PLANTING GEOMETRY AND DOUBLE INTERCROPPING IN CASSAVA

BY

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1989

DECLARATION

I hereby declare that this thesis entitled "PLANTING GEOMETRY AND DOUBLE INTERCROPPING IN CASSAVA" 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 to me any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

(BIJU.L.)

Vellayani.
23rd April, 1989

CERTIFICATE

Certified that this thesis entitled "PLANTING GEOMETRY AND DOUBLE INTERCROPPING IN CASSAVA" is a record of research work done independently by Sri. BIJU.L. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF PLATES

Introduction

INTRODUCTION

Cassava, (Manihot esculenta Crantz.) is the fourth most important energy staple of the tropics, providing food and income for about 750 million people. It is also known as a poor man's food. This starchy root crop is cultivated in tropical Africa, Asia and America where 38, 36 and 26 per cent, respectively of world production occurs.

Special features such as tolerance to low soil pH, low soil fertility, low soil moisture, drought and pests single out cassava as an ideal crop for the tropics, where adverse conditions are common. In India, more than 75 per cent of cassava cultivated area is in Kerala and forms an integral component of farming systems through out the state. Cassava grows well and yields satisfactorily even in poor laterite soils. It is grown in a wide range of topography.

Recent statistics (Anon., 1986) reveal that in Kerala, during the last decade, the area and production of cassava showed considerable decline. The area decreased from 3,26,865 ha in 1975-76 to 2,16,742 ha in 1984-85 and

production declined from 53,90,217 tonnes in 1975-76 to 36,94,270 tonnes in 1984-85. This downward trend may be attributed to the low income from cassava crops making its cultivation an uneconomic practice, compared to the cash crops such as rubber. Intercropping of cassava, without affecting the yield of cassava, is one of the feasible measures for obtaining higher economic returns from lands under cassava cultivation. In almost all indigenously evolved tropical cropping systems in which cassava contributes substantially to the total out put, intercropping predominates (Wilson and Lawson,1980). The range of crops with which cassava can be grown in association is broad. Moreover, when small farmers adopt intercropping as the production system, a relatively small plot is sufficient to provide the family with the basic dietary elements.

The most successful way of obtaining additional returns from unit land area, from an intercropping system, is creating a situation in which the component crops exploit the environmental supplies of growth factors in differing ways. Such complementary use of resources is

termed 'annidation'. 'Annidation in space' where in leaf canopies of intercrop components may occupy different vertical layers with the tallest component having foliage tolerant to strong light and high evaporative demand and the shorter component(s) having foliage requiring shade and relatively high humidity, is possible in an intercropping system. Other possible types of annidation in an intercropping system are 'annidation with respect of nutrients' wherein plant species make differing demands on the nutrient pool of a site and 'annidation in time' where in differences in length of growing season can lead to additional returns in an intercropping system.

The most frequently used planting pattern of cassava in pure stand is 1x1m or similar. However, this arrangement does not provide optimum conditions for the association of intercrops since the cassava canopy covers the ground below more rapidly than in other types of arrangements, shading the intercrop from early on (Castro, 1980). In a modified system of planting cassava known as 'paired row' system of planting, cassava plants never builds up its canopy to completely cover the interspace even at its rank growth stage and thus gives increased returns from the cassava based intercropping systems, due to lack of competition

with intercrops (Anilkumar, 1984). Moreover, the increased availability of solar radiation in the wider interspaces of cassava planted in paired row system even at a later stage of growth of cassava can be effectively utilised for raising a second intercrop succeeding a first intercrop raised during initial stages of growth, in sequence.

Groundnut as an intercrop in a cassava based intercropping system was found to be a successful practice in many studies. Paired row system of planting cassava at a spacing of 1.35x0.90x0.45m with groundnut in the interspaces was the most profitable system compared to intercropping groundnut in interspaces of cassava planted at a spacing of 0.90x0.90m (Anilkumar, 1984). French beans was reported to be a suitable intercrop from many research centres for better returns from a cassava based intercropping system. Reports show that French bean cv. 'contender' is suited as an intercrop in cassava based intercropping system for obtaining an additional income for farmers in India (Thomas et al., 1982). It was seen that a

cassava based intercropping system in which French beans sown 45 days after planting cassava gave the highest economic returns/ha and French bean sown 60 days after planting cassava also did not affect the root yield of cassava, thus revealing the successful cultivation of an intercrop at a later stage in a cassava based intercropping system (Lazarte, 1980). Considering the above aspects groundnut, French beans and horse gram were selected as intercrops for the present study.

Besides the above factors, the intercrops should be selected to fit in the expected rainfall pattern of the area. In Kerala planting time of cassava always coincides with the onset of monsoon rains and the main planting time is April-May when the south-west monsoon starts and an intercrop can be raised at the time of planting cassava. The north-east monsoon starts during September-October and so it is feasible to raise a second intercrop at that time.

Considering the above aspects, the present investigation was undertaken with the following objectives:

1) To find out a suitable planting geometry in a cassava based intercropping system.

2) To study the possibility of raising a second intercrop in sequence,, immediately after the harvest of the first intercrop, in a cassava based intercropping system.

3) To assess the superiority of different cassava based intercropping systems.

4) To study the soil fertility variations due to intercropping in a cassava based intercropping system.

5) To work out the economics of the cassava based intercropping systems.

Review of literature

REVIEW OF LITERATURE

Cassava based intercropping system was reported as early as 1935 (Marcus, 1935) from Brazil. But scientific intercropping in cassava is of recent origin. Reports from various countries indicate that intercropping in cassava with various short duration crops like cereals, millets, minor tubers, pulses and legumes, oil seeds, vegetables, fruits, medicinal plants and forage as a successful practice. The scientific and economic feasibility of a cassava based intercropping system is influenced by various factors like planting geometry, time of planting, planting density, crop compatibility, and cultural practices such as fertilizer management, weed control, plant protection etc. The relevant research works on the above aspects are reviewed hereunder.

A. Influence of various factors on the productivity of a cassava based intercropping system.

a. Planting Geometry:

A modification in the planting pattern of the base crop would make intercropping feasible and

REVIEW OF LITERATURE

Cassava based intercropping system was reported as early as 1935 (Marcus, 1935) from Brazil. But scientific intercropping in cassava is of recent origin. Reports from various countries indicate that intercropping in cassava with various short duration crops like cereals, millets, minor tubers, pulses and legumes, oil seeds, vegetables, fruits, medicinal plants and forage as a successful practice. The scientific and economic feasibility of a cassava based intercropping system is influenced by various factors like planting geometry, time of planting, planting density, crop compatibility, and cultural practices such as fertilizer management, weed control, plant protection etc. The relevant research works on the above aspects are reviewed hereunder.

A. Influence of various factors on the productivity of a cassava based intercropping system.

a. Planting Geometry:

A modification in the planting pattern of the base crop would make intercropping feasible and

remunerative, due to the better utilization of available space, nutritional factors and light. Variation in base crop yield was nil when the orientation of rows were altered, while keeping the plant population per unit area constant (De et al., 1978).

In cassava most frequently used planting pattern in pure stand is 1x1m or similar. However, this arrangement does not provide optimum conditions for the association of intercrops since the cassava canopy covers the ground below more rapidly than in other types of arrangements, shading the intercrops from earlier (Castro, 1980). Reports show that cassava border rows produce higher yields than inner rows probably due to better availability of light and nutrients and making use of this advantage, paired (double) row system of cassava cultivation, has been reported from many research centres.

Ezumah and Okigbo (1980) reported favourable effects on peanut productivity especially at high peanut populations by adopting double row planting technique for cassava. Mattos et al, (1980 a) observed that

cassava planting in paired row system was an advisable practice because besides increasing root and starch yields and profitability, it allowed the free space to be used for growing intercrops such as beans, soybeans, rice, peanut, millet, sweet potato and tobacco successfully. According to him a spacing of 2.0x0.6x0.6m for cassava brought about the highest productivity and the greatest income return rate.

Planting cassava in paired rows brings together two rows of cassava and compared to traditional methods makes available a greater space between these double rows, allowing other crops to be planted successfully. The paired row system improves crop production by allowing the easy use of mechanical equipments, reducing production costs due to decreased labour requirement, allowing possibility of successful intercropping, increasing productivity due to border effect, making crop inspection and application of pesticides easy, allowing possibility of mulching with plants in the free spaces for enriching the soil with organic material etc (Mattos et al ., 1980 a)

While conducting an experiment on utilization of free space between double rows of cassava by Crotalaria juncea, Mattos et al (1980 b) observed that the highest cassava root yields of 34.12 t/ha in CV BGM-116 and 39.72 t/ha in BGM - 001 were given by double rows 2.0 m apart with 0.6m between the two rows of each double row and between plants in the row and these yields were 57 and 16 per cent respectively higher than a control with rows 1m apart and 0.6m between plants in a row. Cassava yields with 2.5 or 3.0m between the double rows were not significantly different from the control. Fresh matter yield of C. juncea ranged from 14.7 t/ha with 2.0m between cassava double rows and 0.5m between plants in the row and between the two rows of each double row to 22.6 t/ha with 3.0m between cassava double rows and 0.7m between plants in the row and between the two rows of each double row.

Ternes (1981) reported that although the total roots per plant were higher with cassava planted in single rows at a spacing of 1x1m, commercial root production was 13 per cent greater with cassava planted in double rows

at a spacing of 2.5x.84x0.60m. The best agronomic and economic cropping system was cassava in double rows intercropped with maize at 25000 plants/ha, and the highest yields per crop of both cassava and maize were obtained from the monocrops.

