References
Total sugars	Copper reduction method using Fehling's solution after HCl digestion	Chopra and Kanwar (1976)
Reducing sugars	Copper reduction method using Fehling's solution	Chopra and Kanwar (1976)
Non–reducing sugars	(Total sugars – reducing sugars) x 0.95	Chopra and Kanwar (1976)
Titrable acidity	Titration against 0.1 N NaOH	Ranganna (1977)

Mature fruits were selected, air dried and then oven dried at 65°C. They were powdered in a willey mill and used for analysis as indicated below.

Table 4b. Analytical methods followed in plant analysis

	Method	References
P	Nitric–perchloric–sulphuric acid (10 : 4 : 1) digestion and colorimetry making use of vandomolybdo phosphoric yellow colour method	Jackson (1973)
Na	Nitric–perchloric–sulphuric acid (10 : 4 : 1) digestion and flame photometry	Jackson (1973)
Ca, Mg	Nitric–perchloric–sulphuric acid (10 : 4 : 1) digestion and titration method	Walton (1960)
Fe	Nitric–perchloric–sulphuric acid (10 : 4 : 1) digestion and atomic absorption spectrophotometry	Chopra and Kanwar (1976)
S	Nitric–perchloric acid (10 : 1) digestion and turbidimetry	Tatabai and Bremner (1970)

3.5 LIGHT INTENSITY

The light intensity and photosynthetically active radiation (PAR) in shaded and open condition was measured using Steady state porometer (T) and expressed as μ mol m^{-2} s^{-1}.

3.6 STATISTICAL ANALYSIS

3.6.1 Analysis of variance

The experimental data were analysed statistically by applying the technique of analysis of variance for split plot design (Gomez and Gomez, 1984).

In cases where the effects were significant, critical differences were calculated for making multiple comparisons among the means. The critical difference for comparison of all the main effects and interaction effects were also computed based on the formula for split plot design. Breakup of total degree of freedom in the analysis of the present study is as given below.

Source	Df
Replications	1
Main plot (shade levels)	2
Error (a)	2
Subplot (accessions)	19
Interaction between shade levels and accessions	38
Error (b)	57
Total	119

3.6.2 SELECTION INDEX

The twenty accessions were discriminated based on sixteen selected important characters using the selection index developed by Smith (1937) and discriminant function of Fisher (1936). A selection index was formulated for twenty five genotypes in ash gourd by Lovely (2001) using fifteen characters. The highest score was recorded by T_3 followed by T_2.

RESULTS

4. RESULTS

The results of the study on "Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] ecotypes in oil palm plantations" are presented in this chapter. Phase1 consists of collection of accessions of *Benincasa hispida*. Phase 2 consists of germination studies. Phase 3 consists of cultural trial of accessions as inter crop in oil palm plantations and as pure crop in open and Phase 4 consists of biochemical analysis

4.1 PHASE 1: COLLECTION OF ACCESSIONS OF *Benincasa hispida*

Seeds of different accessions of *Benincasa hispida* were collected from different parts of state. List of collected accessions with their sources is given in Table 1.

4.2 PHASE 2:GERMINATION STUDIES

Seeds of twenty accessions collected were subjected to germination test. Observations on the germination percentage and days to fifty-per cent germination were recorded for each accession. The results of seed germination test are presented in Table 5.

4.3 PHASE 3: CULTURAL TRIAL OF ACCESSIONS AS INTERCROP IN OILPALM PLANTATION AND AS PURE CROP IN OPEN

The selected accessions were raised in split plot design with two replications under mature plantation, young plantation as well as under open condition. Observations were made at four stages of growth *viz.*, vegetative stages (35 DAS), flowering stage (70 DAS), fruiting stage (105 DAS) and harvest stage (140 DAS).

Table 5.Seed germination studies of *Benincasa hispida*

Sl. No.	Accession	Seed germination percentage	Number of days to 50 per cent germination
1	A_1	90.0	7.00
2	A_2	95.0	6.50
3	A_3	87.5	7.00
4	A_4	90.0	7.00
5	A_5	65.0	9.00
6	A_6	90.0	6.00
7	A_7	87.5	7.50
8	A_8	85.0	7.50
9	A_9	90.0	7.00
10	A_{10}	92.5	6.00
11	A_{11}	95.0	7.00
12	A_{12}	90.0	6.00
13	A_{13}	75.0	8.00
14	A_{14}	80.0	7.00
15	A_{15}	80.0	7.00
16	A_{16}	90.0	6.00
17	A_{17}	85.0	7.00
18	A_{18}	82.5	7.50
19	A_{19}	87.5	6.00
20	A_{20}	70.0	8.00

4.3.1 Growth Parameters

4.3.1.1 Days to 50 per cent Germination

The different shade levels did not produce any significant effect on days to 50-per cent germination. Accessions showed significant differences on days to 50 per cent germination. Lowest days to 50 per cent germination was recorded by A_2 (6.00 days), A6 (6.00 days), A_{10} (6.00 days) and A_{12} (6.00 days). It was on par with A_{16} (6.33 days) and A_{19} (6.17 days) (Table 6).

4.3.1.2 Vine Length

Different shade levels had significant influence on length of the vine. An increase in shade level resulted in an increase in vine length. Higher vine length was observed at S_1 (8.90 m).

There was significant difference among the accessions in length of vine. Higher vine length was recorded by A_{13} (12.01 m) (Table 7).

Interaction effect was found to be significant in influencing vine length. The treatment combination S_1A_{13} (13.48 m) produced higher vine length (Table 8).

4.3.1.3 Branches Plant^{-1}

The different shade levels and accessions did not produce any significant effect on branches plant^{-1} (Table 9).

4.3.1.4 Leaves Plant^{-1}

Number of leaves was significantly influenced by different shade levels at all stages of growth. An increase in shade level resulted in decrease in leaf number at all stages.

Different accessions showed significant difference in leaf number at all growth stages except fruiting stage. At vegetative stage, higher number of leaves was recorded by A_{15} (7.44). It was on par with A_7 (7.21).

At flowering stage, higher number of leaves was recorded by A_{15} (41.12) which was on par with A_{11} (40.13). At fruiting stage, higher

Table 6. Effect of different oil palm shade levels and accessions on days to 50 per cent germination

Treatments	Number of days to 50 per cent germination
Shade levels	
S_1	7.00
S_2	7.03
S_3	6.95
$F_{2, 57}$	0.33
SE	0.07
CD	NS
Accessions	
A_1	6.67
A_2	6.00
A_3	7.00
A_4	7.00
A_5	8.67
A_6	6.00
A_7	7.17
A_8	8.00
A_9	7.33
A_{10}	6.00
A_{11}	7.00
A_{12}	6.00
A_{13}	8.17
A_{14}	7.17
A_{15}	7.00
A_{16}	6.33
A_{17}	7.00
A_{18}	7.17
A_{19}	6.17
A_{20}	8.00
$F_{2, 57}$	38.08**
SE	0.13
CD	0.359

**Significant at 1 per cent level

Table 7. Effect of different oil palm shade levels and accessions on vine length, m

Treatments	Vine length
Shade levels	
S_1	8.90
S_2	7.90
S_3	6.63
$F_{2, 57}$	1064.9**
SE	0.01
CD	0.07
Accessions	
A_1	6.49
A_2	10.70
A_3	6.58
A_4	6.25
A_5	6.32
A_6	6.15
A_7	5.66
A_8	6.22
A_9	6.90
A_{10}	9.67
A_{11}	8.67
A_{12}	7.72
A_{13}	12.01
A_{14}	11.36
A_{15}	9.47
A_{16}	5.97
A_{17}	8.30
A_{18}	6.16
A_{19}	6.81
A_{20}	8.82
$F_{2, 57}$	1742.91**
SE	0.05
CD	0.133

**Significant at 1 per cent level

Table 8. Interaction effect of different oil palm shade levels and accessions on vine length, m

Accession	S_1	S_2	S_3
A_1	7.30	6.42	5.76
A_2	12.30	10.41	9.39
A_3	7.54	6.87	5.33
A_4	7.12	6.47	5.17
A_5	7.26	6.50	5.20
A_6	7.08	6.32	5.06
A_7	6.42	5.88	4.67
A_8	7.15	6.40	5.12
A_9	8.02	6.71	5.98
A_{10}	10.97	10.17	7.88
A_{11}	9.86	9.04	7.12
A_{12}	8.58	7.82	6.76
A_{13}	13.48	12.32	10.23
A_{14}	12.52	11.70	9.85
A_{15}	11.00	9.36	8.05
A_{16}	7.05	5.74	5.12
A_{17}	9.55	8.28	7.06
A_{18}	7.11	6.04	5.34
A_{19}	7.83	6.75	5.86
A_{20}	9.95	8.87	7.66

$F_{38, 57}$: 15.00**
SE : 0.08
CD : 0.230

**Significant at 1 per cent level

Table 9. Effect of different oil palm shade levels and accessions on branches plant^{-1}

Treatments	Branches plant^{-1}
Shade levels	
S_1	1.65
S_2	2.61
S_3	3.33
$F_{2, 57}$	2031.55
SE	0.02
CD	NS
Accessions	
A_1	3.28
A_2	2.15
A_3	1.56
A_4	3.55
A_5	3.93
A_6	2.27
A_7	3.82
A_8	3.01
A_9	2.91
A_{10}	1.67
A_{11}	1.19
A_{12}	1.64
A_{13}	1.62
A_{14}	1.82
A_{15}	1.71
A_{16}	1.06
A_{17}	2.47
A_{18}	3.59
A_{19}	4.01
A_{20}	3.36
$F_{19, 57}$	394.60
SE	0.05
CD	NS

number of leaves was recorded by A_{15} (42.27). At harvest stage, A_{20} (21.17) recorded the highest number of leaves. It was on par with A_{15} (20.77) and A_{11} (19.79) (Table 10).

Interaction effect was significant in influencing the number of leaves at all growth stages except fruiting stage. At vegetative stage, treatment combination S_3A_{15} (9.5) recorded higher number of leaves followed by S_3A_7 (8.3). At flowering stage, treatment combination S_3A_{15} (52.6) recorded higher number of leaves. It was on par with S_3A_{11} (51).

At harvest stage, higher number of leaves was recorded by treatment combination S_3A_{15} (32.12). It was on par with S_3 A_{11} (31.26) and S_3A_{20} (30.6) (Table 11).

4.3.1.5 Nature of leaf Lobes

The nature of leaf lobes of twenty accessions under different shade levels are given in Table 12.

4.3.2 Flowering Characters

4.3.2.1 Days to First Male Flower

Difference shade levels had significant influence on days to first male flower. Least value was obtained at S_3 (56.19 days).

Accessions showed significant differences on the days to first male flower. Among the accessions, A_7 (54.17 days) was the earliest. It was on par with A_8 (54.25 days) A_{17} (54.39 days) and A_3 (54.95 days) (Table 13).

Interaction effect was significant in influencing days to first male flower. Lower days to first male flower was recorded by the treatment combination S_3A_7 (49.07 days). It was on par with S_3A_{17} (50.00 days) (Table 14).

4.3.2.2 Days to First Female Flower

Different shade levels had significant influence on days to first female flower. Lower number of days was recorded at S_3 (65.20 days).

Table 10. Effect of different oil palm shade levels and accessions on leaves plant^{-1}

Treatments	Vegetative stage (35 DAS)	Flowering stage (70 DAS)	Fruiting stage (105 DAS)	Harvest stage (140 DAS)
Shade levels				
S_1	3.93	17.57	18.12	8.01
S_2	5.67	32.88	33.52	16.49
S_3	6.90	39.57	40.30	21.34
$F_{2, 57}$	1983.13**	10507.23**	69623.48**	2011.82**
SE	0.03	0.11	0.04	0.15
CD	0.204	0.670	0.262	0.915
Accessions				
A_1	3.84	24.62	23.76	13.04
A_2	5.20	31.82	31.95	15.91
A_3	5.00	26.44	27.52	14.67
A_4	5.49	32.25	33.32	17.40
A_5	5.74	36.05	36.42	17.50
A_6	5.33	25.42	26.21	12.16
A_7	7.21	31.95	31.99	16.05
A_8	5.54	25.70	25.18	12.62
A_9	4.87	25.45	23.86	13.89
A_{10}	5.55	29.09	29.77	15.05
A_{11}	6.62	40.13	41.73	19.79
A_{12}	5.36	25.54	27.13	12.57
A_{13}	5.15	33.96	35.46	16.69
A_{14}	5.09	28.77	30.05	12.46
A_{15}	7.44	41.12	42.27	20.77
A_{16}	4.94	24.38	24.76	12.64
A_{17}	5.21	25.12	26.12	12.68
A_{18}	5.83	30.77	31.86	15.66
A_{19}	4.51	24.15	25.07	12.86
A_{20}	6.04	37.41	38.40	21.17
$F_{19, 57}$	40.74**	173.01**	78.92	18.43**
SE	0.13	0.41	0.65	0.67
CD	0.376	1.170	NS	1.897

**Significant at 1 per cent level

Table 11. Interaction effect of different oil palm shade levels and accessions on leaves $plant^{-1}$

Treatments	Vegetative stage			Flowering stage			Harvest stage		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
A_1	3.11	3.62	4.80	15.75	26.11	32.00	9.50	14.32	15.30
A_2	3.33	5.12	7.14	18.67	34.66	42.12	9.23	18.40	20.11
A_3	4.04	5.30	5.67	13.32	27.17	38.84	6.11	16.67	21.23
A_4	3.42	6.02	7.02	14.46	38.04	44.26	10.33	19.75	22.12
A_5	3.60	6.42	7.21	20.34	40.41	47.40	10.46	19.14	22.91
A_6	4.00	5.50	6.50	17.8	25.45	33.00	6.62	12.20	17.67
A_7	6.33	7.00	8.30	21.66	35.34	38.86	9.50	18.45	20.21
A_8	3.88	6.75	6.00	16.72	26.05	34.33	7.48	11.17	19.20
A_9	3.05	5.21	6.34	20.00	23.67	32.67	11.00	12.32	18.34
A_{10}	3.11	6.43	7.12	11.46	34.46	41.34	4.28	16.41	24.45
A_{11}	5.65	6.00	8.22	24.10	45.30	51.00	9.12	19.00	31.26
A_{12}	4.13	5.32	6.64	14.54	29.74	32.33	5.38	17.33	14.99
A_{13}	3.20	5.15	7.14	18.37	38.22	45.28	7.86	20.81	21.41
A_{14}	3.00	5.18	7.08	15.28	32.67	38.37	5.19	15.18	17.02
A_{15}	6.00	6.83	9.50	25.02	45.75	52.6	11.50	18.70	32.12
A_{16}	3.33	5.40	6.08	16.50	25.22	31.41	6.44	14.12	17.36
A_{17}	3.46	6.00	6.16	14.52	26.38	34.45	6.23	13.38	18.43
A_{18}	3.71	6.12	7.67	16.75	33.67	41.90	7.56	18.43	20.99
A_{19}	4.07	4.14	5.33	14.00	26.46	32.00	5.09	12.50	21.00
A_{20}	4.11	6.00	8.00	22.13	42.75	47.34	11.35	21.55	30.60
$F_{19,37}$	7.31**			21.07**			5.47**		
SE	0.23			0.71			1.16		
CD	0.62			2.027			3.287		

**Significant at 1 per cent level

Table 12. Nature of leaf lobes

	S_1	S_2	S_3
A_1	Intermediate	Intermediate	Intermediate
A_2	Intermediate	Intermediate	Intermediate
A_3	Intermediate	Intermediate	Intermediate
A_4	Intermediate	Intermediate	Intermediate
A_5	Intermediate	Intermediate	Intermediate
A_6	Intermediate	Intermediate	Intermediate
A_7	Intermediate	Intermediate	Intermediate
A_8	Shallow	Shallow	Shallow
A_9	Intermediate	Intermediate	Intermediate
A_{10}	Intermediate	Intermediate	Intermediate
A_{11}	Shallow	Shallow	Shallow
A_{12}	Intermediate	Intermediate	Intermediate
A_{13}	Intermediate	Intermediate	Intermediate
A_{14}	Intermediate	Intermediate	Intermediate
A_{15}	Intermediate	Intermediate	Intermediate
A_{16}	Intermediate	Intermediate	Intermediate
A_{17}	Intermediate	Intermediate	Intermediate
A_{18}	Intermediate	Intermediate	Intermediate
A_{19}	Intermediate	Intermediate	Intermediate
A_{20}	Intermediate	Intermediate	Intermediate

Accessions showed significance differences on the days to first female flower. Among the accessions, A_7 (62.00 days) was the earliest which was on par with A_{17} (62.28 days) (Table 13).