Field experiments to study the effect of spatial arrangements in cassava - cowpea intercropping system conducted at CIAT (Anon., 1982 a) revealed that intercropping reduced cowpea yields to 75 per cent of the level of corresponding monoculture plots when cassava was planted in the 1x1m arrangement, but only by 13.5 per cent and 14.8 per cent in the 1.4 x 0.7 m and 1.8 x 0.55m arrangements of cassava respectively. Cassava root yields showed opposite trends in response to arrangements comparing monoculture and intercropped plots. In monoculture, fresh root production showed small downward trend when moving from square to rectangular planting and was not significantly different. An inverse trend was observed with intercropped cassava, the 1x1m planting yielding the lowest and the 1.8 x 0.55m arrangement the highest,differences

being large but non-significant.

Anilkumar (1984) concluded from crop geometry studies in cassava based intercropping system that paired row planting of cassava at a spacing of 1.35 x 0.90 x 0.45 m with groundnut in the interspaces was the most profitable system and also cassava in paired row without intercrop recorded a higher profit than cassava at normal spacing of 0.9x0.9m without intercrop.

Many reports on the effect of modification of planting pattern of intercrops in a cassava based intercropping system were published. Among the various planting patterns tried, cassava intercropped with two rows of peanuts (30cm between rows and 20 cm between hills) between cassava rows, 35cm apart from the cassava row was found to be remunerative when compared to cassava monocrop, peanut intercropped within the cassava rows or cassava intercropped with three rows of peanuts between its rows (Ekmahachai et al., 1976).

Kanchanahut (1976 a) reported that planting two rows of mungbeans at a spacing of 30 x 20 cm between cassava rows was found to be superior to cassava monoculture and planting four hills of mungbeans between cassava rows.

Tongham (1976) observed that highest yield was obtained when three rows of mungbeans were sown between the cassava rows compared to four hills of mungbeans between two hills of cassava and two rows of mungbeans between the cassava rows. This was contrary to the observation made by Kanchanahut (1976 a).

While making a comparative evaluation of the various methods of growing peanuts as an intercrop in cassava, Kanchanahut et al (1976) reported that planting peanuts in the cassava row ie., four hills of peanuts at a spacing of 20 cm between two hills of cassava planted at a spacing of 1x1 m was superior to cassava monoculture, planting two rows of peanuts at a spacing of 30 x 20cm between the cassava rows or planting three rows of peanuts between the cassava rows.

Kanchanahut (1976 b) observed that planting two rows of soybeans at 30x20cm spacing between the cassava rows was better than growing cassava in monoculture, or planting four hills of soybeans at 20cm spacing between two hills of cassava or three rows of soybeans between the cassava rows.

Studies on spatial arrangements with both cowpea and peanuts (Anon., 1980 a) showed that grain yields of both legumes were highest in a pattern of three rows between two rows of cassava spaced 1.8m apart. Outside rows of legumes were 0.55m from the cassava with 0.35m spacing between rows of legumes. Cassava yields were high when two rows of legumes were planted 0.7m from cassava rows spaced 1.8m apart. Rego (1981) evaluated different spatial arrangements as to the rate of soil cover and light interception and identified the spatial arrangement that minimised interspecific competition and maximised the productivity of the intercropping system with cassava as base crop and cowpea as intercrop. He observed that cassava in monoculture exhibited a slow initial growth and at two

months cassava had an average of 33 per cent soil cover while in association with cowpea the average soil cover was 75 per cent.

Experiments conducted at Mannuthy, Kerala (Anon., 1982 b) indicated that high yields from groundnut and cassava could be obtained when one row of groundnut was raised at a spacing of 30 cm apart in cassava grown at a spacing of 0.75 x 0.75 m.

b. Planting time

Relative time of planting in a cassava based intercropping system was found to have significant effects on the productivity of the system. Results of experiments on intercropping cassava with maize, melons and vegetables, conducted at Ibadan, Nigeria (Anon., 1975 a) indicated that it was essential to plant cassava one to two months before maize to ensure a relay crop prior to the harvesting of cassava. When intercropped with maize and melons, cassava yielded 34 t fresh tuber/ha as compared to 28t when planted alone.

Kanchanahut (1976 a) reported that planting time had no effect on mungbean yields when mungbeans were planted 40, 20 and 0 days before cassava, although planting cassava 40 days after mungbeans gave higher income. A similar study conducted by Kanchanahut et al., (1976) showed that simultaneous planting of groundnut and cassava was the best. It was observed that planting cassava, 0,20 and 40 days after soybeans yielded nearly the same amount of roots, but at 40 days, soybeans gave more income (Kanchanahut, 1976 b).

In intercropping studies with cassava and beans (Anon., 1977), cassava root yield was little affected by the planting date of the beans, compared with monoculture cassava harvested at 340 days. When intercropped cassava was harvested earlier at 260 days, cassava yields were markedly reduced when the beans were planted four weeks before cassava. Bean yields were not reduced by intercropping with cassava when beans were planted from four to six weeks before cassava but bean yields showed a marked decline when beans were planted from three weeks before to six weeks

after cassava. Studies on the effect of time of planting cassava on upland cropping pattern performance (Anon., 1978 a) revealed that the optimum planting date for cassava was 20 days after sowing maize and 40 days after sowing upland rice.

Gerodetti (1979) reported that simultaneous planting reduced total production of cassava by 40 per cent in cassava/maize associations. Thung and Cock (1979) observed from a trial conducted with cassava and common beans that greatest total yields were achieved when both crops were planted at the same time or with a difference in planting time of less than one week. Simultaneous planting of both maize and cassava was found to be profitable (Anon., 1980 b)

Lazarte (1980) reported that relative planting date affected both cassava and bean (Phaseolus vulgaris) production. Beans were planted 60, 45, 30 and 0 days before cassava and 30,45 and 60 days after cassava and concluded that root weight did not vary due to planting or intercropping date. Cassava planted 60 days after bean planting gave greater land use efficiency, productivity

and total profit/ha. The highest economic returns/ha per month were obtained when beans were planted 45 days after cassava.

The yields of cowpea, lima beans and common beans (both climbing and bush type), intercropped with cassava at the end of its growth cycle (after 240 days of cassava planting) were analysed by Moreno and Meneses (1980) and observed that cowpea and limabean yields were decreased by 33 and 35 per cent with respect to the monocultures Reduction in the yield of bush variety of common beans to the tune of 17 per cent was noted due to competition with cassava while 14 per cent increase was noted with climbing variety as compared to their respective monocultures. Cassava both in monoculture and in association with beans gave similar yields (25.40 and 25.61 t/ha respectively).

In an experiment (Anon., 1981 a) Phaseolus sp. was sown upto six weeks before or six weeks after cassava planting and concluded that Phaseolus seed yield declined with lateness of sowing. Yields of cassava roots harvested at 260 days were reduced by early sowing of Phaseolus sp.

but at 340 days cassava yields were not affected. The most efficient biological land utilization as measured by the L.E.R. was 1.7 when the crops were sown or planted at the same time or Phaseolus sp. was sown one week earlier.

Studies indicated that cassava can be intercropped with beans at later stages of development (9 months after planting cassava) without modifying the cassava canopy or affecting root or starch yields and a small bean yield (500 - 800 Kg / ha) can be obtained (Anon., 1981 b). Field trials carried out by Nilaipon et al., (1981) to study the effect of sowing time of stylo on cassava + stylo intercropping system showed that simultaneous planting of cassava and stylo reduced cassava yield significantly as compared with monocropping of cassava. It was also noted that planting stylo six weeks after planting cassava caused only very little and insignificant reduction in cassava yield.

C. Groundnut:

Groundnut as an intercrop in a cassava based intercropping system was found to be successful practice

in many studies, though yield reduction of base crop of cassava was also reported. Singh and Mandal (1968) reported that growing groundnut as an intercrop in cassava did not substantially affect the growth and yield of cassava. It was observed that tuber yield of cassava was not affected by legume intercrops, groundnut and cowpea (Singh et al., 1969)

From their experiments on cassava intercropping using groundnut, cowpea, green gram, sunflower, soybean and maize Nbhankumar and Hrishi (1973) reported that though groundnut intercropped plots recorded lowest tuber yield of cassava, it was found superior to other intercrops from the point of net returns. Katyal and Dutta (1976) observed that growing of groundnut and cowpea in between cassava rows did not affect normal yield of main crop.

Patanothai et al., (1977) revealed that there were no significant yield differences between cassava in monoculture and those obtained from intercropping with peanuts, soybeans, mungbeans, maize and uplandrice.

Among the field crops used, peanuts produced the best yields also. In general peanuts and mungbeans, appeared to be the most suitable crops for intercropping in cassava. In another study (Anon., 1978 b) it was found that tuber yield of cassava was not seriously affected by groundnut as intercrop.

Ramakrishna Bhat (1978) reported that the tuber and top yields of cassava were not affected by growing groundnut, cowpea, black gram and green gram as intercrops. It was observed in Malaysia (Chew, 1978) that groundnut had great potential to grow as intercrop in cassava without affecting the tuber yield considerably. From an experiment conducted at CTCRI, Trivandrum by Mohankumar and Hrishi (1978) it was concluded that maximum gross returns were obtained when groundnut was intercropped with cassava.