Interaction effect was significant in influencing days to first female flower. Lower number of day was recorded by the treatment combination S_3A_{17} (56.31 days). It was on par with S_3A_7 (58.67 days) and S_3A_1 (59.92 days) (Table 14).

4.3.2.3 Node to First Male Flower

Node to first male flower was influenced significantly by different shade levels. The lowest node at which first male flower was produced was recorded at S_3 (16.10).

Accession varied significantly among them in node to first male flower. Lowest node was recorded by A_{10} (11.83). It was on par with A_{15} (12.29) (Table 15).

4.3.2.4 Node to First Female Flower

Node to first female flower was influenced significantly by different shade levels. The lowest node at which first female flower was produced was recorded at S_3 (22.51).

Accessions differed significantly among them in node to first female flower. Lowest node was recorded by A_{18} (18.88). It was on par with A_{14} (18.95) and A_{15} (19.06) (Table 15).

4.3.3 Physiological Parameters

4.3.3.1 Dry Matter Production

Dry Matter Production (DMP) was significantly influenced by different shade levels at all stages of growth. An increase in shade level resulted in decrease in DMP at all stages. Higher DMP at vegetative stage (8.59 g), flowering stage (57.54 g), fruiting stage (64.98 g) and harvest stage (261.86 g) was observed at S_3.

Table 13. Effect of different oil palm shade levels and accessions on days to first male flower and days to first female flower

Treatments	Days to first male flower	Days to first female flower
Shade levels S_1	66.05	74.57
S_2	59.53	67.89
S_3	56.19	65.20
$F_{2, 57}$	1572.07**	763.23**
SE	0.13	0.17
CD	0.770	1.062
Accessions A_1	60.78	63.88
A_2	58.89	68.47
A_3	54.95	65.38
A_4	57.21	70.53
A_5	78.96	93.41
A_6	55.84	66.47
A_7	54.17	62.00
A_8	54.25	64.63
A_9	58.10	65.55
A_{10}	64.83	71.46
A_{11}	58.92	69.67
A_{12}	62.69	74.51
A_{13}	67.71	71.91
A_{14}	63.55	65.31
A_{15}	69.43	77.64
A_{16}	58.03	67.36
A_{17}	54.39	62.28
A_{18}	58.17	64.76
A_{19}	60.14	67.27
A_{20}	60.78	71.91
$F_{19, 57}$	253.29**	358.23**
SE	0.38	0.37
CD	1.087	1.050

** Significant at 1 per cent level

Table 14. Interaction effect of different oil palm shade levels and accessions on days to first male flower and days to first female flower

	Days to first male flower			Days to first female flower		
	S_1	S_2	S_3	S_1	S_2	S_3
A_1	65.74	59.58	57.01	69.12	62.6	59.92
A_2	62.83	58.14	55.71	71.41	67.56	66.43
A_3	59.50	54.34	51.00	70.22	64.25	61.67
A_4	60.75	56.17	54.72	75.65	69.93	66.00
A_5	82.45	78.31	76.12	98.20	92.04	90.00
A_6	61.17	53.95	52.40	72.25	65.61	61.56
A_7	60.24	53.21	49.07	66.33	60.99	58.67
A_8	58.60	53.06	51.10	69.99	63.20	60.72
A_9	62.43	57.04	54.83	70.84	64.82	61.00
A_{10}	70.26	63.88	60.34	77.33	70.04	67.00
A_{11}	63.22	58.04	55.50	72.93	69.65	66.43
A_{12}	69.00	61.78	57.30	80.46	72.41	70.67
A_{13}	75.78	65.34	62.00	77.68	70.72	67.33
A_{14}	69.86	62.11	58.67	71.99	63.33	60.60
A_{15}	75.14	69.82	63.33	82.14	76.48	74.30
A_{16}	62.38	57.48	54.22	74.33	65.76	62.00
A_{17}	59.83	53.33	50.00	68.5	60.04	58.31
A_{18}	66.70	56.49	51.33	68.88	63.22	62.18
A_{19}	67.62	59.12	53.67	73.69	65.09	63.03
A_{20}	67.56	59.34	55.43	79.42	70.11	66.20
$F_{38, 57}$	4.58**			3.02**		
SE	0.66			0.64		
CD	1.883			1.819		

** Significant at 1 per cent level

Table 15. Effect of different oil palm shade levels and accessions on node to first male flower and node to first female flower

Treatments	Node to first male flower	Node to first female flower
Shade levels		
S_1	17.44	23.94
S_2	16.71	23.18
S_3	16.10	22.51
$F_{2, 57}$	1545**	431.86**
SE	0.02	0.03
CD	0.104	0.208
Accessions		
A_1	15.67	21.68
A_2	15.52	25.70
A_3	16.76	23.69
A_4	22.76	26.28
A_5	20.12	27.49
A_6	16.94	24.00
A_7	24.84	33.71
A_8	15.55	20.52
A_9	16.74	23.11
A_{10}	11.83	20.07
A_{11}	16.15	24.67
A_{12}	18.25	22.22
A_{13}	16.17	22.09
A_{14}	12.72	18.95
A_{15}	12.29	19.06
A_{16}	17.83	24.66
A_{17}	16.29	22.33
A_{18}	13.12	18.88
A_{19}	15.88	22.16
A_{20}	19.63	22.97
$F_{19, 57}$	373.96**	594.72**
SE	0.17	0.14
CD	0.481	0.402

** Significant at 1 per cent level

Different accessions showed significant difference in DMP at all growth stages. At vegetative stage, higher DMP was recorded by A_{15} (9.50 g plant^{-1}). It was on par with A7 (8.99 g plant^{-1}).

At flowering stage, higher DMP was recorded by A_{15} (60.49 g plant^{-1}) which was significantly different from all other accessions.

At fruiting stage, A_{15} (66.07 g plant^{-1}) recorded higher DMP. It was on par with A_{11} (64.00 g plant^{-1}).

At harvest stage, higher DMP was recorded by A_2 (429.99 g plant^{-1}) which was significantly higher than other accessions (Table 16).

Interaction effect was significant in influencing DMP at all growth stages. At vegetative stage, treatment combination S_3A_{15} (12.4 g plant $^{-1}$) recorded higher DMP. It was on par with S_3A_7 (12.05 g plant^{-1}).

At flowering stage, S_3A_{15} (77.37 g plant^{-1}) recorded higher DMP which was followed by S_3A_{11} (72.04 g plant^{-1}) and S_3A_{20} (69.62 g plant^{-1}).

At fruiting stage, higher DMP was recorded by treatment combination S_3A_{15} (85.48 g plant^{-1}). It was on par with S_3A_{11} (81.72 g plant^{-1}).

At harvest stage, higher DMP was recorded by treatment combination S_3A_2 (608.66 g plant^{-1}) which was significantly different from all other accessions (Table 17).

4.3.3.2 Leaf Area Index

Different shade levels significantly influenced Leaf Area Index (LAI) at all stages of growth. An increase in shade level resulted in decrease in LAI. At harvest stage, LAI at S_3 (0.03) was on par with S_2 (0.023).

LAI varied significantly among the different accessions. At vegetative stage, higher LAI was recorded by A_7 (0.004), A_{11} (0.004) and A_{15} (0.004).

Table 16. Effect of different oil palm shade levels and accessions on dry matter production, g plant^{-1}

Treatments	Vegetative stage	Flowering stage	Fruiting stage	Harvest stage
Shade levels				
S_1	4.65	25.44	27.03	68.19
S_2	6.79	46.73	51.97	228.43
S_3	8.59	57.54	64.98	261.86
$F_{2, 57}$	1099.52**	62082.46**	25727.16**	79753.05**
SE	0.06	0.07	0.12	0.37
CD	0.362	0.399	0.732	2.231
Accessions				
A_1	4.74	35.42	37.97	94.07
A_2	6.14	45.15	51.49	429.99
A_3	5.58	37.61	43.47	79.18
A_4	7.12	41.43	47.13	114.54
A_5	7.00	49.40	53.22	65.41
A_6	6.42	36.72	39.74	87.80
A_7	8.99	51.33	55.33	114.64
A_8	6.57	37.77	43.16	125.40
A_9	6.29	37.01	40.51	121.86
A_{10}	6.75	42.42	46.71	198.72
A_{11}	7.82	57.99	64.00	348.56
A_{12}	6.31	36.79	42.14	268.58
A_{13}	6.19	49.03	56.16	292.53
A_{14}	6.19	41.29	45.57	284.46
A_{15}	9.50	60.49	66.07	334.12
A_{16}	5.73	34.89	39.29	115.51
A_{17}	5.86	36.61	40.46	127.98
A_{18}	6.69	43.26	48.49	132.36
A_{19}	6.10	35.44	37.37	81.58
A_{20}	7.52	54.68	61.63	305.89
$F_{19, 57}$	30.09**	1250.56**	101.65**	2161.90**
SE	0.20	0.23	0.88	2.39
CD	0.577	0.641	2.487	6.774

** Significant at 1 per cent level

Table 17. Interaction effect of different oil palm shade levels and accessions on dry matter production, g plant^{-1}

	Vegetative stage			Flowering stage			Fruiting stage			Harvest stage		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
A_1	4.10	4.15	5.96	22.36	36.82	47.07	23.71	38.56	51.63	52.79	108.57	120.86
A_2	4.15	6.08	8.18	26.43	48.45	60.58	27.68	55.64	71.14	120.50	560.83	608.66
A_3	4.20	6.12	6.43	19.51	38.96	54.37	19.88	46.42	64.11	24.25	94.78	118.50
A_4	4.12	7.10	10.15	21.27	38.92	64.11	23.97	45.69	71.74	40.13	131.10	122.38
A_5	4.14	8.24	8.62	28.54	50.94	68.72	29.96	54.77	75.53	37.85	75.88	82.49
A_6	5.01	6.88	7.38	25.18	36.43	48.54	27.05	39.81	52.35	38.45	103.43	121.53
A_7	6.50	8.41	12.05	30.86	57.98	65.16	32.85	61.94	71.19	72.78	120.44	150.7
A_8	4.18	7.50	8.02	24.49	38.32	50.49	27.55	43.57	58.36	54.18	148.23	173.79
A_9	3.82	7.16	7.88	29.42	34.05	47.57	30.62	36.55	54.37	72.14	136.12	157.33
A_{10}	4.12	7.36	8.76	16.46	50.71	60.10	17.96	55.25	66.92	22.65	257.51	315.99
A_{11}	6.21	7.15	10.11	35.31	66.61	72.04	35.95	74.34	81.72	108.58	451.23	485.87
A_{12}	5.32	6.18	7.44	21.07	42.74	46.56	22.91	49.53	53.99	81.24	356.52	367.97
A_{13}	4.36	6.05	8.15	26.22	55.22	65.64	29.96	63.58	75.15	113.15	354.3	410.15
A_{14}	4.10	6.10	8.38	21.47	48.01	54.39	22.11	51.31	63.29	101.72	361.00	390.67
A_{15}	7.03	9.08	12.40	37.82	66.29	77.37	38.48	74.26	85.48	111.34	377.08	513.95
A_{16}	4.13	5.96	7.10	24.27	36.03	44.37	25.58	41.74	50.54	55.65	140.29	150.58
A_{17}	3.85	6.89	6.84	21.35	38.8	49.67	23.34	42.35	55.68	91.08	140.48	152.39
A_{18}	4.18	7.14	8.76	23.63	48.52	57.63	25.06	54.95	65.46	42.67	159.14	195.28
A_{19}	4.18	5.08	9.03	20.59	38.92	46.80	21.25	40.47	50.38	27.43	102.05	115.27
A_{20}	5.26	7.11	10.20	32.54	61.88	69.62	35.44	68.82	80.62	95.24	389.65	432.78
$F_{38, 57}$	5.31**			151.62**			12.99**			333.50**		
SE	0.35			0.39			1.52			4.14		
CD	0.999			1.110			4.308			11.733		

** Significant at 1 per cent level

At flowering stage, A_{15} (0.052) recorded higher LAI. It was on par with A_{11} (0.050).

At fruiting stage, higher LAI was recorded by A_{15} (0.046). It was on par with A_{11} (0.045) and A_{20} (0.045).

At harvest stage, higher LAI was recorded by A_6 (0.040). It was on par with A_4 (0.030) and A_2O (0.029) (Table 18).

Interaction effect was significant in influencing LAI at all growth stages except harvest stage. At vegetative stage higher LAI was recorded by treatment combination S_3A_{15} (0.0065). It was on par with S_3A_7 (0.0062).

At flowering stage, treatment combination S_3A_{15} (0.075) recorded higher LAI. It was on par with S_3A_{11} (0.073).

At fruiting stage, higher LAI was recorded by S_3A_{13} (0.067) and S_3A_{15} (0.067) which was on par with S_3A_{11} (0.065) and S_3A_{20} (0.064) (Table 19).

4.3.3.3 Crop Growth Rate

Crop growth rate (CGR) was significantly influenced by different shade levels during the three periods of growth. Higher CGR was observed at S_3 during all the growth periods.

During the period from vegetative to flowering, there was significant difference in CGR among the accessions. Higher CGR was recorded by A_{11} (0.16 g m^{-2} day^{-1}) and A_{15} (0.16 g m^{-2} day^{-1}).

For the period from flowering to fruiting, accessions varied significantly among them in CGR. Higher CGR was recorded by A_2 (0.02 g m^{-2} day^{-1}), A_3 (0.02 g $m^{-2}day^{-1}$), A_4 (0.02 g m^{-2} day^{-1}), A_8 (0.02 g m^{-2} day^{-1}), A_{11} (0.02 g m^{-2} day^{-1}), A_{12} (0.02 g m^{-2} day^{-1}), A_{13} (0.02 g m^{-2} day^{-1}), A_{15} (0.02 g m^{-2} day^{-1}), A_{18} (0.02g $m^{-2}day^{-1}$) and A_{20} (0.02 g m^{-2} day^{-1}).

Table 18. Effect of different oil palm shade levels and accessions on LAI

Treatments	Vegetative stage	Flowering stage	Fruiting stage	Harvest stage
Shade levels				
S_1	0.001	0.019	0.017	0.014
S_2	0.002	0.036	0.034	0.023
S_3	0.004	0.054	0.050	0.030
$F_{2, 57}$	9246.87**	99607.25**	3804.00**	23.53**
SE	0.00002	0.00005	0.0003	0.002
CD	0.0001	0.0003	0.002	0.010
Accessions				
A_1	0.001	0.028	0.026	0.018
A_2	0.002	0.041	0.038	0.023
A_3	0.002	0.033	0.032	0.020
A_4	0.003	0.041	0.039	0.030
A_5	0.003	0.044	0.040	0.025
A_6	0.003	0.029	0.026	0.018
A_7	0.004	0.039	0.036	0.040
A_8	0.003	0.031	0.029	0.018
A_9	0.001	0.028	0.026	0.020
A_{10}	0.003	0.035	0.034	0.022
A_{11}	0.004	0.050	0.045	0.027
A_{12}	0.002	0.031	0.027	0.017
A_{13}	0.002	0.041	0.043	0.025
A_{14}	0.003	0.039	0.035	0.016
A_{15}	0.004	0.052	0.046	0.028
A_{16}	0.002	0.027	0.026	0.019
A_{17}	0.002	0.030	0.027	0.018
A_{18}	0.002	0.039	0.035	0.022
A_{19}	0.001	0.025	0.023	0.017
A_{20}	0.003	0.044	0.045	0.029
$F_{2, 57}$	92.21**	45.97**	91.77**	2.11**
SE	0.00008	0.001	0.0008	0.004
CD	0.0002	0.003	0.002	0.011

**Significant at 1 per cent level

Table 19. Interaction effect of different oil palm shade levels and accessions on LAI

Treatments	Vegetative stage			Flowering stage			Fruiting stage		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
A_1	0.0003	0.0006	0.0028	0.015	0.023	0.045	0.017	0.021	0.041
A_2	0.0004	0.0015	0.0049	0.021	0.041	0.061	0.018	0.040	0.056
A_3	0.0003	0.0029	0.0035	0.014	0.030	0.055	0.017	0.028	0.050
A_4	0.0007	0.0018	0.0052	0.018	0.046	0.059	0.020	0.042	0.056
A_5	0.0012	0.0026	0.0056	0.022	0.049	0.061	0.018	0.044	0.060
A_6	0.0012	0.0028	0.004	0.018	0.025	0.044	0.017	0.021	0.041
A_7	0.0018	0.0029	0.0062	0.025	0.042	0.050	0.022	0.041	0.045
A_8	0.0014	0.0025	0.0041	0.018	0.024	0.051	0.017	0.027	0.044
A_9	0.0004	0.0016	0.0025	0.016	0.023	0.046	0.015	0.022	03.042
A_{10}	0.0004	0.0027	0.0048	0.015	0.040	0.050	0.013	0.041	0.048
A_{11}	0.0023	0.0038	0.0053	0.027	0.049	0.073	0.019	0.051	0.065
A_{12}	0.0004	0.002	0.0048	0.017	0.030	0.045	0.014	0.028	0.040
A_{13}	0.0003	0.0012	0.0046	0.020	0.047	0.058	0.017	0.045	0.067
A_{14}	0.0003	0.0014	0.006	0.018	0.044	0.056	0.016	0.041	0.048
A_{15}	0.0021	0.0028	0.0065	0.030	0.050	0.075	0.025	0.048	0.067
A_{16}	0.0003	0.0018	0.0033	0.017	0.022	0.043	0.018	0.020	0.041
A_{17}	0.0003	0.002	0.0044	0.016	0.024	0.049	0.014	0.023	0.044
A_{18}	0.0004	0.0023	0.0043	0.020	0.038	0.060	0.017	0.034	0.055
A_{19}	0.0004	0.0007	0.0021	0.014	0.020	0.041	0.013	0.019	0.038
A_{20}	0.0004	0.003	0.005	0.026	0.052	0.055	0.023	0.048	0.064
$F_{38, 57}$	23.41**			6.87**			17.49**		
SE	0.0001			0.002			0.001		
CD	0.0004			0.006			0.004		

**Significant at 1 per cent level

For the period from fruiting to harvest also, accessions differed significantly among them, in CGR and A_2 (1.20 g m^{-2} day^{-1}) recorded higher CGR which was significantly different from all other accessions (Table 20).

Interaction effect was significant in influencing CGR during the period from vegetative to flowering. Higher CGR was recorded by the treatment combination S_3A_{15} (0.21 g m^{-2} day^{-1}) followed by S_3A_{11} (0.20 g m^{-2} day^{-1}).

During the period from flowering to fruiting, interaction effect was not significant in influencing CGR.

For the period from fruiting to harvesting, interaction effect was significant in influencing CGR. Higher CGR was recorded by treatment combination S_3A_2 (1.7 g m^{-2} day^{-1}) which was significantly different from all other accessions (Table 21).

4.3.3.4 Absolute Growth Rate

Absolute growth rate (AGR) was significantly influenced by different shade levels during the three periods of growth. Higher AGR was observed at S_3 during all the growth periods.

During the period from vegetative to flowering, AGR varied significantly among the accessions. Higher AGR was recorded by A_{15} (1.46 g day^{-1}). It was on par with A_{11} (1.43 g day^{-1}).

During the period from flowering to fruiting, accessions differed significantly in AGR. Higher AGR was recorded by A_{13} (0.20 g day^{-1}) and A_{20} (0.20 g day^{-1}). It was on par with A_2 (0.18 g day^{-1}), A_3 (0.17 g day^{-1}), A_{11} (0.17 g day^{-1}), A_4 (0.16 g day^{-1}), A_{15} (0.16 g day^{-1}), A_8 (0.15 g day^{-1}), A_{12} (0.15 g day^{-1}) and A_{18} (0.15 g day^{-1}).

For the period from fruiting to harvesting also, accessions varied significantly among them in AGR. A_2 (10.82 g day^{-1}) recorded higher AGR which was significantly different from all other accessions (Table 20).

Table 20. Effect of different oil palm shade levels and accessions on CGR and AGR

Treatments	CGR, g m^{-2} day^{-1}			AGR, g day^{-1}		
	Period I (35-70 DAS)	Period II (70-105 DAS)	Period III (105-140 DAS)	Period I (35-70 DAS)	Period II (70-105 DAS)	Period III (105-140 DAS)
Shade levels						
S_1	0.07	0.01	0.14	0.59	0.05	1.18
S_2	0.13	0.017	0.56	0.14	0.15	5.04
S_3	0.16	0.024	0.63	1.40	0.21	5.63
$F_{2, 57}$	20821.46**	268.61**	50417.26**	38381.7**	236.07**	47887.51**
SE	0.0003	0.0006	0.001	0.002	0.005	0.01
CD	0.002	0.003	0.007	0.013	0.033	0.067
Accessions						
A_1	0.10	0.01	0.18	0.88	0.07	1.60
A_2	0.12	0.02	1.20	1.11	0.18	10.82
A_3	0.10	0.02	0.11	0.92	0.17	1.02
A_4	0.11	0.02	0.21	0.98	0.16	1.93
A_5	0.14	0.01	0.04	1.21	0.11	0.35
A_6	0.10	0.01	0.15	0.87	0.09	1.37
A_7	0.14	0.01	0.19	1.21	0.11	1.70
A_8	0.10	0.02	0.26	0.89	0.15	2.35
A_9	0.10	0.01	0.26	0.87	0.10	2.33
A_{10}	0.11	0.01	0.51	1.02	0.12	4.34
A_{11}	0.16	0.02	0.90	1.43	0.17	8.13
A_{12}	0.10	0.02	0.72	0.87	0.15	6.47
A_{13}	0.14	0.02	0.75	1.22	0.20	6.76
A_{14}	0.11	0.01	0.76	1.00	0.12	6.83
A_{15}	0.16	0.02	0.85	1.46	0.16	7.66
A_{16}	0.09	0.01	0.24	0.83	0.13	2.18
A_{17}	0.10	0.01	0.28	0.88	0.11	2.50
A_{18}	0.12	0.02	0.27	1.04	0.15	2.40
A_{19}	0.09	0.01	0.14	0.84	0.06	1.26
A_{20}	0.15	0.02	0.78	1.35	0.20	6.98
$F_{19, 57}$	525.07**	2.69**	1114.49**	509.53**	2.67**	1996.73**
SE	0.001	0.003	0.01	0.009	0.02	0.07
CD	0.003	0.008	0.029	0.026	0.071	0.192

**Significant at 1 per cent level

During the period from vegetative to flowering interaction effect was significant in influencing AGR. Higher AGR was recorded by treatment combination S_3 A_{15} (1.86g day^{-1}) followed by S_3A_{11} (1.77 g day^{-1}).

For the period from flowering to fruiting, interaction effect was not significant in influencing AGR.

During the period from fruiting to harvesting, interaction effect was significant in influencing AGR. Treatment combination S_3A_2 (15.36g day^{-1}) recorded higher AGR which was significantly different from all other combinations (Table 21).

4.3.3.5 Relative Growth Rate

Relative growth rate (RGR) was significantly influenced by different shade levels during different periods except from flowering to fruiting. During the period from vegetative to flowering higher RGR was recorded at S_2 (0.055 g day^{-1}) which was on par with S_3 (0.054 g day^{-1}). During the period from fruiting to harvesting, higher RGR was recorded at S_2 (0.038 g day^{-1}) which was on par with S_3 (0.034 g day^{-1}).

During the period from vegetative to flowering, there was significance difference in RGR among the accessions. Higher RGR was recorded by A13 (0.058 g day^{-1}). It was on par with A_2 (0.057 g day^{-1}) A_{11} (0.057 g day^{-1}), A_1 (0.056 g day^{-1}), A_5 (0.056 g day^{-1}) and A_{20} (0.056 g day^{-1}).

For the period from flowering to fruiting, there was significant difference in RGR among the accessions. Higher RGR was recorded by A_3 (0.004 g day^{-1}), A_4 (0.004 g day^{-1}), A_8 (0.004 g day^{-1}), A_{12} (0.004 g day^{-1}) and A_{13} (0.004 day^{-1}).

For the period from fruiting to harvesting also, accessions differed significantly among them in RGR. Higher RGR was recorded by A_2 (0.057 g day^{-1}) which was followed by A_{14} (0.050 g day^{-1}) (Table 22).

Table 21. Interaction effect of different oil palm shade levels and accessions on CGR and AGR

Treatments	CGR, g m^{-2} day^{-1}						AGR, g day^{-1}					
	Period I (35-70 DAS)			Period III (105-140 DAS)			Period I (35-70 DAS)			Period III (105-140 DAS)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
A_1	0.06	0.10	0.13	0.09	0.22	0.22	0.53	0.93	1.18	0.83	2.00	1.98
A_2	0.07	0.13	0.17	0.29	1.61	1.71	0.64	1.21	1.50	2.66	14.44	15.36
A_3	0.05	0.10	0.15	0.01	0.15	0.17	0.44	0.94	1.37	0.13	1.38	1.56
A_4	0.05	0.10	0.17	0.05	0.27	0.32	0.49	0.91	1.54	0.46	2.44	2.88
A_5	0.08	0.14	0.19	0.03	0.07	0.02	0.70	1.22	1.72	0.24	0.60	0.20
A_6	0.06	0.09	0.13	0.04	0.20	0.22	0.58	0.84	1.18	0.33	1.82	1.98
A_7	0.08	0.16	0.17	0.13	0.19	0.25	0.70	1.42	1.52	1.14	1.67	2.28
A_8	0.06	0.10	0.14	0.08	0.33	0.37	0.58	0.88	1.22	0.76	2.99	3.30
A_9	0.08	0.09	0.12	0.13	0.32	0.33	0.73	0.77	1.12	1.19	2.85	2.95
A_{10}	0.04	0.14	0.16	0.10	0.64	0.79	0.35	1.24	1.47	0.13	5.78	7.12
A_{11}	0.09	0.19	0.20	0.23	1.20	1.28	0.83	1.70	1.77	2.07	10.77	11.55
A_{12}	0.05	0.12	0.12	0.19	0.97	1.00	0.45	1.05	1.12	1.67	8.77	8.97
A_{13}	0.07	0.16	0.18	0.26	0.92	1.07	0.63	1.41	1.64	2.38	8.32	9.57
A_{14}	0.06	0.13	0.15	0.25	0.98	1.04	0.50	1.20	1.32	2.28	8.85	9.35
A_{15}	0.10	0.18	0.21	0.23	0.96	1.36	0.88	1.63	1.86	2.08	8.65	12.25
A_{16}	0.06	0.10	0.12	0.10	0.31	0.32	0.58	0.86	1.07	0.86	2.82	2.86
A_{17}	0.06	0.10	0.14	0.22	0.31	0.31	0.50	0.91	1.23	1.93	2.81	2.77
A_{18}	0.06	0.13	0.16	0.06	0.33	0.41	0.56	1.18	1.40	0.50	2.98	3.71
A_{19}	0.05	0.11	0.12	0.02	0.20	0.21	0.47	0.97	1.08	0.18	1.76	1.86
A_{20}	0.09	0.17	0.19	0.19	1.02	1.12	0.78	1.57	1.70	1.71	9.17	10.07
$F_{19, 57}$	79.14**			173.76**			76.70**			314.80**		
SE	0.002			0.02			0.016			0.12		
CD	0.005			0.049			0.044			0.332		

**Significant at 1 per cent level

Interaction effect was significant in influencing RGR during the period from vegetative to flowering. Higher RGR was recorded by treatment combination S_2A_{11} (0.064 g day^{-1}). It was on par with S_2A_1 (0.063g day^{-1}), S_2A_{13} (0.063 g day^{-1}), S_2A_{20} (0.062 g day^{-1}), S_3A_3 (0.061 g day^{-1}), S_2A_2 (0.060 g day^{-1}), S_3A_5 (0.060 g day^{-1}), S_3A_{13} (0.060 g day^{-1}), S_2A_{14} (0.059 g day^{-1}), S_2A_{19} (0.059 g day^{-1}) and S_1A_9 (0.059 g day^{-1}).

For the period from flowering to fruiting, interaction effect was not significant in influencing RGR.

For the period from fruiting to harvesting, interaction effect was significant in influencing RGR. Higher RGR was recorded by treatment combination S_2A_2 (0.066 g day^{-1}). It was on par with S_3A_2 (0.062 g day^{-1}) and S_2A_{12} (0.057 g day^{-1}) (Table 23).