Prabhakar et al., (1979) reported that all the intercrops (groundnut, cowpea, maize, fodder maize, horsegram, greengram, blackgram and red gram) had their deleterious effects on the main crop, which resulted in the reduction of cassava tuber yield. Contrary to this an increase in tuber yield of cassava by 0.49 t/ha was

observed by Thomas and Nair (1979) when it was intercropped with groundnut.

Leihner (1979) developed a new intercropping technology for cassava/grain associations at CIAT, which suggested the use of a high yielding cassava CV. with an erect, late branching growth habit with minimum competition with intercrops and the use of legume crops, preferably Arachis hypogaea, Phaseolus vulgaris or Vigna unguiculata, which are early maturing, rapidly covering the ground and with determinate growth habits, as companion crops.

Higher yields of cassava (26.76 t/ha) was obtained when intercropped with groundnuts compared to sole culture, in an experiment conducted at Khonkaen University, Thailand (Anon., 1980 c). Significant difference in tuber yield was noticed by Mohanakumar (1980) when cassava was intercropped with groundnut, green gram, maize, soybeans and sunflower.

In an experiment to evaluate different varieties of groundnut and cowpea as intercrops with cassava (Anon., 1981c) it was observed that all the groundnut varieties affected the cassava growth but maximum was seen

with TG-17. However, TG-17 recorded highest yield as intercrop and TMV-2 the lowest. Sheela (1981) found groundnut to be the best suited intercrop of cassava and also observed that the overall net return was maximum for cassava intercropped with groundnut.

In trials at CIAT (Anon., 1982 c) it was found that groundnut suffered seed reduction of 15 per cent from intercropping with cassava and reduced cassava root yields by 18 per cent. In an experiment conducted at Chalakkudy (Anon., 1982 b) for evaluating groundnut varieties like JL-24, Pollachi-1, Pollachi-2, FSB-7-2 and TMV-2 for mixed cropping with cassava, it was found that though the difference in pod yield was non significant, highest yield was reported by TMV-2 (482 Kg/ha).

Mason (1983) observed that intercropping cassava with either groundnut or cowpea resulted in approximately 25 per cent greater land use efficiency for the eleven month growing season than did sole cropped cassava and

sole cropped groundnut or cowpea. The greater land use efficiency when intercropped was associated with significantly greater leaf area and dry matter production during early growth stages than for those of sole cropped cassava, although at harvest the total leaf area and dry matter produced were similar.

d. French beans:

French beans was reported to be a suitable intercrop for better return from a cassava based intercropping system. A study (Anon., 1975b) revealed that cassava grown alone gave tuber yields of 12.9 t/ha while it was 13.2 t/ha and 11.0 t/ha when intercropped with beans and maize respectively. Bieber (1975) reported that intercropping cassava with cowpea reduced tuber yield of cassava than the intercrop of common beans.

Wilson and Adenisan (1976) observed that when cassava was intercropped with a sequence of three vegetables (tomatoes, okra and French beans) the yields of okra and French beans were suppressed but land equivalent ratios showed that this system was more

efficient than any of the crops alone. From experiments conducted at CIAT (Anon., 1978 a) it was observed that there was a non-significant but positive correlation between bean yield and cassava fresh root yield. The Phaseolus bean completed its growth cycle (100 days) before cassava covered the ground and hence could yield well with cassava. On the other hand, the soybean had a growth cycle of 125 days and its grain filling stage occured only when cassava completely covered the ground and so severe competition occurred between cassava and soybean. In another study at CIAT (Anon., 1978c) cassava was planted with various legumes like beans, perennial peanuts, soybeans, cowpea, stylo, kudzu etc and it was found that beans, perennial peanuts and soybeans grew poorly because of toxic levels of aluminium and manganese in the soil and thus competed less with cassava.

Leihner (1978) analysed weed growth in a cassava sole crop compared to a cassava/common bean intercropping system at CIAT - Palmira in Colombia. Without other

control measures the practice of intercropping common beans with cassava reduced total weed dry weight to 30,47 and 33 per cent of the amount observed in the cassava sole crop at 45, 90 and 135 days after planting respectively. The reduced weed weight at 135 days indicated that the associated beans had a residual control effect, since the crop had been harvested at 105 days after planting. Only at 180 days after planting were equal amounts of weeds found under both cassava solecrop and cassava bean intercrop condition. In the association, cassava yield was the same with or without additional chemical and manual weed control measures. However, in single culture, cassava suffered a yield reduction of 30 per cent when no chemical or manual weed control was practiced.

Correa and Rocha (1979) recommended intercropping of cassava with French beans, soybeans, cowpea, maize, rice, grain sorghum and crotalaria for maximum landuse and productivity. Escalda and Javier (1979) observed that maximum quantity of marketable cassava tubers can

be harvested when it was intercropped with inoculated bush beans. A new intercropping technology for cassava/ grain associations was developed at CIAT by Leihner (1979). According to this high yielding cassava CV. with an erect, late branching growth habit with minimum intercrop competition should be used. Legume crops, preferably, Phaseolus vulgaris, Arachis hypogaea or Vigna unguiculata which are early maturing, rapidly covering the ground and with determinate growth habits should be used as companion crops. The associated crops should be planted simultaneously, each at its normal, monocropping density.

Prabhakar et al., (1979) observed that tuber yield was significantly superior when cassava was grown as a pure crop and intercropping with any vegetable crop (cowpea, Frenchbeans, amaranthus, cucumber or bhindi) has reduced the tuber yield of cassava significantly. Among the different intercrops tried treatment with beans recorded the maximum tuber yield of cassava; but was on par with other intercrops. Thomas et al (1982) reported management practices of cassava

intercropped with snap bean CV. contender and recommended this intercropping system for an additional income for farmers in India.

Kawano and Thung (1982) found that beans planted in association with cassava had no significant reductions in yields whereas, yields of soybeans were severely reduced. In experiments conducted by Caetano (1983) cassava and beans were planted at the same time with 0.40m between cassava plants and 1.40m between rows and bean population consisted of 1,2 and 3 rows between cassava. It was observed that productivity of cassava roots was reduced by 25.1, 35.6 and 48.2 per cent when cassava was intercropped with 1,2 and 3 rows of beans respectively.

Arias and Obandog (1984) recommended planting of cassava in association with bush beans as a good alternative to increase crop productivity, improve the income and obtain foods with high nutritive value. It was noted by Neumann (1984) that when cassava was associated with beans and soybeans at different plant spacings, root productivity was 3.5 times higher in the association than in the pure stand (9.07 VS 2.37 t/ha).

Promising associations with cassava, developed at CTCRI, Trivandrum, India were reported by Prabhakar and Pillai (1984) and they were: (1) cassava/grain legumes (Vigna unguiculata, Cajanus cajan, Phaseolus aureus, P. mungo, Glycine max); (2) cassava/oil seeds (Arachis hypogaea and Helianthus annus); (3) cassava/ vegetable crops (cucumber, cowpea, okra, French beans) (4) cassava/medicinal plants like Catharanthus roseus and (5) cassava/maize. Among these the most profitable combinations were found to be cassava/french beans, cassava/groundnut and cassava/Catharanthus roseus and french bean was noted as the most economical intercrop.

In an experiment at CTCRI, Trivandrum (Prabhakar and Nair, 1984) peanut, cowpea and green bean (Phaseolus vulgaris) were intercropped with cassava planted at a spacing of 0.9 x 0.9 m. The highest yield of cassava in association (24.04 t/ha) was obtained with the association cassava/green beans, and this association also gave the highest net income. Cassava yield in monoculture (control) was 26.58t/ha.

e. Horse gram:

Works on feasibility of horse gram as intercrop in a cassava based intercropping system are few. In an experiment conducted by Singh and Mandal (1970) with different intercrops like horsegram, sesamum, coleus, bhindi, groundnut and cowpea, it was found that horsegram and sesamum considerably reduced the tuber yield of cassava.

Prabhakar et al., (1979) from an experiment in cassava based intercropping system noted that all the intercrops used like horsegram, greengram, blackgram, red gram, groundnut, cowpea, maize and fodder maize had their deleterious effects on the main crop, which resulted in the reduction of cassava tuber yield.

f. Planting density:

The results of experiments conducted by Meneses and Moreno (1979) at Turrialba in Coasta Rica, to establish optimum planting density in cassava/maize association, revealed very strong effect of competition

by maize over cassava. Maize planting density showed highly significant effect on cassava with respect to parameters like height of the plant, height at the first branching, number, weight and length of commercial roots and diameter of stem. Cassava yields varied from 75 per cent (with 10,000 maize plants/ha) to 46 per cent (with 50,000 maize plants/ha) compared to sole crop of cassava.

Hagewald (1980) reported, while making a study on intercropping grain legumes with cassava on acid sulphate soils, that cowpea and groundnut gave maximum yields with 1,00,000 and 2,00,000 plants/ha respectively. From an experiment to study the effect of maize plant population on cassava/maize intercropping system, Kang and Wilson (1980) observed that increasing maize population from 10,000 to 30,000 plants/ha increased maize grain yield significantly and had no significant effect on root yield of cassava. Higher population of maize (maximum tried 70,000 plants/ha) had no effect on grain yield of maize but significantly reduced root

yields of cassava. It was also found that three maize plants per cassava hill to be optimum.

It was reported from field trials (Anon., 1981d) in which cowpea or groundnuts were sown at various populations and spacings in cassava planted at 9259 plants/ha in rows 180cm apart, that seed yields were highest at 110,000 and 222,000 plants/ha respectively. It was also seen that these legumes reduced root yields of cassava with least and greatest effect when rows of legumes were placed 70 and 45 cm respectively distant from cassava rows.