4.3.3.6 Net Assimilation Rate

The different shade levels and accessions did not produce any significant effect on net assimilation rate for the period from vegetative to flowering. The NAR was calculated for the first period and could not be calculated for second period (flowering to fruiting) and third period (fruiting to harvest) as negative values in leaf weight difference occurred, due to leaf shedding (Table 22).

4.3.3.7 Harvest Index

Different shade levels had significant influence on harvest index. Higher harvest index was recorded at S_2 (0.81) and S_3 (0.81).

There was significant difference among the accessions in harvest index. Higher harvest index was recorded by A_{14} (0.92). It was on par with A_2 (0.91), A_{12} (0.90), A_{13} (0.89), A_{11} (0.87) and A_{15} (0.87). A_5 (0.51) recorded lower harvest index (Table 24).

Table 22.Effect of different oil palm shade levels and accessions on RGR and NAR

Treatments	RGR, g day^{-1}			NAR, g m^{-2} day^{-1}
	Period I (35-70 DAS)	Period II (70-105 DAS)	Period III (105.140 DAS)	Period I (35-70 DAS)
Shade levels				
S_1	0.049	0.002	0.025	6.21
S_2	0.055	0.003	0.038	7.87
S_3	0.054	0.003	0.034	5.95
$F_{2, 57}$	92.85**	12.56	66.90*	595.86
SE	0.0004	0.0002	0.0008	0.04
CD	0.002	NS	0.005	NS
Accessions				
A_1	0.056	0.002	0.026	7.62
A_2	0.057	0.003	0.057	6.50
A_3	0.053	0.004	0.015	6.37
A_4	0.049	0.004	0.023	4.99
A_5	0.056	0.002	0.006	6.59
A_6	0.049	0.002	0.021	6.47
A_7	0.049	0.002	0.021	6.54
A_8	0.050	0.004	0.029	6.54
A_9	0.052	0.002	0.031	7.52
A_{10}	0.050	0.003	0.032	5.99
A_{11}	0.057	0.003	0.045	7.18
A_{12}	0.049	0.004	0.049	5.98
A_{13}	0.058	0.004	0.045	6.70
A_{14}	0.053	0.003	0.050	5.72
A_{15}	0.052	0.002	0.043	6.38
A_{16}	0.052	0.003	0.029	6.98
A_{17}	0.052	0.003	0.034	6.76
A_{18}	0.053	0.003	0.032	6.02
A_{19}	0.050	0.001	0.025	9.61
A_{20}	0.056	0.001	0.042	7.03
$F_{19, 57}$	6.07**	2.03*	51.74**	5.48
SE	0.001	0.0005	0.002	0.39
CD	0.003	0.001	0.005	NS

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 23. Interaction effect of different oil palm shade levels and accessions on RGR

	Period I (35-70 DAS)			Period III (105-140 DAS)		
	S_1	S_2	S_3	S_1	S_2	S_3
A_1	0.049	0.063	0.055	0.023	0.030	0.024
A_2	0.053	0.060	0.058	0.042	0.066	0.062
A_3	0.044	0.053	0.061	0.005	0.021	0.018
A_4	0.047	0.049	0.053	0.015	0.030	0.025
A_5	0.056	0.053	0.060	0.008	0.009	0.003
A_6	0.047	0.048	0.054	0.010	0.028	0.024
A_7	0.045	0.055	0.048	0.023	0.019	0.022
A_8	0.051	0.047	0.053	0.019	0.035	0.032
A_9	0.059	0.045	0.052	0.025	0.038	0.031
A_{10}	0.041	0.056	0.055	0.007	0.044	0.045
A_{11}	0.050	0.064	0.056	0.032	0.052	0.051
A_{12}	0.039	0.056	0.053	0.036	0.057	0.055
A_{13}	0.051	0.063	0.060	0.038	0.049	0.049
A_{14}	0.048	0.059	0.054	0.044	0.056	0.052
A_{15}	0.048	0.057	0.052	0.031	0.047	0.051
A_{16}	0.051	0.052	0.053	0.022	0.035	0.031
A_{17}	0.049	0.050	0.057	0.039	0.034	0.029
A_{18}	0.050	0.051	0.054	0.033	0.031	0.031
A_{19}	0.046	0.059	0.047	0.025	0.027	0.024
A_{20}	0.052	0.062	0.055	0.029	0.050	0.048
$F_{38, 57}$	5.04**			4.17**		
SE	0.002			0.003		
CD	0.005			0.009		

** Significant at 1 per cent level

Interaction effect was significant in influencing harvest index. The treatment combination S_3A_2 (0.95) recorded higher harvest index (Table 25).

4.3.4 Yield and Fruit Characters

4.3.4.1 Fruits Plant^{-1}

The fruits plant^{-1} was significantly influenced by different shade levels. Higher number of fruits was produced at S_3 (4.43).

Accessions showed significant difference in fruits plant^{-1}. Higher number of fruits was recorded by A_{15} (4.86). It was on par with A_{12} (4.72) and A_{13} (4.72) (Table 26).

Interaction effect was significant in influencing fruits plant^{-1}. The treatment combination S_3A_{15} (7.18) recorded higher number of fruits, followed by S_3A_2 (6.25) and S_3A_{12} (6.25) (Table 27).

4.3.4.2 Fruit Length

Different shade levels had no significant influence on fruit length.

Accessions differed significantly among them in fruit length. Higher fruit length was recorded by A_{20} (16.86 cm). It was on par with A_{11} (16.77 cm) (Table 28).

4.3.4.3 Fruit Diameter

Different shade levels had no significant influence on fruit diameter.

Accessions showed significant difference among them in fruit diameter. Higher fruit diameter was recorded by A_2 (11.31 cm). It was on par with A_{10} (11.26 cm) (Table 28).

4.3.4.4 Mean Fruit Weight

Different shade levels had no significant influence on mean fruit weight.

Table 24. Effect of different oil palm shade levels and accession on harvest index

Treatments	Harvest index
Shade levels	
S_1	0.73
S_2	0.81
S_3	0.81
$F_{2, 57}$	180.38**
SE	0.003
CD	0.018
Accessions	
A_1	0.72
A_2	0.91
A_3	0.64
A_4	0.68
A_5	0.51
A_6	0.74
A_7	0.75
A_8	0.80
A_9	0.78
A_{10}	0.80
A_{11}	0.87
A_{12}	0.90
A_{13}	0.89
A_{14}	0.92
A_{15}	0.87
A_{16}	0.80
A_{17}	0.82
A_{18}	0.75
A_{19}	0.71
A_{20}	0.85
$F_{19, 57}$	33.50**
SE	0.02
CD	0.050

**Significant at 1 per cent level

Table 25. Interaction effect of different oil palm shade levels and accessions on harvest index

	S_1	S_2	S_3
A_1	0.68	0.75	0.75
A_2	0.83	0.93	0.95
A_3	0.54	0.68	0.69
A_4	0.53	0.73	0.77
A_5	0.50	0.54	0.50
A_6	0.69	0.78	0.75
A_7	0.76	0.72	0.76
A_8	0.75	0.86	0.87
A_9	0.72	0.83	0.80
A_{10}	0.66	0.87	0.88
A_{11}	0.85	0.91	0.88
A_{12}	0.88	0.91	0.93
A_{13}	0.87	0.89	0.91
A_{14}	0.90	0.92	0.93
A_{15}	0.81	0.91	0.90
A_{16}	0.79	0.83	0.79
A_{17}	0.87	0.82	0.77
A_{18}	0.68	0.78	0.81
A_{19}	0.66	0.78	0.71
A_{20}	0.78	0.88	0.89
$F_{38, 57}$		2.01**	
SE		0.03	
CD		0.087	

** Significant at 1 per cent level

Accessions differed significantly among them in mean fruit weight. A_{14} (1.31 kg) recorded higher mean fruit weight which was on par with A_{11} (1.24 kg) and A_2 (1.09 kg) (Table 26).

4.3.4.5 Total Yield

There was significant difference in total yield under different shade levels. Higher fruit yield was recorded at S_3 (2.69 kg).

Accessions differed significantly among them in total fruit yield. Higher yield was recorded by A_2 (4.92 kg) which was significantly different from all other accessions. A_5 (0.41 kg) recorded lower yield which was on par with A_3 (0.64 kg) (Table 29).

Interaction effect was found to be significant in influencing total fruit yield. The treatment combination S_3A_2 (6.91 kg) recorded higher yield closely followed by S_2A_2 (6.46 kg). Lower yield was recorded by treatment combination S_1A_3 (0.16 kg) (Table 30).

4.3.4.6 Rind Thickness

Rind thickness was significantly influenced by different shade levels. Higher rind thickness was recorded at S_3 (1.36 mm).

There was significant difference in rind thickness among the different accessions. A_{10} (1.96 mm) recorded higher rind thickness followed by A_4 (1.73 mm) (Table 31).

4.3.4.7 Flesh Thickness

Different shade levels did not influence flesh thickness significantly.

Accessions differed significantly among them in flesh thickness. Higher flesh thickness was recorded by A_{10} (11.07 cm). It was on par with A_2 (11.05 cm) (Table 31).

Table 26. Effect of different oil palm shade levels and accessions on fruits plant^{-1} and mean fruit weight

Treatments	Fruits plant^{-1}	Mean fruit weight, kg
Shade levels		
S_1	1.42	0.62
S_2	3.93	0.62
S_3	4.43	0.62
$F_{2,57}$	3600.59**	0.003
SE	0.03	0.01
CD	0.163	NS
Accessions		
A_1	2.61	0.35
A_2	4.48	1.09
A_3	3.27	0.26
A_4	2.52	0.38
A_5	2.16	0.20
A_6	3.36	0.29
A_7	1.35	0.93
A_8	3.05	0.41
A_9	3.37	0.33
A_{10}	2.99	0.77
A_{11}	3.27	1.24
A_{12}	4.72	0.85
A_{13}	4.72	0.71
A_{14}	3.07	1.31
A_{15}	4.86	0.81
A_{16}	4.26	0.28
A_{17}	2.50	0.57
A_{18}	2.62	0.47
A_{19}	2.26	0.33
A_{20}	3.85	0.87
$F_{19,57}$	68.57**	20.20**
SE	0.12	0.08
CD	0.330	0.218

** Significant at 1 per cent level

Table 27. Interaction effect of different oil palm shade levels and accessions on fruits plant^{-1}

	S_1	S_2	S_3
A_1	1.30	3.12	3.40
A_2	1.33	5.87	6.25
A_3	1.00	4.11	4.70
A_4	1.75	2.90	3.90
A_5	1.21	2.60	2.67
A_6	1.72	4.10	4.25
A_7	1.00	1.38	1.67
A_8	1.34	3.72	4.10
A_9	2.10	4.00	4.00
A_{10}	0.33	4.04	4.60
A_{11}	1.10	4.20	4.50
A_{12}	2.00	5.90	6.25
A_{13}	3.02	5.14	6.00
A_{14}	1.70	3.60	3.90
A_{15}	2.20	5.21	7.18
A_{16}	1.80	4.97	6.00
A_{17}	2.00	2.70	2.80
A_{18}	0.75	3.11	4.00
A_{19}	0.67	3.00	3.10
A_{20}	1.17	5.02	5.35
$F_{38, 57}$	12.00**		
SE	0.20		
CD	0.572		

** Significant at 1 per cent level

Table 28. Effect of different oil palm shade levels and accessions on fruit length and fruit diameter, cm

Treatments	Fruits length	Fruit diameter
Shade levels		
S_1	13.27	8.63
S_2	13.33	8.67
S_3	13.40	8.75
$F_{2, 57}$	1.66	0.32
SE	0.05	0.11
CD	NS	NS
Accessions		
A_1	13.15	7.99
A_2	15.54	11.31
A_3	12.02	7.52
A_4	12.09	8.37
A_5	12.47	7.60
A_6	11.26	8.47
A_7	15.19	9.08
A_8	13.19	7.13
A_9	10.63	8.06
A_{10}	14.65	11.26
A_{11}	16.77	9.41
A_{12}	12.14	9.05
A_{13}	13.39	10.13
A_{14}	16.29	8.86
A_{15}	11.29	8.32
A_{16}	10.05	7.77
A_{17}	14.52	8.48
A_{18}	14.32	7.41
A_{19}	10.92	8.33
A_{20}	16.86	9.13
$F_{19, 57}$	317.15**	149.19**
SE	0.12	0.09
CD	0.333	0.268

** Significant at 1 per cent level

Table 29. Effect of different oil palm shade levels and accessions on total yield, kg

Treatments	Total yield
Shade levels	
S_1	0.66
S_2	2.40
S_3	2.69
$F_{2, 57}$	4103.18**
SE	0.02
CD	0.104
Accessions	
A_1	0.87
A_2	4.92
A_3	0.64
A_4	1.00
A_5	0.41
A_6	0.79
A_7	1.03
A_8	1.24
A_9	1.17
A_{10}	2.07
A_{11}	3.77
A_{12}	2.96
A_{13}	3.17
A_{14}	3.14
A_{15}	3.58
A_{16}	1.13
A_{17}	1.25
A_{18}	1.26
A_{19}	0.72
A_{20}	3.26
$F_{19, 57}$	223.57**
SE	0.09
CD	0.250

** Significant at 1 per cent level

Table 30. Interaction effect of different oil palm shade levels and accessions on total yield, kg

	Total yield		
	S_1	S_2	S_3
A_1	0.43	1.08	1.09
A_2	1.38	6.46	6.91
A_3	0.16	0.78	0.97
A_4	0.26	1.15	1.60
A_5	0.23	0.50	0.50
A_6	0.32	0.98	1.08
A_7	0.67	1.05	1.38
A_8	0.49	1.54	1.68
A_9	0.63	1.37	1.50
A_{10}	0.18	2.74	3.28
A_{11}	1.12	5.00	5.18
A_{12}	0.86	3.91	4.12
A_{13}	1.19	3.83	4.48
A_{14}	1.11	4.02	4.29
A_{15}	1.09	4.15	5.50
A_{16}	0.53	1.41	1.44
A_{17}	0.96	1.38	1.41
A_{18}	0.35	1.52	1.90
A_{19}	0.22	0.96	0.98
A_{20}	1.02	4.23	4.54
$F_{38, 57}$		32.92**	
SE		0.15	
CD		0.433	

** Significant at 1 per cent level

4.3.4.8 Seeds Fruit^{-1}

Different shade levels had no significant influence on seeds fruit^{-1}.

There was significant difference in seeds fruit^{-1} among different accessions. Higher seed number was recorded by A_{11} (461.91). It was on par with A_8 (458.48) and A_2 (454.15) (Table 31).

4.4 PHASE IV: BIOCHEMICAL ANALYSIS

4.4.1 Biochemical Characters of Fruit

4.4.1.1 Titrable Acidity

Different shade levels did not influence titrable acidity significantly.

Accessions differed significantly among them in titrable acidity. Higher titrable acidity was recorded by A_1 (0.38 per cent). It was on par with A_9 (0.36 per cent), A_{19} (0.36 per cent) and A_{14} (0.34 per cent) (Table 32).

4.4.1.2 Total Sugars

Total sugars was not significantly influenced by different shade levels.

Accessions showed significant difference among them in total sugars. Higher total sugars was recorded by A_{14} (1.55 per cent) which was significantly different from all other accessions (Table 32).

4.4.1.3 Reducing Sugars

Different shade levels did not significantly influence reducing sugars.

Reducing sugars varied significantly among different accessions. A_{14} (1.31 per cent) recorded higher reducing sugars which was followed by A_{11} (1.21 per cent) (Table 32).

4.4.1.4 Non Reducing Sugars

Non-reducing sugars was not significantly influenced by different shade levels.

Table 31. Effect of different oil palm shade levels and accessions on rind thickness, flesh thickness and seeds fruit^{-1}

Treatments	Rind thickness, mm	Flesh thickness, cm	Seeds fruit $^{-1}$
Shade levels			
S_1	1.27	8.51	294.49
S_2	1.28	8.52	297.78
S_3	1.36	8.62	300.02
$F_{2,57}$	54.44*	0.35	11.90
SE	0.007	0.10	0.81
CD	0.040	NS	NS
Accessions			
A_1	1.08	7.88	395.61
A_2	1.05	11.05	454.15
A_3	1.28	7.39	55.87
A_4	1.73	8.20	421.18
A_5	1.34	7.46	333.64
A_6	1.07	8.36	325.76
A_7	1.15	8.96	249.88
A_8	1.09	7.02	458.48
A_9	1.16	7.95	404.10
A_{10}	1.96	11.07	113.86
A_{11}	1.08	9.31	461.91
A_{12}	1.66	8.88	177.73
A_{13}	1.20	10.01	103.87
A_{14}	1.30	8.73	390.78
A_{15}	1.21	8.20	121.19
A_{16}	1.27	7.64	83.51
A_{17}	1.19	8.36	441.55
A_{18}	1.41	7.27	404.24
A_{19}	1.50	8.18	382.26
A_{20}	1.31	9.00	169.00
$F_{19,57}$	14.29**	135.40**	424.74**
SE	0.06	0.10	7.07
CD	0.183	0.276	20.05

* Significant at 5 per cent level

** Significant at 1 per cent level

Accessions showed significant difference among them in non-reducing sugars. Higher non-reducing sugars was recorded by A_{14} (0.25 per cent). It was on par with A_2 (0.24 per cent), A_1 (0.23 per cent) and A_{17} (0.22 per cent) (Table 32).

4.4.1.5 Phosphorus Content

Phosphorus content was significantly influenced by different shade levels. Phosphorus content increased as shade level increased. Higher phosphorus content was recorded at S_1 (0.23 per cent).

Accessions showed significant difference among them in phosphorus content. Higher phosphorus content was recorded by A_5 (0.31 per cent). It was on par with A_4 (0.30 per cent), A_{10} (0.30 per cent), A_{13} (0.30 per cent) and A_2 (0.29 per cent) (Table 33).

4.4.1.6 Calcium content

Calcium content was not significantly influenced by different shade levels.

Calcium content varied significantly among different accessions. A_6 (0.96 per cent) recorded higher calcium content among the accessions which was on par with A_{18} (0.93 per cent) (Table 33).

4.4.1.7 Magnesium Content

Different shade levels and accessions did not influence magnesium content significantly (Table 33).

4.4.1.8 Sodium Content

Different shade levels did not influence sodium content significantly.

Accessions showed significant difference among them in sodium content. Higher sodium content was recorded by A_{17} (0.17 per cent). It was on par with A3 (0.15 per cent), A_8 (0.15 per cent) and A_{16} (0.15 per cent) (Table 34).

Table 32. Effect of different oil palm shade levels and accessions on titrable acidity, total sugars, reducing sugars and non-reducing sugars

Treatments	Titrable acidity, %	Total sugars, %	Reducing sugars, %	Non-reducing sugars, %
Shade levels				
S_1	0.23	1.27	1.09	0.17
S_2	0.23	1.27	1.10	0.17
S_3	0.24	1.27	1.10	0.17
$F_{2, 57}$	0.75	0.49	1.21	0.18
SE	0.007	0.004	0.004	0.003
CD	NS	NS	NS	NS
Accessions				
A_1	0.38	1.29	1.06	0.23
A_2	0.24	1.44	1.19	0.24
A_3	0.15	1.31	1.12	0.19
A_4	0.13	1.34	1.18	0.17
A_5	0.21	1.15	0.98	0.17
A_6	0.21	1.30	1.14	0.17
A_7	0.19	1.41	1.19	0.20
A_8	0.28	1.10	1.01	0.09
A_9	0.36	1.08	0.96	0.12
A_{10}	0.21	1.34	1.19	0.15
A_{11}	0.13	1.39	1.21	0.18
A_{12}	0.28	1.32	1.11	0.21
A_{13}	0.17	1.16	1.04	0.12
A_{14}	0.34	1.55	1.31	0.25
A_{15}	0.30	1.24	1.12	0.11
A_{16}	0.24	1.11	1.01	0.09
A_{17}	0.30	1.26	1.04	0.22
A_{18}	0.13	1.22	1.00	0.21
A_{19}	0.36	1.07	0.97	0.10
A_{20}	0.19	1.28	1.11	0.16
$F_{19, 57}$	16.17**	94.48**	62.40**	22.75**
SE	0.02	0.001	0.01	0.009
CD	0.062	0.038	0.034	0.027

** Significant at 1 per cent level

Table 33. Effect of different oil palm shade level and accessions on phosphorous content, calcium content and magnesium content of fruits

Treatments	Phosphorus content, %	Calcium content, %	Magnesium content, %
Shade levels			
S_1	0.23	0.49	0.42
S_2	0.22	0.49	0.42
S_3	0.21	0.50	0.42
$F_{2, 57}$	26.04*	4.67	1.85
SE	0.002	0.002	0.0008
CD	0.010	NS	NS
Accessions			
A_1	0.10	0.40	0.33
A_2	0.29	0.80	0.43
A_3	0.24	0.33	0.24
A_4	0.30	0.91	0.39
A_5	0.31	0.31	0.30
A_6	0.12	0.96	0.58
A_7	0.14	0.23	0.55
A_8	0.24	0.92	0.42
A_9	0.27	0.71	0.43
A_{10}	0.30	0.24	0.38
A_{11}	0.24	0.51	0.44
A_{12}	0.13	0.31	0.51
A_{13}	0.30	0.40	0.38
A_{14}	0.26	0.22	0.43
A_{15}	0.16	0.15	0.54
A_{16}	0.25	0.29	0.24
A_{17}	0.19	0.88	0.46
A_{18}	0.24	0.93	0.43
A_{19}	0.10	0.31	0.34
A_{20}	0.17	0.10	0.62
$F_{19, 57}$	104.38**	1015.82**	4076.32
SE	0.007	0.009	0.002
CD	0.020	0.027	NS

* Significant at 5 per cent level

** Significant at 1 per cent level

4.4.1.9 Sulphur Content

Sulphur content was not significantly influenced by different shade levels.

Accessions showed significant difference among them in sulphur content. A_{10} (0.20 per cent) recorded higher sulphur content which was significantly different from all other accessions (Table 34).

4.4.1.10 Iron Content

Iron content was not significantly influenced by different shade levels.

Iron content varied significantly among different accessions. Higher iron content was recorded by A_{18} (0.51 mg $100g^{-1}$). It was on par with A_{16} (0.50 mg 100 g^{-1}) (Table 34).

4.5 LIGHT INTENSITY

The incident solar energy in the open condition and under oil palms of various age groups are presented in Table 35.

4.6 SELECTION INDEX

Discriminant function technique was used for the construction of selection index based on sixteen selected important characters *viz.*, days to first male and female flower, node to first male and female flower, vine length, branches per plant, fruit length, fruit diameter, fruits per plant, fruit yield per plant, average fruit weight, flesh thickness, seeds per fruit, titrate acidity, calcium content and sodium content. The selection index were worked out as follows :

Under mature oil palm plantation, S_1,

$$I = -4.020301X_1 + 4.595816X_2 - 185.8414X_3 + 12.17448X_4 - 11.39477X_5 + 183.0058X_6 + 0.888139X_7 + 3.639008X_8 + 2.537023X_9 + 0.884268X_{10} + 0.96924X_{11} + 3.95376X_{12} + 0.496143X_{13} + 113.4008X_{14} - 220.7194X_{15} + 47.89489X_{16}$$

Table 34. Effect of different oil palm shade level and accessions on sodium content, sulphur content and iron content of fruits

Treatments	Sodium content, %	Sulphur content, %	Iron content, mg $100g^{-1}$
Shade levels			
S_1	0.10	0.14	0.40
S_2	0.10	0.14	0.40
S_3	0.10	0.14	0.40
$F_{2, 57}$	0.71	0.35	0.12
SE	0.002	0.0003	0.0008
CD	NS	NS	NS
Accessions			
A_1	0.11	0.17	0.33
A_2	0.10	0.14	0.34
A_3	0.15	0.14	0.33
A_4	0.11	0.13	0.43
A_5	0.08	0.18	0.38
A_6	0.06	0.11	0.48
A_7	0.09	0.12	0.43
A_8	0.15	0.13	0.37
A_9	0.05	0.18	0.34
A_{10}	0.06	0.20	0.34
A_{11}	0.07	0.12	0.39
A_{12}	0.11	0.14	0.39
A_{13}	0.12	0.12	0.37
A_{14}	0.10	0.11	0.47
A_{15}	0.07	0.14	0.38
A_{16}	0.15	0.14	0.50
A_{17}	0.17	0.13	0.42
A_{18}	0.08	0.11	0.51
A_{19}	0.04	0.17	0.35
A_{20}	0.09	0.13	0.41
$F_{19, 57}$	26.86**	515.16**	354.68**
SE	0.007	0.001	0.003
CD	0.020	0.003	0.009

** Significant at 1 per cent level

Table 35 PAR in the interspaces of oil palm of various age groups

Shade levels	PAR (μ mol m^{-2} sec^{-1})	% of open
Open	1756	100
Young	737	42
Mature	386	22

Under young oil palm plantation, S_2,

$$I = 16.91612X_1 + 6.005195X_2 - 6.28346X_3 - 7.150334X_4 + 16.2379X_5 - 2.65893X_6 + 0.7688353X_7 - 0.0552765X_8 + 0.4624535X_9 + 1.202281X_{10} + 1.461942X_{11} + 2.128862X_{12} + 1.565158X_{13} + 198.1757X_{14} - 150.7762X_{15} + 83.97726X_{16}$$

Under open condition, S_3.

$$I = -29.36883X_1 + 0.9897621X_2 - 46.87694X_3 - 51.44995X_4 + 30.43783X_5 + 46.20422X_6 + 0.8173403X_7 - 6.693033X_8 - 5.080355X_9 + 1.314111X_{10} + 0.9962662X_{11} + 5.659321X_{12} - 3.564899X_{13} + 100.7349X_{14} + 17.03761X_{15} + 46.17153X_{16}$$

The selection index scores are presented in Table 36 along with ranking of each accession.

Under mature oil palm plantation and open condition A_{11} ranked first followed by A_2 and A_8. A_3 was the poorest performer. Under young oil palm plantation A_2 ranked first followed by A_{11}. A_3 was the poorest performer. Irrespective of the light condition, it was observed that A_{11} and A_2 are the top ranking accessions.

An overall evaluation of shade levels on growth characters revealed that growth of ash gourd was significantly affected by shade levels. Vine length was significantly higher under mature palms. Higher leaf number was recorded under open condition during all growth stages. Lower days to first male and female flower and lowest node to first male and female flower was recorded under open condition. Dry matter production was highest under open condition throughout the growth period. Highest harvest index was recorded under young palms and open condition. The yield per plant under young palm canopy was comparable with that under open condition.

Table 36. Selection index scores and ranks of *Benincasa hispida* accessions

Accessions	S_1		S_2		S_3	
	Selection index score	Rank	Selection index score	Rank	Selection index score	Rank
A_1	1222.52	10	1199.14	10	788.12	8
A_2	1402.38	2	1366.65	1	923.62	2
A_3	578.03	20	496.32	20	95.73	20
A_4	1309.31	5	1277.57	5	856.37	5
A_5	1220.92	11	1206.81	8	747.34	10
A_6	1141.69	12	1070.05	12	639.00	12
A_7	989.94	13	969.76	13	532.04	13
A_8	1354.32	3	1324.09	3	896.04	3
A_9	1270.32	6	1229.91	6	806.49	6
A_{10}	708.01	18	695.05	17	252.89	17
A_{11}	1408.35	1	1337.20	2	966.09	1
A_{12}	823.63	15	844.01	14	387.18	14
A_{13}	749.94	17	664.74	18	251.30	18
A_{14}	1244.28	7	1200.48	9	795.51	7
A_{15}	754.30	16	727.14	16	300.88	16
A_{16}	606.88	19	572.06	19	134.35	19
A_{17}	1340.68	4	1302.53	4	877.26	4
A_{18}	1241.74	8	1227.67	7	768.68	9
A_{19}	1228.05	9	1140.02	11	738.96	11
A_{20}	857.06	14	803.43	15	377.86	15

DISCUSSION

5. DISCUSSION

The study entitled 'Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations' was carried out at the oil palm plantations, Kulathupuzha of the Oil palm India Ltd., in Kollam district. The objectives of the study were to identify superior ecotypes of neykumbalam suitable for intercropping in oil palm plantations. characterization of collected ecotypes, their growth, yield and bio-chemical analyses.

The results of the study are discussed in this chapter.

5.1 SEED GERMINATION

When the seeds of the accessions selected for the study were subjected to germination trial, three accessions A_2, A_{10} and A_{11} exhibited more than 90 per cent germination under laboratory conditions. Higher germination percentage of these accessions may be attributed to their high genetic vigour. The accessions A_2, A_6, A_{10}, A_{12}, A_{16} and A_{19} took least number of days to achieve 50 per cent germination. Total number of days taken to achieve 50 per cent germination varied from 6 to 9 days in various accessions. This may be due to the genetic variation among the accessions.

5.2 GROWTH PARAMETERS

Present study revealed that shading had marked influence on vine length and number of leaves in ash gourd.

Significant variations for vine length and number of leaves were observed among the accessions under all shade levels. This may be due to inherent variability that existed among the accessions. Higher vine length was recorded by A_{13}.

Vine length was found to increase with increase in shade levels. Higher vine length was observed at S_1 and lower vine length was observed at S_3. Plants growing under mature oil palm plantation were found to be taller compared to those under open conditions and young plantations. The interspaces of mature oil palm plantations are much shaded due to luxuriant growth of the palm canopy.

Similar results of increasing plant height under shade was reported by Bai (1981) in sweet potato, Babu and Nagarajan (1993) in soybean, Devadas (1997) in pepper and Filho *et al.* (1997) in *Phyllanthus stipulatus*.