Ternes (1981) observed, from an intercropping experiment, in which treatments included two cassava monocrops in single (1x1m) and double rows (2.5x0.84x0.60m) at 10,000 plants/ha; three monocrops of maize at 10000, 25000 and 40000 plants/ha; and six intercrops in all possible combinations, that the best agronomic and economic cropping system was cassava in double rows intercropped with maize at 25000 plants/ha. In another trial two cassava CV. and two bean CV. with different

growth habits and vegetative cycles and with different bean population densities were studied by Caetano (1983). Cassava and beans were planted at the same time with 0.40m distance between cassava plants and 1.40m between rows and bean population consisted of 1,2 and3 rows between cassava. It was observed that productivity of cassava roots was reduced by 25.1, 35.6 and 48.2 per cent when cassava was intercropped with 1,2 and 3 rows of beans respectively.

g. Fertilizer application:

It was observed by Mohankumar and Hrishi (1973) that, application of fertilizers to both the main and intercrops produced higher yields which were significantly superior to application of fertilizers to main crop alone. Experiments conducted at CIAT (Anon., 1974) showed that without high applications of lime and phosphorus, French beans, the best suited intercrop of cassava, failed to produce grain in acid infertile soils.

It was found from experiments conducted at CIAT (Anon., 1975b) that cowpea and peanuts in association with cassava produced grainyields of 1.9 t/ha and 1.5 t/ha with a fertilizer level of 0.5 t/ha of lime 100, 105, 35, 3 and 1 Kg/ha of N, P_2O_5, K_2O, Zn and B respectively but the yield of mungbean was severaly disturbed by these conditions and its yield was less than 400 Kg/ha. It was also noted that small amounts of nitrogen appeared to be optimal both for cassava root production and grain legume production whereas higher levels of phosphorus was essential for better root yield and initial legume growth.

Ekpete (1976) in an experiment raised cassava as pure crop and intercropped with maize and okra, under three NPK ratios and observed that tuber yield of cassava increased with increase in quantity of fertilizers applied in pure stands but no increase was noticed in tuber yield of cassava in mixed stands with increase in quantity of fertilizers applied. But yield of intercrops increased with increase in quantity of fertilizers applied.

Investigations conducted, on the changes in nutrient absorption in different stages of physiological development of the crops and its effects on bean, maize and cassava production agrosystem, by Lacharme (1976), showed that greatest need of the crops for soil nutrients was between 25 to 75 days. The need was of the order cassava > maize > beans. Fertilizer efficiency was of the order K>N>P>S. In the above study cassava and maize were found to be great biomass producers and soil nutrient extractors.

Nitis (1977) reported that stylo was beneficial as a companion crop because of the increased N supply for cassava equivalent to about 20 Kg urea/ha. The N supply by stylo with P and K fertilizers reached the equivalent of 160 Kg urea/ha. In association, cassava shoot and root yields increased by 0.39 and 0.43 t dry matter/ha respectively. The extra green feed produced by stylo ranged from 0.14 - 0.39 t dry matter/ha. Trials conducted in Philippines by Palada and Harwood

(1977), to compare monoculture plantings of maize, rice and cassava with intercrop combinations at different nitrogen levels, showed that when the three crops were sown or planted together at the same date, maize and cassava had a better competitive ability than rice in terms of light and nutrients. It was also noted that growth balance between the three crops was best at low nitrogen level of 60 Kg/ha but total productivity was lower. Higher total productivity was obtained at 180 Kg nitrogen/ha, with a land equivalent ratio (L.E.R) value of 1.9 for the three crop combinations.

No response by cassava to fertilizer application was noted by Patanothai and Laohasiriwong (1977), when it was intercropped with peanuts, soybeans and mungbeans. It was also found that on similar soils fertilization in cassava legume intercropping system was not profitable. Mohankumar and Hrishi (1978) conducted trials which consisted of combination of the method of planting cassava and level of fertility in the main plot and

the companion crops in the sub plots. The treatments in main plot were (a) planting method M_1 (90x90cm) and M_2 (double rows) and (b) levels of fertility F_1 (application of 12.5t FYM/ha + recommended dose of NPK for main crop) and F_2 (recommended dose of fertilizers for main crop + recommended dose of companion crops) and treatments in sub plots were green gram, groundnut, maize, soybeans and sunflower as companion crops. It was observed that in all cases application of fertilizers to both crops (F_2) resulted in maximum tuber yield.

Nitis (1978) studied the effect of cassava/stylo combination on cassava/stylo production and land productivity after two years of intercropping and found that residual effect of fertilizers was still beneficial for the natural pasture after companion cropping. The effect of nitrogen derived from the stylo root nodule seemed to be greater than that from urea. The carry over effect of companion cropping increased the quality and quantity of live stock feed, gave better water and soil conservation

and more efficient land utilisation. It was reported by Ramakrishna Bhat (1978) that in addition to fertilization of base crop of cassava, seperate fertilization of intercrops should also be done. He also found that fertility status of soil was improved due to intercropping cassava with legumes. But Lira et al., (1979) observed that intercropping increased production with or without fertilizers.

Meneses and Moreno (1979) reported that the level of fertilization had a highly significant effect on the number and weight of commercial roots of cassava in a maize/cassava association. Best cassava yields were obtained by Porto et al., (1979) when single super phosphate, potassium chloride and ammonium sulphate were applied at 300, 100 and 150 Kg/ha respectively to an association of cassava with beans, soybeans, rice, peanuts, sorghum or maize.

Sheela (1981) observed that a common fertilizer dose of 50:62.5 :62.5 and 93.75: 75: 93.75 Kg of N, P_2O_5 and K_2O /ha gave maximum returns for cassava/ cowpea and cassava/groundnut combinations respectively.

She also noted that fertility status of soil was improved by intercropping cassava with legumes. Anilkumar (1983) concluded, from a trial on nitrogen economy and soil conservation in cassava/ stylo intercropping system, that growth characters and yield attributing characters were not influenced by intercropping and nitrogen levels. Though the tuber and top yields were numerically lower in intercropped plots, the reductions were not statistically significant.

B. Possibility of raising a second intercrop in a cassava based inter cropping system.

Though reports about the possibility of raising a second intercrop in sequence in a cassava based intercropping system are not available, many trials were conducted to study the possibility of raising an intercrop at later stages of growth of cassava and both favourable and unfavourable results were obtained which are reviewed hereunder.

In a trial (Anon., 1976), in which an intercrop of Phaseolus vulgaris was sown six weeks after planting cassava the seed yield of P. vulgaris was reduced to 53 per cent of what was obtained in monoculture. Results of an experiment conducted by Prabhakar et al., (1979) showed that under the agro-climatic conditions prevailing in Kerala and also due to growth habit of cassava crop it is not possible to raise a second intercrop in cassava planted at a spacing of 90x90 cm. This is probably due to the fact that at the time of harvest of the first intercrop the cassava developed enough canopy to cover the entire field and the sunlight penetration into the ground was less than 10 percent of the light falling on the top of the cassava plant. It was also observed that all the second intercrops reduced the productivity of cassava.

Lazarte (1980) observed, from experiments conducted on sandy loam soils of Peru, to study effect of planting date of Phaseolus vulgaris on the

productivity of a cassava based intercropping system, that root weight of cassava did not vary due to intercropping date. It was also found that the highest economic returns/ha per month were obtained when P. vulgaris was sown 45 days after planting cassava, revealing the successful cultivation of an intercrop at a later stage in a cassava based intercropping system. P. vulgaris sown 60 days after planting cassava also did not affect the root yield of cassava.

An experiment on cassava/maize association (Maurya and Lal., 1980) revealed that a second maize intercrop was not possible during the second season. Moreno and Meneses (1980) conducted trials to analyse the yields of cowpea, lima beans and common beans (both climbing and bush type) intercropped with cassava at the end of its growth cycle. These legumes were intercropped with cassava after 240 days of cassava planting and it was observed that cowpea and lima bean yields were decreased by 33 and 35 per cent with respect to the corresponding monocultures. Reduction in the yield of bush variety of common beans to the

tune of 17 per cent was noted due to competition with cassava while 14 per cent increase in yield was noted with climbing variety as compared to their respective monocultures. Cassava both in monoculture and in association with beans presented similar yields (25.40 and25.61 t/ha respectively).

Studies indicated that cassava can be intercropped with beans at later stages of development (9 months after planting) without modifying the cassava canopy or affecting root or starch yields and a small bean yield of 500 to 800 Kg/ha can be obtained. (Anon., 1981 b). When cassava was defoliated simulataneously with bean sowing trials (7,8 and 9 months after cassava planting) and the effects of one and two defoliations at different intervals after bean planting (0,15 or 30 days; 0 and 30 days., 15 and 45 days; 30 and 60 days) were compared, cassava yields tended to show a greater reduction by early than by late defoliation. Defoliation reduced cassava yield by 15 per cent on the average. It was recommended that to obtain higher bean yields without drastically affecting the yield

of cassava (1) interplant beans with 9 months old cassava and sufficient moisture should be available during the first 60 days. (2) make 2 defoliations of cassava (done at planting and another 4 weeks after planting of beans) at an intensity of 67 per cent.