High rate of transpiration and respiration in open leading to deficiencies of carbohydrates and water may have resulted in retarded cell division and enlargement and thereby reduced height in open grown plants (Meyer *et al.*, 1973). Janardhan and Murthy (1980) reported such an increase in plant height under low light intensity due to higher content of GA. Increasing shade had caused the shoots to elongate which is a normal reaction of shade avoidance by herbaceous plants (Smith, 1986). The height increment under deep shade may be an adaptive mechanism to gain better access to available light (Evans *et al.*, 1992). The stem elongation under shade may be due to growth substances formed under etiolated condition (Nasiruddin *et al.*, 1995).

Number of leaves per plant showed significant variation among different shade levels and among the different accessions.

Variation in number of leaves among the accessions may be attributed to the fact that it is purely a function of genetic makeup and environmental conditions (Gardner *et al.*, 1988). At vegetative, flowering and fruiting stage higher number of leaves was recorded by A_{15} whereas at harvest stage higher leaf number was recorded by A_{20}.

An increase in shade level resulted in decrease in number of leaves at all growth phases. Higher number of leaves were observed at S_3 during vegetative stage, flowering stage, fruiting stage and harvest stage. Similar observations were made by Laura *et al.* (1986) in sweet potato, Simbolon and Sutarno (1986) in *Amaranthus* spp., Sunitha (1996) and Reshmi (2001) in *Clitoria ternatea.* Shivasankara *et al.* (2000) observed that high light intensity has increased leaf number in betel vine. This may be due to the zero competition for light, space, water or nutrients in pure cropping system resulting in higher production of leaves.

The low availability of photosynthates which resulted from the low irradiance might be the reason for the retarded growth under heavy shade (Meyer and Anderson, 1952).

5.3 FLOWERING CHARACTERS

The flowering characters like days to first male flower, days to first female flower, node to first male flower and node to first female flower were significantly influenced by different shade levels and accessions.

The present study revealed that shading prolonged the days to first flowering in comparison to open (Fig. 2 and 3). Lower days to first male flower and first female flower was observed at S_3. Similar result of delayed flowering in ashgourd due to shade were also reported by Hedge *et al.* (1991).

Lower days to first male flower and first female flower was recorded by A_7. The lowest node to first male flower was recorded by A_{10} and the lowest node to first female was recorded by A_{18}.

Under shaded condition there is reduced rate of transpiration and respiration compared to open, which favours vegetative growth (Schoch, 1972). Shading might have reduced the net photosynthesis favouring vegetative development (Logendra *et al.*, 1990).

An increase in the height of node to first male flower and node to first female flower was found with an increase in the shade level. Lowest node to first male flower and first female flower was observed at S_3.

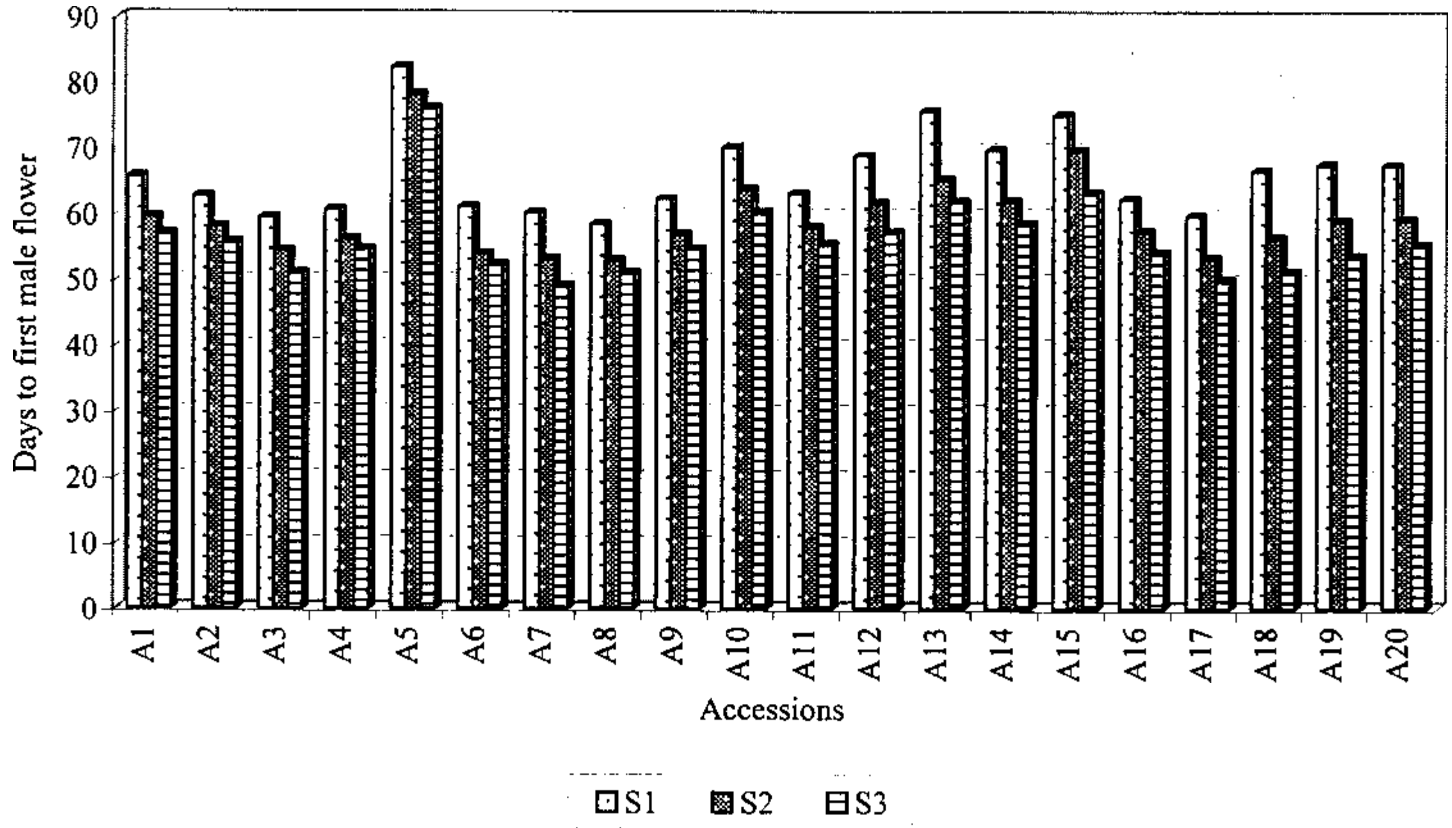

Fig. 2 Interaction effect of different oil palm shade levels and accessions on days to first male flower

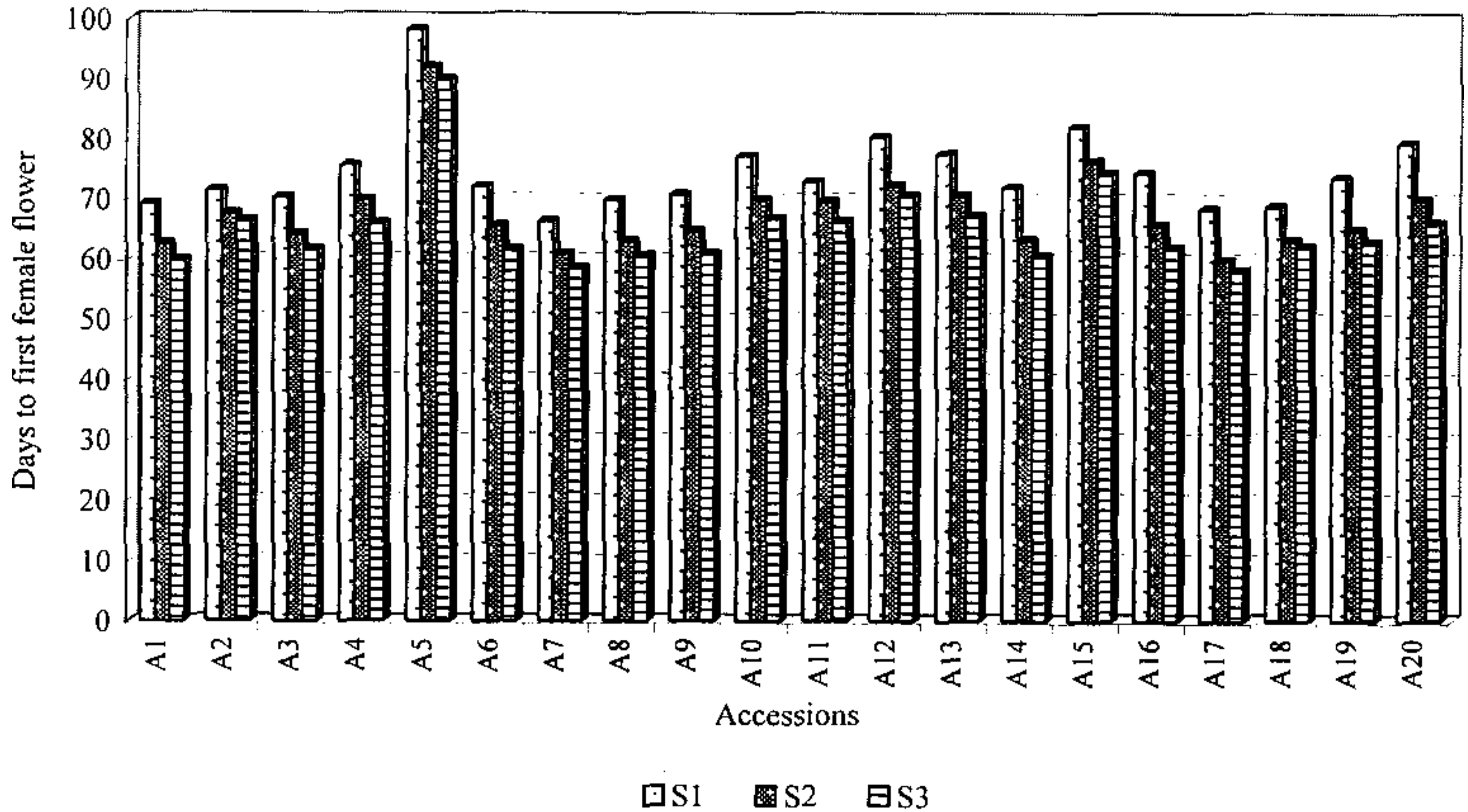

Fig. 3 Interaction effect of different oil palm shade levels and accessions on days to first female flower

Increased height of neykumbalam under shade might have resulted in increased height of node to first male flower and node to first female flower.

5.4 PHYSIOLOGICAL PARAMETERS

The effect of shade on dry matter production (DMP) was found to be significant at all stages of growth. Higher DMP was observed at vegetative stage, flowering stage, fruiting stage and harvest stage at S_3 (Fig. 4).

A decrease in DMP was observed with increase in shade level. The report of Monteith (1969) that the higher amount of drymatter produced by a crop was strongly correlated with the amount of light intercepted by its foliage supports the above finding. A similar decrease in DMP was observed by Sreekala (1999) in ginger and Louis (2000) in turmeric under shaded situation.

Shading might have resulted in less photosynthetically active radiation falling on the leaf surface compared to that under open condition. As sunlight passes through the tree canopy in plantations, the leaves absorb the light in the 400-700 nm wave bands preferentially and the PAR incident on the herbaceous understorey may be substantially lower than that of full sunlight (Baldocchi *et al.*, 1984). This might have led to less development of branches, leaves and subsequently lower DMP.

Different accessions showed significant difference in DMP at all growth stages. At vegetative, flowering and fruiting stage higher DMP was recorded by A_{15} and at harvest stage higher DMP was recorded by A_2.

The leaf area index (LAI) was found to differ significantly among different shade levels and accessions.

The LAI was found to be the least at vegetative stage. It increased from vegetative to flowering stage and decreased afterwards. This conforms to the reports of Sebastian (1987) in ashgourd. According to

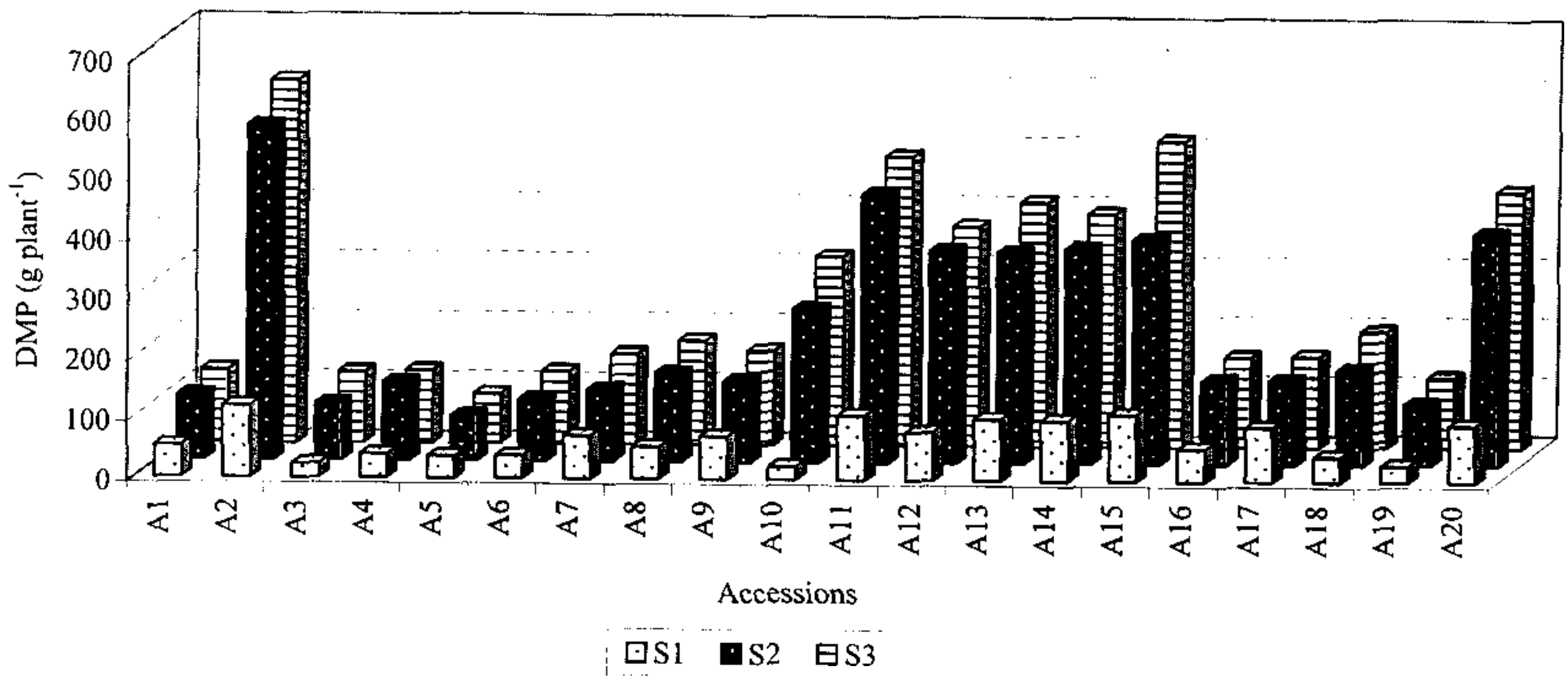

Fig. 4 Interaction effect of different oil palm shade levels and accessions on dry matter production (harvest stage)

Pearce and Mitchell (1990), LAI is found to lower during reproductive phase, as vegetative growth is reduced at this phase.

The data indicated higher values of LAI at all stages under open condition when compared to shade conditions. Higher LAI was observed at S_3 during vegetative stage, flowering stage, fruiting stage and harvest stage. This agrees with the findings of Bai (1981) in sweet potato and Shivasankara *et al.* (2000) in betel vine.

Increase in total leaf area results in higher LAI (Russell, 1961). Leaf area showed significant increase with increase in light levels. This can be attributed to the influence of light intensity on cell enlargement and differentiation which thus influenced the growth and leaf size of the plants (Thompson and Miller, 1963). The optimum LAI depends not only on the arrangement of leaves within the canopy but also on the light intensity that the canopy receives (Bleasdale, 1973).

LAI varied significantly among all the accessions. At vegetative stage higher LAI was recorded by A_7, A_{11} and A_{15}. At flowering stage and fruiting stage higher LAI was recorded by A_{15} and at harvest stage higher LAI was recorded by A_6.

Crop growth rate (CGR) varied significantly among the different shade levels and different accessions during all the three periods of growth.

CGR showed a decrease in almost all the accessions from first to second period of growth. During the final period of growth it showed an increasing trend.

During the period from vegetative to flowering, higher CGR was recorded by A_{11} and A_{15}. From flowering to fruiting and fruiting to harvest higher CGR was recorded by A_2.

As per the data CGR values were higher under open condition. This is in line with reports of Ramadasan and Satheesan (1980) in turmeric and

Ramanujam and Jose (1984) in cassava. This could be due to their higher LAI in the open condition.

Absolute growth rate (AGR) differed significantly among different shade levels and accessions

AGR displayed a similar trend in variation among the periods of growth similar to that of CGR. This may be because CGR is a function of AGR and the whole plant dry matter is taken into consideration for their computation.

During the period from vegetative to flowering higher AGR was recorded by A_{15}. From flowering to fruiting higher AGR was recorded by A_{13} and A_{20} and from fruiting to harvesting, A_2 recorded higher AGR.

Data indicated that, AGR values were higher under open condition. With increase in shade level the photosynthetically active radiation falling on leaf surface may be less compared to open and this may have reflected in the low AGR. The observation was in line with that of Reshmi (2001) in *Clitoria ternatea.*

Relative growth rate (RGR) varied significantly among different shade levels during different periods of growth except during the second period (flowering to fruiting).

During the period from vegetative to flowering higher RGR was recorded by A_{13}. From flowering to fruiting higher RGR was recorded by A_3, A_4, A_8, A_{12} and A_{13}. From fruiting to harvesting, A_2 recorded higher RGR.

RGR showed a declining trend from first period and it was higher during vegetative to flowering stage. As the plant develops and number of leaves increases, more of them get shaded resulting in decrease of photosynthetic rate leading to lower RGR (Pearce and Mitchell, 1990). This was in line with findings of Haloi and Baldev (1986) who reported high value of RGR at the initial growth stages in *Cicer arietinum*. Similar reports were made by Nair (2000) and Reshmi (2001) in *Clitoria ternatea*.

As per the data, higher RGR value was observed in young oil palm plantation which was on par with that of open condition.

Harvest index (HI), which indicate the efficiency of accumulation of photosynthates in economic parts, differed significantly among different shade levels and accessions (Fig. 5). Higher harvest index was recorded under open condition and among young oil palm plantation. This may be due to the high rate of photosynthesis under open condition. The young oil palm plantation is almost similar to open conditions since the palm canopy is limited.

Significant variations for harvest index were observed among accessions under all shade levels. This is due to inherent variability that exists among accessions. Higher harvest index was recorded by A_{14}.

5.5 YIELD AND FRUIT CHARACTERS

The environmental conditions under which a plant grows control the productivity of the plant to a greater extent. The present study revealed that there was significant variation in fruits per plant among the different shade levels and among the different accessions (Fig. 6). Higher number of fruits was produced at S_3. Higher number of fruits was recorded by A_{15}.

As the shade level increased there was reduction in fruits per plant. This result is in conformity with the results reported by Jung *et al.* (1994) in pepper, Sharma and Tiwari (1993) and Thankam (1998) in tomato and Sreelathakumary (2000) in chilli.

Under shaded condition, reduced photosynthetic activity may have resulted in poor fruit set coupled with high flower drop.

No significant difference was observed among the different shade levels for fruit characters like fruit length, fruit diameter, fruit weight and

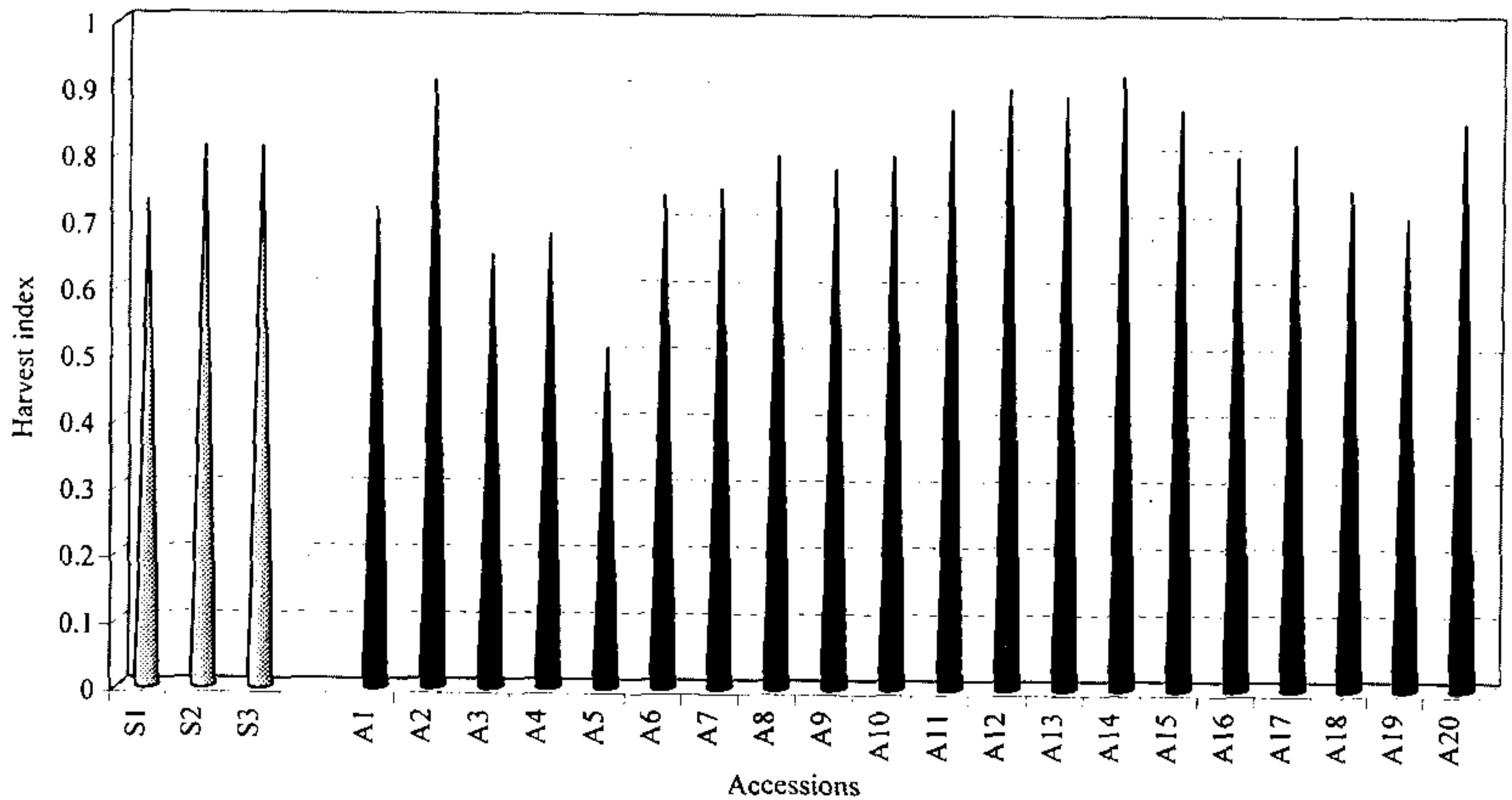

Fig. 5 Effect of different oil palm shade levels and accessions on harvest index

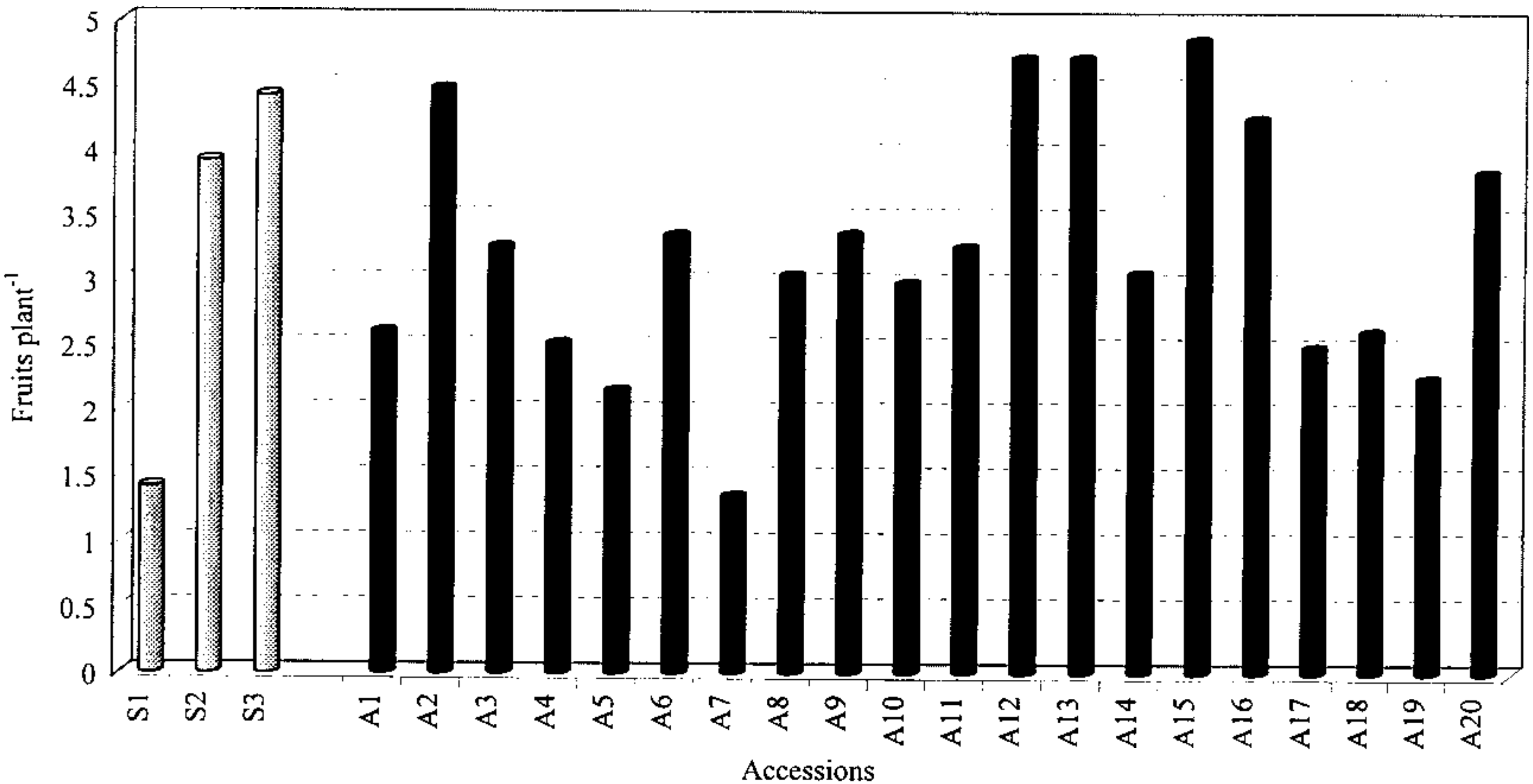

Fig. 6 Effect of different oil palm shade levels and accessions on fruits per plant

flesh thickness. This indicates that fruit morphology is governed by the genetic architecture, which is not altered by the environment. Similar findings were given by Sreelathakumary (2000) in chilli and Smitha (2002) in tomato.

Significant difference was noticed among the different accessions and different shade levels for rind thickness. Rind thickness increased with decrease in shade level. Higher rind thickness was recorded by A_{10}.

There was significant difference among different accessions and among different shade levels for total fruit yield (Fig. 7).

The result of the present study revealed that yield per plant was reduced under shade in comparison to open condition. Higher fruit yield was recorded at S_3 and lower fruit yield at S_1. Similar results of decreased yield under shade condition were reported by Nair (1991) in sweet potato, Nair *et al.* (1996) in cocoa and Shukla *et al.* (1997) in vegetables.

Under shaded condition, only small amount of light reaches the leaf surface which impairs the photosynthetic activity. Similar finding of reduced photosynthetic rate due to shade was also made by Noggle and Fritz (1979) and Logendra *et al.* (1990). Shading reduce net photosynthesis favouring vegetative development.

Among the accessions higher yield was recorded by A_2 and lower yield was recorded by A_5.