Castellanos (1981) conducted two experiments at CIAT, Colombia from December 1979 to January, 1981. Experiments were intercropping bush beans with cassava and intercropping climbing beans with cassava and the treatments were established when cassava was 7,8 and 9 months old ie., in the second half of cassava growth cycle, with or without pruning of cassava. It was observed that cassava root yields in monoculture and in association with beans (average 18 mt/ha) were not affected by pruning in cassava and nutrient extraction in cassava was similar in performance in both monoculture and in association with beans. Pruned cassava + bush beans was found to have a higher land equivalent ratio surpassing the corresponding monoculture values by

56 per cent and unpruned cassava + climbing beans was 33 per cent more efficient regarding land use efficiency than their respective monocultures.

Trials carried out by Wilaipon et al., (1981), to study the effect of sowing time of stylo on cassava-stylo production, showed that planting cassava and stylo at the same time significantly reduced cassava yields as compared with monocropping of cassava. However, planting stylo six weeks after cassava caused only very little and non-significant reduction in cassava yield.

C. Economics of Cassava based intercropping systems

Results of most of the trials conducted on cassava based intercropping systems showed that intercropping gave an additional income from unit area in unit time, over and above the income obtained from monocropping of cassava.

Singh and Mandal (1970) found groundnut to be the best intercrop while considering the economics of a cassava based intercropping system.

Mohankumar and Hrishi (1974) reported that intercropping cassava with greengram or soybeans was uneconomic as the net returns were less than that obtained from the control plot. An increase of 14 to 41.7 per cent more income was observed by Tongham (1975) from intercropping cassava with sweet corn, soybeans and peanuts.

Katyal and Dutta (1976) obtained significantly higher net returns when cassava was intercropped with groundnut. From experiment conducted in Tamilnadu by Thamburaj and Muthukrishnan (1976) it was observed that onion as intercrop in cassava provided an additional profit of Rs. 1,046/ha. From trials in cassava/peanut intercropping, Mohankumar (1978) noted that 25 per cent more returns can be obtained from the intercropping system when compared to monoculture of cassava.

Ramakrishna Bhat (1978) got maximum net profit of Rs.5489.70/ha when cassava was intercropped with groundnut and supplied with 20 : 30 : 40 Kg/ha of N, P_2O_5 and K_2O. Nambiar et al., (1979) reported that

cassava-cowpea combination gave an additional income of Rs.2,048/ha which was about 58 per cent more than the control. Prabhakar et al., (1979) also recorded maximum returns when cassava was intercropped with groundnut. Mohankumar et al., (1980) proved the superiority of groundnut as an intercrop in cassava from the point of view of maximum returns. However, the next best intercrop was french beans.

Sheela (1981) observed that cassava/groundnut intercropping system gave the maximum economic returns. Thomas et al., (1982) reported that an additional income of of Rs.2400/ha was obtained by intercropping cassava with french beans, when compared to monocropping of cassava. Anilkumar (1984) recorded the highest economic returns when cassava was planted in paired rows and groundnut was raised as intercrop in between the paired rows of cassava.

Arias and Obandog (1984), recommended planting of cassava in association with bush beans as a good alternative to increase crop productivity, improve the

income and obtain foods with high nutritive value. From trials conducted at CTCRI, Trivandrum, India, to develop promising associations with cassava, Prabhakar and Pillai (1984) observed that intercropping gives more income than the cassava sole cropping and the most profitable combinations found were cassava/groundnut, cassava/French beans, and cassava/Catharanthus roseus.

Materials and methods

MATERIALS AND METHODS

The present investigation was undertaken to study the possibility of raising a second intercrop after the harvest of the first intercrop in a cassava based intercropping system with a suitable planting geometry. The materials used and the methods adopted are detailed below:

Materials

Experimental site.

The experiment was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani. The College is located at 8° N latitude and at an altitude of 29 metres above mean sea level.

Soil.

The soil of the experimental site is red loam with the following physico-chemical properties.

A. Mechanical composition

Coarse sand	(%)	..	13.70
Fine sand	(%)	..	33.40
Silt	(%)	..	28.00
Clay	(%)	..	24.90

B. Chemical composition

pH	..	5.30
Total nitrogen	..	0.058 per cent
Available P_2O_5	..	42.840 Kg/ha
Available K_2O	..	39.753 Kg/ha

Cropping history of the field.

The experimental area was lying fallow for the preceeding three months and before that it was under a bulk crop of cassava.

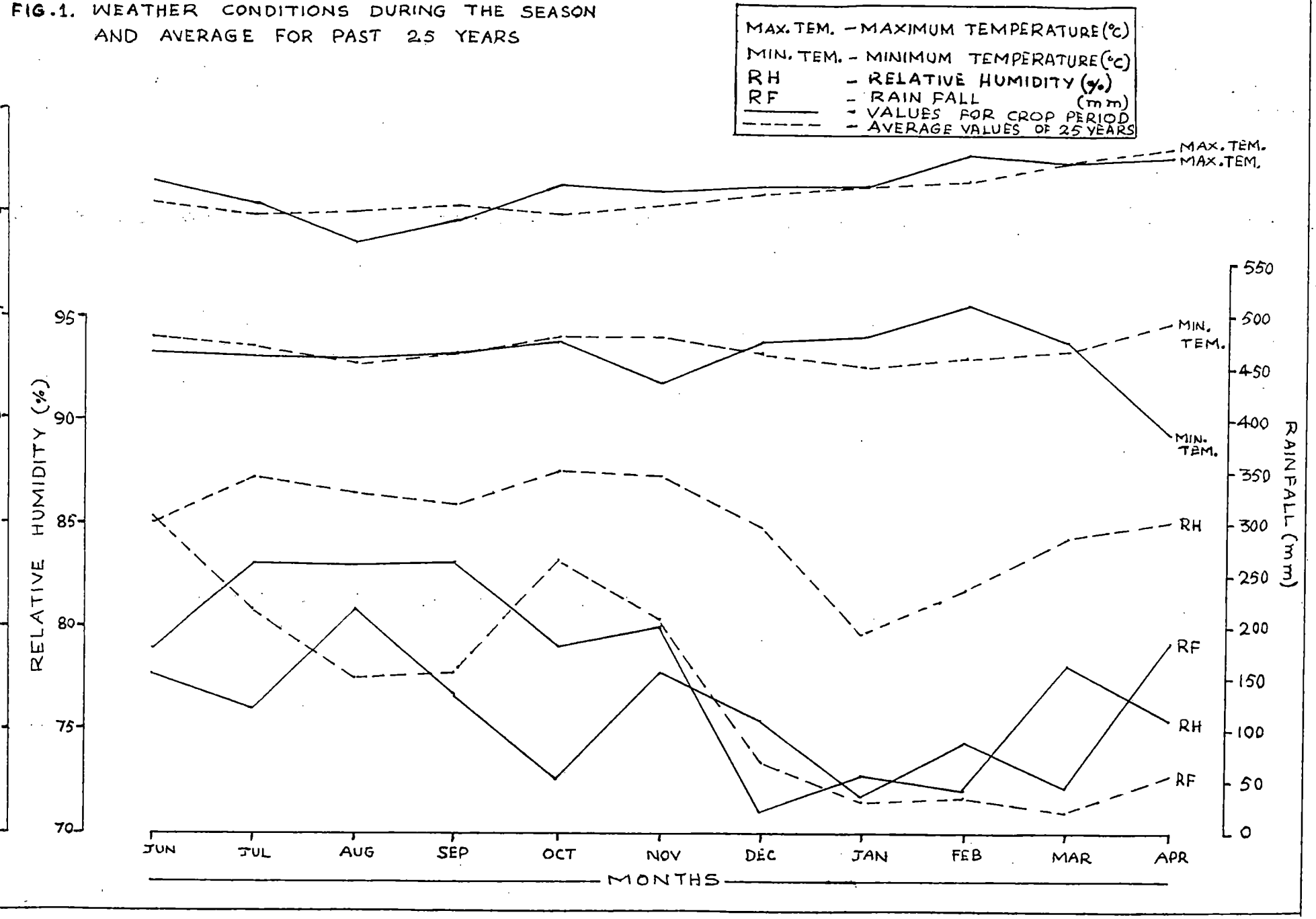
Season.

The experiment was conducted during the period from June 1983 to April 1984, which is the main growing season of cassava in Kerala. The crops were raised as rainfed.

Weather conditions.

The metereological parameters such as maximum and minimum temperature, rainfall and relative humidity were recorded and collected from the metereological observatory of the Department of Agronomy, College of Agriculture, Vellayani. The average monthly values and their variation from the average for the past 25 years (1957-1982) from the planting to harvest of main crop were worked out and presented in Appendix I and illustration given in Fig. 1.

FIG.1. WEATHER CONDITIONS DURING THE SEASON AND AVERAGE FOR PAST 25 YEARS



Planting material.

Cassava.

The variety used was M_4, an introduction from Malaysia, which is a popular table variety in Kerala. It is a tall growing, non-branching variety with moderate yields and matures in ten months. It produces medium size tubers with low hydrocyanic acid content and excellent cooking quality. The variety is tolerant to cassava mosaic disease. The planting material of cassava required for the study was obtained from the Instructional Farm, attached to the College of Agriculture, Vellayani.

Groundnut.

TMV-2, a short duration bunch variety, which is a selection from Spanish bunch, was used. It comes to harvest in 100-110 days. The pods are small and one to two seeded. The shell is thin and kernels are light rose in colour. The seeds are non-dormant. The oil content in kernel is 49 per cent. It is suited for both rainfed and irrigated conditions. This variety is popular among the groundnut growers of Kerala.

The planting material for the experiment was obtained from the Oil seeds Experiment station, Tindivanam, Tamilnadu.

French beans.

'Contender', a variety suited for cultivation in the plains, was used for this study. It is a variety with bush type of growth and has a duration of 60 days. The green pods are light green in colour, medium long and has an oval shaped cross-section. The green pods form an excellent vegetable for culinary purposes.

The seeds for this investigation was obtained from the National Seed Corporation, Coimbatore.

Horse gram.

The variety used for this study was 'Pattambi local', a popular one in Kerala. It comes to harvest within 110-120 days.

The seeds for this study was obtained from the Department of Agronomy, College of Agriculture, Vellayani.

Manures and Fertilizers.

Farm yard manure containing, 0.46 per cent N, 0.30 per cent P_2O_5 and 0.27 per cent k_2O, was used for this trial. Fertilizers used for this study were urea with N content of 46 per cent, superphosphate with P_2O_5 content of 16 per cent and muriate of potash, with K_2O content of 60 per cent. The liming material used for this trial was quick lime (Ca O) with a neutralising value of 163.10.

Methods

Design and layout.

The experiment was laid out in a Randomised Block Design with three replications. The layout plan of the experiment is given in Fig.2. and a detailed illustration of crop arrangement in a single plot in Fig. 3.

Number of replications : 3

Total number of plots : 39

Treatments.

The treatment details are furnished below:

T_1 Ordinary method of planting Cassava + Groundnut

T_2 Ordinary method of planting Cassava + French beans

T_3 Paired row system of planting Cassava + Groundnut

T_4 Paired row system of planting Cassava + French beans

T_5 Paired row system of planting Cassava + (Groundnut - French beans)

T_6 Paired row system of planting Cassava + (Groundnut - Horse gram)

T_7 Paired row system of planting Cassava + (French beans - French beans)

T_8 Paired row system of planting Cassava + (French beans - Horse gram)

T_9 Pure crop of Cassava in ordinary method of planting (June Planting)

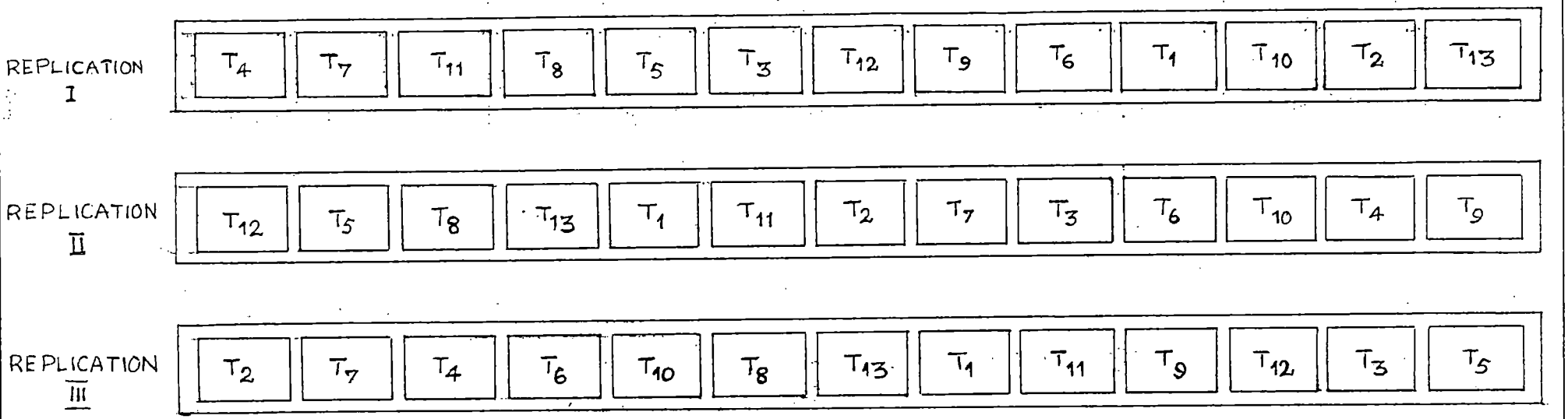
T_{10} Pure crop of Cassava in paired row system of planting (June planting)

T_{11} Sole crop of Groundnut (June planting)

T_{12} Sole crop of French beans - French beans

T_{13} Sole crop of Horse gram (September planting)

FIG.2. LAY-OUT PLAN RANDOMISED BLOCK DESIGN

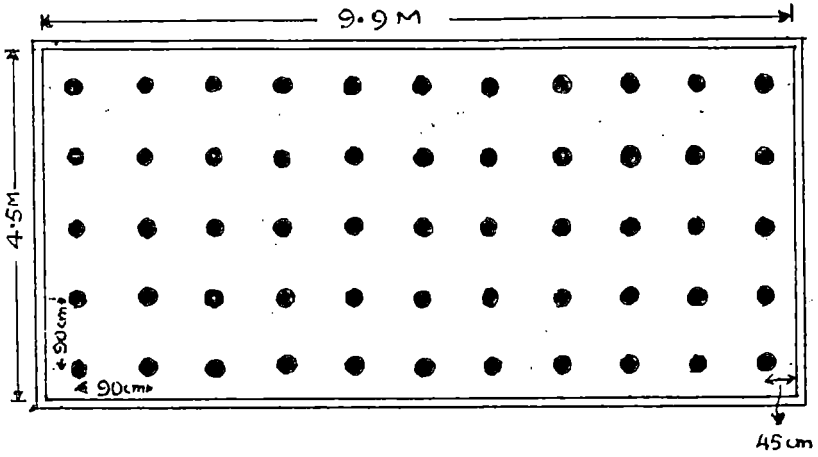


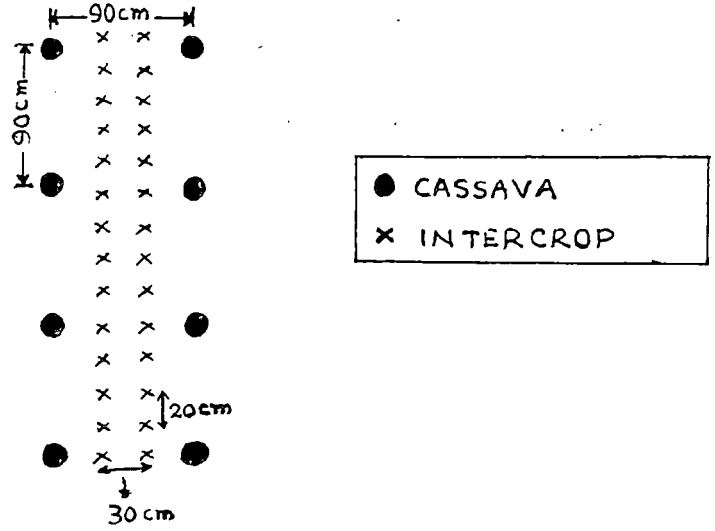
TREATMENTS

T_1	ORDINARY METHOD OF PLANTING CASSAVA + GROUNDNUT.
T_2	ORDINARY METHOD OF PLANTING CASSAVA + FRENCH BEANS.
T_3	PAIRED ROW SYSTEM OF PLANTING CASSAVA + GROUNDNUT.
T_4	PAIRED ROW SYSTEM OF PLANTING CASSAVA + FRENCH BEANS.
T_5	PAIRED ROW SYSTEM OF PLANTING CASSAVA + (GROUNDNUT + FRENCH BEANS)
T_6	PAIRED ROW SYSTEM OF PLANTING CASSAVA + (GROUNDNUT + HORSE GRAM)
T_7	PAIRED ROW SYSTEM OF PLANTING CASSAVA + (FRENCH BEANS + FRENCH BEANS)
T_8	PAIRED ROW SYSTEM OF PLANTING CASSAVA + (FRENCH BEANS + HORSE GRAM)
T_9	PURE CROP OF CASSAVA IN ORDINARY METHOD OF PLANTING (JUNE PLANTING).
T_{10}	PURE CROP OF CASSAVA IN PAIRED ROW SYSTEM OF PLANTING (JUNE PLANTING).
T_{11}	SOLE CROP OF GROUNDNUT (JUNE PLANTING).
T_{12}	SOLE CROP OF FRENCH BEANS + FRENCH BEANS.
T_{13}	SOLE CROP OF HORSE GRAM (SEPTEMBER PLANTING).