Variation in shade response of different accessions may be due to inherent variability that exists among them. In any environment the successful plant populations are those which have evolved the most appropriate physiological mechanisms (Bjorkman and Holmgren, 1963). Some accessions are more efficient in the utilization of light and such accessions perform better even under low light condition (Nilwik *et al.*,

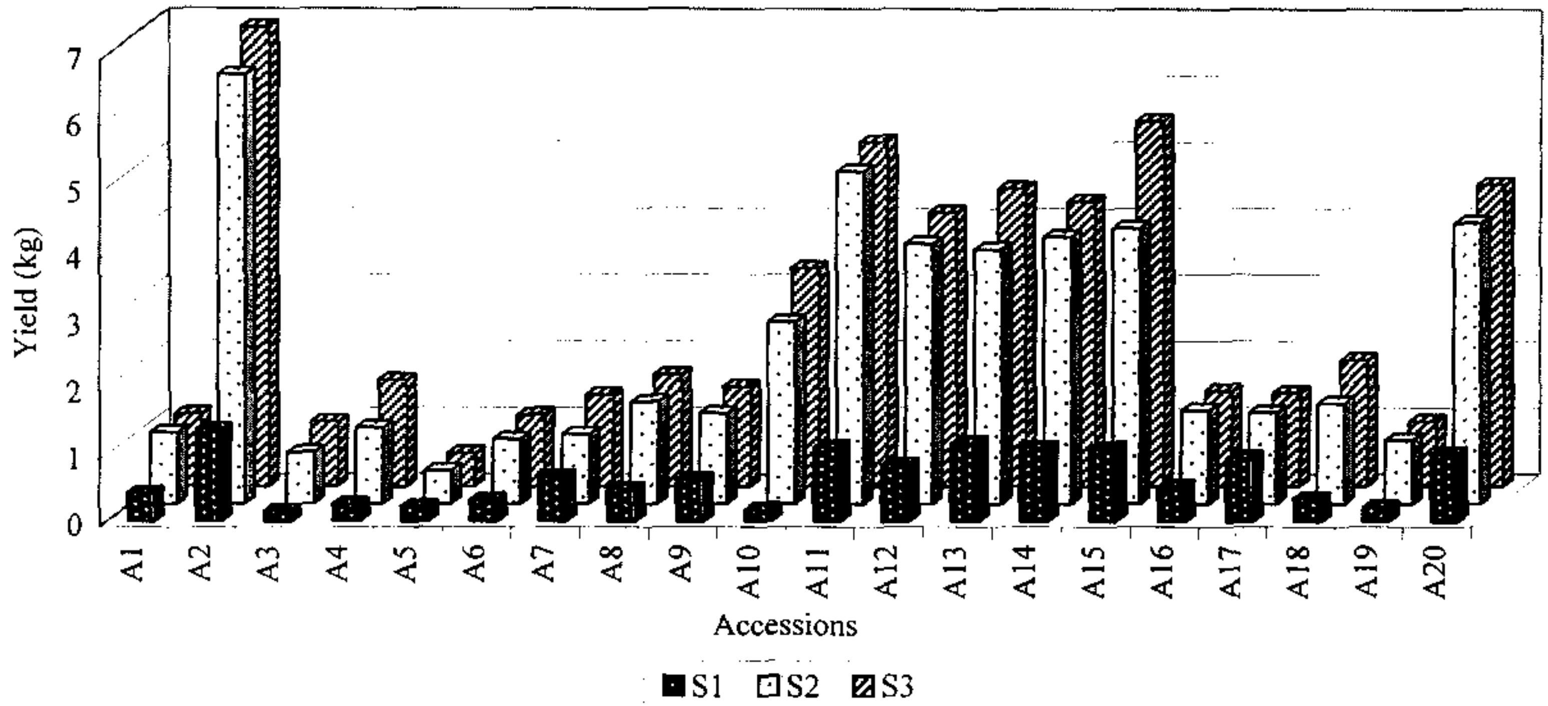

Fig. 7 Interaction effect of different oil palm shade levels and accessions on total yield

1982). This is in conformity with the reports that even cultivars within a crop differ in their productivity under intercropping (Ntari, 1989).

There was significant variation in seeds fruit^{-1} among the different accessions. Higher seed number was recorded by A_{11}.

5.6 BIOCHEMICAL CHARACTERS

There was significant variation in the content of total sugars, reducing sugars, non-reducing sugars and titrable acidity among the accessions. This may be due to inherent variability that exists among accessions.

Higher content of total sugars, reducing sugars and non-reducing sugars was recorded by A_{14}. Higher titrable acidity was recorded by A_1.

There was significant variation in the contents of P among the accessions and between different shade levels. Higher P content was recorded at S_1. Higher P content was recorded by A_5.

P content increased with increase in shade level. Such chemical change under low light may be a mechanism to enhance photosynthetic efficiency (Wong and Wilson, 1980). Similar reports of increased P content under shade was given by Murray (1961) in banana, Bai (1981) in sweet potato, Sulikeri (1986) in cardamom and Prameela (1990) in colocasia.

There was significant variation in the content of calcium, sodium, iron and sulphur among the accessions. Higher Ca content was recorded by A_6. A_{17} recorded higher Na content and A_{10} recorded higher sulphur content. Higher iron content was recorded by A_{18}.

5.7 SELECTION INDEX

The selection index scores based on sixteen characters *viz.*, days to first male and female flower, node to first male and female flower, vine length, branches per plant, fruit length, fruit diameter, fruits per plant.

fruit yield per plant, average fruit weight, flesh thickness, seeds per fruit, titrable acidity, calcium content and sodium content were used to identify superior accessions suited for intercropping under oil palm as well as open conditions. The accessions A_{11} and A_2 were found to show superior performance under intercropping situation and open condition.

The present study was conducted at the oil palm plantations of the Oil Palm India Ltd., Kulathupuzha. However, for almost all characters studied all the accessions showed superior performance under open condition. However, phytochemical analysis revealed no significant variation in mineral content of *Benincasa hispida* accessions except P grown both under shaded and open condition. The data on growth and yield analysis revealed that the harvest index of neykumbalam under the young oil palm canopy was equal to that under open condition. The yield under young oil palm canopy was comparable with that under open condition. This indicates its suitability as intercrop in young oil palm plantations. But the yield per plant under mature plantation was very low. Hence neykumbalam cannot be intercropped in mature oil palm plantations. The accessions A_{11} and A_2 were found to show superior performance under intercropping situation and open condition with respect to growth and yield characters.

Future Line of Work

The present experiment revealed the suitability of growing *Benincasa hispida* as intercrop in young oil palm plantation. Standardization of cultivation practices for economic cultivation of medicinal ash gourd at different levels of shades of oil palm canopy is necessary. The influence of intercropping on the performance of oil palm need to be investigated in detail. The experiment can be repeated under medium plantation (between 5 year and 11 year) and also under other agroclimatic situations.

SUMMARY

6. SUMMARY

A study on 'Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations' was carried out at the oil palm plantations, of the Oil palm India Ltd., Kulathupuzha, Kollam district, Kerala during the period 2001-2002. The objective of the study is to study the growth behaviour and yield of *Benincasa hispida* in the interspaces of oil palm and open condition and to identify superior ecotypes of neykumbalam suitable for intercropping in oil palm plantation.

The experiment was carried out in four phases *viz.*, collection of accessions of *Benincasa hispida*, germination studies, cultural trial of selected accessions as intercrop in oil palm plantation and as pure crop in open and biochemical analysis. The salient features of the investigation are summarized below :

Phase I

Twenty different accessions were collected from different parts of Kerala.

Phase II

The seeds of 20 collected accessions were subjected to germination studies. Out of these A_2 and A_{11} recorded the highest germination percentage of 95.

Phase III

The twenty accessions were raised in split plot design with two replications under mature plantation, young plantation as well as under open condition and pertinent observations were recorded. Analysis of the results revealed the following findings:

1. The direct effect of the treatment showed that plants raised under mature plantation showed superior vine length (8.90 m). Among the accessions, significantly superior vine length was recorded by A_{13} (12.01 m).

   Interactions of shade levels and accessions revealed that accession A_{13} under mature plantation (S_1A_{13}) produced higher vine length (13.48 m).

2. The shade levels, accessions and their interaction did not produce any influence on branches plant^{-1}.

3. Different shade levels significantly influenced leaf number. Higher number of leaves were recorded under open condition. Among the accessions, A_{15} recorded higher number of leaves.

   Among the treatment combinations, higher number of leaves was recorded by accessions A_{15} under open condition (S_3A_{15}).

4. The direct effect of shade levels were significant for male flower opening. It was early in plants under open condition (56.19 days). Accessions A_7 recorded lower days (54.17 days) to male flower opening.

   Interaction of shade levels and accessions revealed that accession A_7 under open condition (S_3A_7) was earlier in male flower opening (49.07 days).

5. The direct effect of shade levels were significant for female flower opening. It was early in plants under open condition (65.20 days). Accession A_7 recorded lower days (62.00 days) to female flower opening.

   Interaction of shade levels and accessions revealed that accession A_{17} under open condition (S_3A_{17}) was earlier in female flower opening (58.31 days).

6. Plants grown under open condition had first male flower on the lower nodes. Among the accessions, lowest node was recorded by A_{10} (11.83).

Interaction between shade levels and accessions did not influence node to first male flower.

7. Plant grown under open condition had first female flower on the lower nodes. Among the accessions, lowest node was recorded by A_{18} (18.88).

   Interaction between shade levels and accessions did not influence node to first female flower.

8. Higher dry matter production (DMP) was observed under open condition. Among the accessions, higher DMP was recorded by A_{15} at all growth stages except harvest stage. At harvest stage, A_2 recorded higher DMP (429.99 g $plant^{-1}$).

   Interaction between shade levels and accessions revealed that higher DMP was recorded by accession A_{15} grown under open condition (S_3A_{15}) at all growth stages except harvest stage.

9. The different shade levels influenced leaf area index (LAI) at all growth stages. Higher LAI was observed under open condition. Among the accessions, higher LAI was recorded by accession A_{15} under all growth stages except harvest stage. At harvest stage, higher LAI was recorded by A_6.

   Among the treatment combinations, higher LAI was recorded by accession A_{15} under open condition (S_3A_{15})

10. Higher crop growth rate (CGR) was observed under open condition during all periods of growth. Among the accessions, higher CGR was recorded by A_{11} during first and second period of growth and A_2 during third period of growth.

    Among the treatment combinations, accessions A_{15} under open condition (S_3A_{15}) recorded higher CGR during first period of growth and accession A_2 under open condition (S_3A_2) recorded higher CGR during third period of growth.

11. Higher absolute growth rate (AGR) was observed under open condition, during all periods of growth. Among the accessions, higher AGR was recorded by A_{15} during first period of growth and A_{13} and A_{20} during second growth period and A_2 during third growth period.

    Among the treatment combinations, accession A_{15} under open condition (S_3A_{15}) recorded higher AGR during first growth period and accession A_2 under open condition (S_3A_2) recorded higher AGR during third growth period.

12. Higher relative growth rate (RGR) was observed in plants under young plantation. Among the accessions, higher RGR was recorded by A_{13} during first and second growth period and A_2 during third growth period.

    Among the treatment combinations, accession A_{11} under young plantation (S_2A_{11}) recorded higher RGR during first growth period and accession A_2 under young plantation (S_2A_2) recorded higher RGR during third growth period.

13. Different shade levels, accessions and their interaction did not produce any significant effect on net assimilation rate.

14. Higher harvest index was observed in plants under open condition and among young plantation. Among the accessions higher harvest index was recorded by A_{14} (0.92).

    Among the treatment combinations accessions A_2 under open condition (S_3A_2) recorded higher harvest index (0.95).

15. Higher number of fruits was observed under open condition (4.43). Accession A_{15} recorded higher number of fruits (4.86).

    Interaction of shade levels and accessions revealed that accession A_{15} under open condition (S_3A_{15}) recorded higher number of fruits (7.18).

16. Different shade levels did not produce any significant effect on fruit length. Among the accessions A_{20} recorded higher fruit length (16.86 cm).

    Interaction of shade levels and accessions did not produce any significant effect on fruit length.

17. Different shade levels did not produce any significant effect on fruit diameter. Accession A_2 recorded higher fruit diameter (11.31 cm).

    Interaction effect was found to be insignificant in effecting fruit diameter.

18. Different shade levels had no significant influence on mean fruit weight. Among the accessions, A_{14} recorded higher mean fruit weight.

    Interaction effect was found to be insignificant in influencing mean fruit weight.

19. Higher fruit yield was recorded under open condition. Among the accessions, A_2 recorded higher yield (4.92 kg).

    Interaction of shade levels and accessions revealed that accession A_2 under open condition (S_3A_2) recorded higher yield (6.91 kg).

20. Direct effect of shade levels influenced rind thickness. Higher rind thickness was observed under open condition. Accession A_{10} recorded higher rind thickness (1.96 mm).

    Interaction effect was found to be insignificant in influencing rind thickness

21. Different shade levels had no significant influence on flesh thickness. Among the accessions, accession A_{10} recorded higher flesh thickness (11.07 cm).

    Interaction effect was found to be insignificant in influencing flesh thickness.

22. Shade levels did not influence seeds fruit^{-1}. Accessions A_{11} recorded higher seed number (461.91).

Interaction effect was found to be insignificant in influencing seeds fruit^{-1}.

Phase IV

1. Different shade levels had no significant influence on titrable acidity. Among the accessions, A_1 recorded higher titrable acidity (0.38 %).

   Interaction effect had no significant influence on titrable acidity.

2. Shade levels had no significant influence on total sugars, reducing sugars and non-reducing sugars. Among the accessions, A_{14} recorded higher total sugars (1.55 %), reducing sugars (1.31 %) and non-reducing sugars (0.25 %).

   Interaction effect was insignificant in influencing total sugars, reducing sugars and non-reducing sugars.

3. Higher phosphorus content was recorded in plants under mature plantation (0.23 %). Among the accessions, A_5 recorded higher phosphorus content (0.31 %).

   Interaction effect had no significant influence on phosphorus content.

4. Shade levels had no significant influence on calcium content. Accession A_6 recorded higher calcium content (0.96 %).

   Interaction effect was insignificant in influencing calcium content.

5. Different shade levels, accessions and their interactions did not produce any significant influence on magnesium content.

6. Different shade levels did not influence sodium content significantly. Accession A_{17} recorded higher sodium content (0.17 %)

   Interaction effect was insignificant in influencing sodium content.

7. Shade levels had no significant influence on sulphur content. Among the accessions A_{10} recorded higher sulphur content (0.20 %).

   Interaction effect did not produce any influence on sulphur content.

8. Different shade levels had no significant influence on iron content. *Among the accessions,* A_{18} *recorded higher iron content (0.51 mg 100* g^{-1}*).*

   Interaction effect did not produce any influence on iron content.

The present study revealed that neykumbalam can be cultivated as intercrop in young oil palm plantations but is not suitable for intercropping in mature oil palm plantation.

Based on the selection index scores developed using sixteen selected important characters, A_{11} (Thiruvananthapuram local-3) and A_2 (Idukki local-1) showed superior performance under intercropping situation and open condition.

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* Original not seen

EVALUATION OF NEYKUMBALAM [*Benincasa hispida* (Thunb.) Cogn.] IN OIL PALM PLANTATIONS

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Abstract of the thesis submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
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2003

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ABSTRACT

The study titled "Evaluation of neykumbalam [*Benincasa hispida* (Thunb.) Cogn.] in oil palm plantations" was carried out at the oil palm plantations of the Oil palm India Ltd., Kulathupuzha, Kollam district, Kerala during the period 2001-2002.

Seeds of twenty different neykumbalam accessions were collected from different parts of Kerala and were subjected to seed germination studies. These accessions were raised as intercrop in oil palm plantations of different age groups (above eleven years and below five years) and in open as a pure crop.

Various biometric observations were taken at four different stages *viz.*, vegetative stage (35 DAS), flowering stage (70 DAS), fruiting stage (105 DAS) and harvest stage (140 DAS). Growth parameters like vine length, number of branches and number of leaves and flowering characters and yield characters were evaluated. Physiological parameters evaluated included leaf area index, dry matter production, crop growth rate, absolute growth rate, relative growth rate, net assimilation rate and harvest index.

The different shade levels significantly influenced almost all characters. All the accessions showed superior performance under open condition. However, the yield under young oil palm canopy was comparable with that under open condition.

Under mature oil palm canopy and open condition, accession A_{11} performed best and A_3 was the poorest performer. Under young oil palm canopy, accession A_2 was the best performer and A_3 the poorest performer. From the study, A_{11} (Thiruvananthapuram local-3) and A_2 (Idukki local-1) were the most promising accessions identified, irrespective of the light condition.

Results of the present study indicated that neykumbalam is a fair proposition as an intercrop in young oil palm plantation.