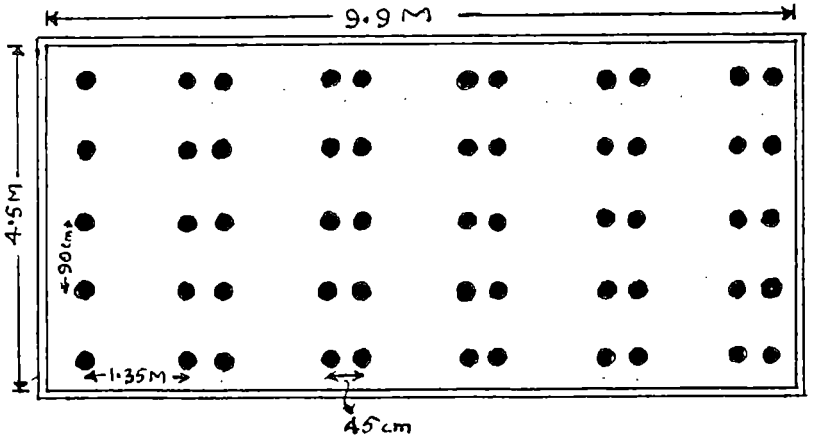
FIG.3. ILLUSTRATION OF CROP ARRANGEMENT IN A PLOT

ORDINARY METHOD OF PLANTING CASSAVA AND ARRANGEMENT OF INTERCROP IN THE INTERSPACE

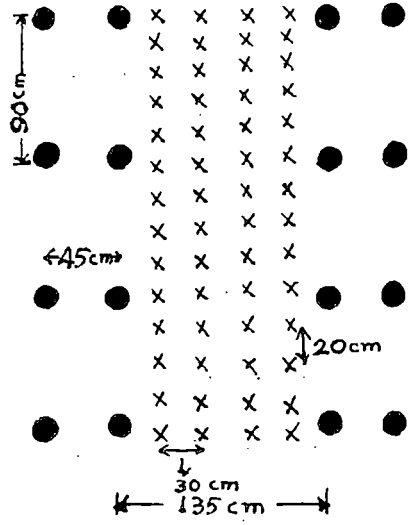




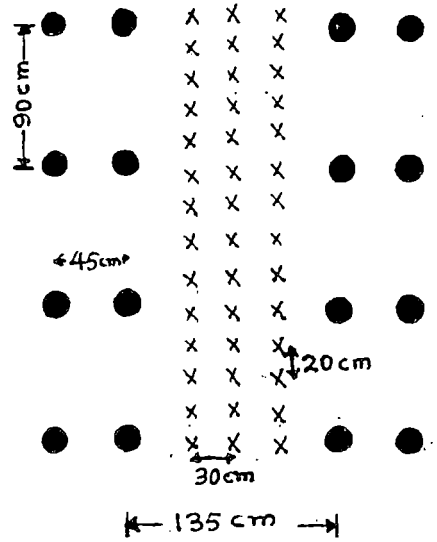
PAIRED ROW SYSTEM OF PLANTING CASSAVA AND ARRANGEMENT OF INTERCROPS IN THE INTERSPACE



FIRST INTERCROP



SECOND INTERCROP



In treatments T_1, T_2, T_3, T_4 the intercrops of groundnut and french bean are sown on the same day of planting cassava. In treatments T_5 and T_6 first intercrops of groundnut are sown on the same day of planting cassava followed by second intercrops of french bean and horse gram in sequence, respectively. Similarly in treatments T_7 and T_8 first intercrops of french bean are followed by second intercrops in sequence.

Methods of planting and spacing for cassava.

Cassava was planted in ordinary method and paired row system. The spacing adopted was as follows:

Ordinary method : 90cm x 90cm

Paired row method : 45cm / 135cm x 90cm

- 45cm between two rows making up a pair of rows
- 135cm between two such rows
- 90cm between plants within a row.

Methods of planting and spacing for intercrops.

In ordinary method of planting cassava, for the first intercrop, two rows of intercrops were planted, in the interspaces of rows of cassava, at a spacing of 30cm x 20cm.

In paired row system of planting cassava, four rows of first intercrops were planted, in the interspaces of paired rows of cassava, at a spacing of 30cm x 20cm. For the second intercrops, three rows of Intercrops were planted, in the interspaces of paired rows of cassava, at a spacing of 30cm x 20cm.

Spacing for sole crops of intercrops.

For groundnut, a spacing of 15cm x 15cm was used for the sole crop.

For French bean, a spacing of 30cm x 20cm was used for the sole crop.

For horsegram, a spacing of 25cm x 25cm was used for the sole crop.

Plot Size.

Gross plot size : 4.5m x 9.9m

Net plot size : 2.7m x 8.1m

Net area of a plot : 21.87 m^2

Number of cassava plants in the gross plot : 55

Number of cassava plants in the net plot : 27

Intercrop population.

For the first intercrops, the intercrop population was the same in ordinary method and paired row system of planting cassava.

Number of rows : 20

Number of plants per row : 20 (out of 22 plants in a row one plant each on both ends were not taken to avoid border effect)

Plant population : 20x20 = 400

For the second intercrops (tried only in paired row system of planting cassava), plant population was reduced.

Number of rows : 15

Number of plants per row : 20

Plant population : 15x20 = 300

Plant population of solecrops of intercrops.

Groundnut

A spacing of 15cm x 15cm was used for sole crop.

Number of rows : 62 (out of 66 rows, two border rows on both ends were avoided)

Number of plants per row : 26 (out of 30 plants in a row two plants on both ends were avoided)

Net plant population: 62x26 = 1612

French beans

A spacing of 30cmx20cm was used for sole crop.

Number of rows: 29 (out of 33 rows, two border rows on both ends were avoided)

Number of plants: 18 (out of 22 plants in a row, two plants on both borders were avoided)

Net plant population: 29x18 = 522

Horse gram

A spacing of 25cm x 25cm was used for sole crop.

Number of rows : 35 (out of 39 rows, two border rows on both ends were avoided)

Number of plants per row: 14 (out of 18 plants in a row, two plants on both borders were avoided)

Net plant population: 35x14 = 490

(All spacings adopted were according to the Package of practices - Recommendations. 1982., published by the Kerala Agricultural University.)

Field culture.

Preparation of land.

The experimental area was dug twice, stubbles removed, clods broken and the field was laid out into blocks and plots. Mounds for planting cassava were prepared as per the treatments. For sole crops of intercrops plots were prepared to a fine tilth and levelled.

Manuring.

A uniform basal dose of 12.5 t/ha of farm yard manure was applied and well incorporated into the soil before preparation of mounds. For sole crops of groundnut a basal dose of 2t/ha of farm yard manure was applied

and well incorporated into the soil at the time of land preparation. Farm yard manure at the rate of 20t/ha was applied for the sole crop of French beans, and well incorporated into soil at the time of land preparation. For horsegram farm yard manure was not applied.

Fertilizer and lime application.

The fertilizer nutrients were applied in the form of urea, super phosphate and muriate of potash for N, P_2O_5 and K_2O respectively. Lime was applied as quick lime (Ca O).

The nutrient dosages applied for cassava and intercrops were as follows:

	N Kg/ha	P_2O_5 Kg/ha	K_2O Kg/ha	Time of application
Cassava	15	50	15	basal application
	20	-	20	after 2 months from planting
	15	-	15	after 3 months from planting
Sole crop of groundnut	10	75	75	basal application
Sole crop of French beans	30	40	60	basal application
	30	-	-	after 20 days from planting
Horsegram	-	25	-	basal application

Intercrop of groundnut (22% of dose for pure crop)	2.20	16.50	16.50	basal application
First inter-crop of French beans (60% of dose for pure crop)	18	24	36	basal application
	18	-	-	after 20 days from planting
Second inter-crop of French beans (46% of dose for pure crop)	13.80	18.40	13.80	basal application
	13.80	-	-	after 20 days from planting
Horsegram second inter crop (47% of dose for pure crop)	-	11.75	-	basal application

Lime at the rate of 1000 Kg/ha was applied on 40th day of planting groundnut.

For cassava, top dressing was done over the mounds and raked well into the soil. For intercrops, the fertilizers and lime were throughly mixed with the soil at the time of application.

Planting.

Planting of cassava and sowing of first intercrops of groundnut and french beans and parallel sole crops of cassava, groundnut and frenchbeans were done on 18.6.1983. The second intercrop of French beans and horse gram (following first intercrop of French beans) and parallel sole crops of French beans and horse gram were sown

on 3.9.1983. Sowing of second intercrops of French beans and horse gram (following first intercrop of groundnut) was done on 20.10.1983.

Cassava setts of 20cm length were planted upright on the top of the mounds to a depth of 3 to 4cm. The seeds of intercrops were sown in the interspaces of the rows of cassava and paired rows of cassava, in ordinary method and paired row method of planting cassava, respectively. Groundnut and French bean seeds were sown at the rate of one seed per hole and that of horse gram at the rate of two seeds per hole. The seeds were pressed into the soil by hand to a depth of 1.5 cm and covered with soil. After cultivation.

Setts of cassava showed good germination. Unsprouted setts were replaced by fresh ones ten days after planting. Excess sprouts were removed retaining only two healthy and vigorous shoots. Intercrops also showed good germination. Gap filling was done wherever found necessary, in the case of groundnut and French beans intercrops. Thinning was done one week after sowing in the case of horse gram and the population was maintained uniform.

The soil was slightly stirred in groundnut plots at the time of flowering in order to facilitate pegging of groundnut which was combined with the application of

lime. The first earthing up for cassava was done at the time of harvest of first intercrops (ie on 18.8.1983 for French beans intercropped plots and on 7.10.1983 for groundnut intercropped plots) along with incorporation of bhusa of intercrops in the interspaces. One more earthing up was given at the time of harvest of second intercrops (ie on 3-11-1983 and 20-12-1983) along with incorporation of bhusa of intercrops in the interspaces.

Plant protection.

Plant protection measures were adopted against termite attack by dusting 10% B.H.C. Prophylatic spraying of 0.05% malathion was effected for the french beans for controlling aphids. Ekalux (0.1%) was sprayed to groundnut as a prophylatic measure against incidence of redhairy caterpillar. Prophylatic spraying with Bordeaux mixture (1%) before flowering was done to control tikka leaf spot disease of groundnut and drenching the soil with Bordeaux mixture (1%) was done to control collar rot disease of French beans.

General condition of the crops.

The general condition of the crops was good throughout the period of growth.

Harvest.

The first intercrop of french bean and parallel sole crop of French bean were harvested on 18.8.1983 and

first intercrop of groundnut and parallel sole crop of groundnut were harvested on 7.10.1983. The second intercrop of French beans (following first intercrop of french beans) and parallel sole crop of French beans were harvested on 3.11.1983, and second intercrop of French beans (following first intercrop of groundnut) was harvested on 20.12.1983. The sole crop of horse gram was harvested on 5.1.1984. The bhusa of the intercrops was incorporated into the soil in situ at the time of harvest and allowed to decompose. The main crop of cassava was harvested on 20.4.1984.

Observations recorded.

Main crop (Cassava)

Sampling technique for biometric studies.

Five plants each were tagged alternately from the net plot area for detailed biometric observations. Averages of the observations from each replication were used for statistical analysis.

A. Observations on growth characters.

The following growth characters of cassava were observed and data recorded.

a. Height of the plant.

Cumulative height of the shoot of each plant including branches were measured from the base of the

sprouts to the tip of the terminal bud at monthly intervals commencing from the first month after planting till harvest.

b. Total number of leaves per plant.

The total number of leaves was recorded at monthly intervals by counting the number of fully opened leaves as well as fallen leaves as indicated by the leaf scars on the stem.

c. Number of functional leaves per plant.

The number of fully opened leaves retained in the plants was recorded at monthly intervals from the first month after planting till harvest.

d. Leaf area index.

The method evolved by Ramanujam and Indira (1978) was followed in this experiment for determining the leaf area index of tapioca at monthly intervals, from the first month after planting till harvest.

B. Observations on yield attributes and yield.

a. Number of tubers per plant.

The total number of fully developed tubers from the observation plants was recorded at the time of harvest and the average per plant worked out.

b. Length of tubers.

The average length of tuber was worked out by measuring the length of ten tubers at random from the observation plants and expressed in cm.

c. Girth of tubers.

Girth measurements were recorded from the same tubers that were used for length measurements. Girth values were recorded at three places, one at the centre and the other two at half way between the centre and both ends of tubers. The average was taken as the tuber girth and expressed in cm.

d. Tuber yield.

The tubers were seperated at the time of harvest and cleaned to remove the adhering soil and the fresh weight of the tuber from the net plot was recorded. The per hectare yield was worked out from this data.

e. Top yield.

The total weight of stem and leaves of the plants from net plot was taken at the time of harvest and converted to t/ha

f. Utilisation index.

This is the ratio of the root weight to top yield and is an important yield determinant factor (Obigbesan, 1973). This was worked out from the already recorded observations.

C. Observations on quality attributes.

a. Dry matter content of the tuber flesh.

A uniform quantity of flesh from the fresh tuber was taken and dried to constant weight in an air oven at 65° C. The weight of dry matter expressed as percentage of fresh weight gave the dry matter content of the tuber flesh (A.O. A.C., 1969)

b. Crude protein content of tuber.

The total nitrogen content of oven dried samples from each plot was estimated by modified micro-kjeldahl method (Jackson, 1967). To get the crude protein content of the tuber, the nitrogen values were mutiplied by the factor 6.25 (A.O. A.C., 1969)

D. Plant analysis.

Seperate samples of tuber, stem and leaves were collected for chemical analysis, dried at 80° c ± 5 and were ground in Willey mill. The nitrogen, phosphorus and potassium contents of tuber, stem and leaves were seperately analysed.

a. Nitrogen content.

The total nitrogen content of the samples was determined by the modified micro Kjeldahl method (Jackson, 1967)

b. Phosphorus content.

Phosphorus content of samples was determined by Vanado-molybdo - Phosphoric yellow colour method (Jackson, 1967)

c. Potassium content.

Potassium content of samples was determined by using 'EEL' flame photometer.

Intercrops.

Ten plants were selected at random from groundnut, French beans and horsegram plots for recording detailed biometric observations.

A. Observations on growth attributes.

a. Height of the plant.

The height of the observation plants was measured at twenty days interval. The measurement was taken from the base to the growing tips of the plants and mean height worked out.

b. Number of branches per plant.

The number of branches on each of the observation plants was counted and the average number worked out and recorded at twenty days interval.

c. Number of functional leaves per plant.

The total number of green leaves present in the observation plants was counted at twenty days interval and the average worked out and recorded.

d. Leaf area index.

The general graph paper method was followed for determining the leaf area index at twenty days interval.

B. Observations on yield attributes and yield.

a. Pod yield of groundnut.

The pod yield from each plot was recorded after seperating and drying the pods and converted to Kg/ha.

b. Pod yield of French beans.

The green pod yields at different harvests from each plot was recorded and total green pod yield from each plot was calculated and converted to Kg/ha.

c. Grain yield of horsegram.

Pods from control plot were harvested, dried, threshed and winnowed for recording the grain yield of horsegram. The yield in Kg/ha was then worked out. No yield was obtained from intercrops, as the horsegram intercrops failed to survive in interspaces of cassava.

d. Bhusa yield.

The weight of bhusa obtained from sample plants was taken and recorded. The yield in Kg/ha was calculated from this data.

C. Quantity of nitrogen, phosphorus and potassium incorporated into the soil by bhusa.

The quantity of nitrogen, phosphorus and potassium incorporated into the soil by means of bhusa of the intercrops in each treatment was found out from the corresponding dry matter yield and nitrogen, phosphorus and potassium content of the plant samples.

The dry matter percentage was found out by A.O. A.C. (1969) method. Percentage of nitrogen was found out by modified micro-kjeldahl method (Jackson, 1967). Vanado-molybdo-phosphoric yellow colour method (Jackson, 1967) was followed for phosphorus estimation and 'EEL' flame photometer was used for potassium estimation.

Land Equivalent Ratio.

Willey (1979) defined land equivalent ratio (L.E.R) as the relative land area under sole crops that is

required to produce the yields achieved in intercropping; it is usually stipulated that the 'level of management' must be the same for intercropping as for sole cropping. In this study LER for the cassava based intercropping system with one intercrop was calculated using the formula

$$LER = \frac{\text{mixture yield of 'a'}}{\text{pure stand yield of 'a'}} + \frac{\text{mixture yield of 'b'}}{\text{pure stand yield of 'b'}}$$

In cassava based intercropping system involving two intercrops raised in sequence,

$$LER = \frac{\text{mixture yield of 'a'}}{\text{pure stand yield of 'a'}} + \frac{\text{mixture yield of 'b'}}{\text{pure stand yield of 'b'}} + \frac{\text{mixture yield of 'c'}}{\text{pure stand yield of 'c'}}$$

The symbols used are:

LER	=	Land Equivalent Ratio
'a'	=	Cassava
'b'	=	first inter crop (groundnut/French beans)
'c'	=	second inter crop (French beans)

Soil analysis.

Mechanical composition of the soil before starting the experiment was determined by the 'International pipette method'. A composite soil sample collected blockwise prior to the experiment and soil samples collected from individual plots after the experiment, were analysed for total nitrogen.

available phosphorus and available potassium. Total nitrogen was determined by modified micro-kjeldahl method, available phosphorus by Bray's method and available potassium by Ammonium acetate method (Jackson, 1967).

Statistical analysis.

Date relating to different observation were statistically analysed using the 'analysis of variance technique' for Randomised Block Design and significance was tested by using the 'F' test (Snedecor and Cochran, 1967). The data were analysed with the help of a computer, at the 'Computer centre' of the Kerala Agricultural University, Vellanikkara, Trichur.

PLATE 1. Groundnut intercropped with Cassava planted in ordinary method.

PLATE. 2 Groundnut intercropped with Cassava planted in paired row system.

PLATE.3 French beans intercropped with Cassava planted in ordinary method.

PLATE.4 French beans intercropped with Cassava planted in paired row system.

Results

RESULTS

The observations of growth characters, yield and yield attributes of both main crop and intercrops, the economics of various cassava based intercropping systems and the results from the various chemical analysis are presented in this chapter. The observations recorded were statistically analysed and the mean values are given in Tables 1 to 32. The corresponding analysis of variance tables are given in Appendices II to XVI

Observations on main crop (Cassava)

A. Growth characters

1. Height of the plant.

The height of cassava was recorded at monthly intervals. The mean values are presented in Table 1 and the analysis of variance in Appendix II.

No significant difference was observed between treatments with regard to the height of plants throughout the growth of cassava.

Table.1. Height of Cassava as influenced by planting geometry and intercropping systems (cm).

M.A.P.	Treatments										S.E.	C.D.
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}		
I	17.600	19.133	18.600	17.067	17.333	17.400	18.267	18.600	19.867	19.933	1.010	NS
II	79.267	93.600	90.533	88.667	90.800	86.733	90.200	92.800	96.467	95.933	4.071	NS
III	98.450	121.483	118.500	116.733	112.917	112.167	116.833	126.850	136.600	142.283	8.596	NS
IV	122.150	146.183	143.500	145.917	138.417	139.667	147.750	150.050	158.817	161.933	8.688	NS
V	150.967	172.650	167.900	171.500	160.917	160.417	184.750	180.683	185.317	184.733	11.472	NS
VI	172.400	192.283	187.150	190.850	181.083	184.200	205.133	199.500	197.650	196.667	10.852	NS
VII	191.417	204.200	203.667	205.750	199.150	202.283	223.817	214.667	214.467	211.417	10.869	NS
VIII	207.800	217.417	214.550	218.133	210.083	213.550	236.017	225.767	229.333	226.333	10.880	NS
IX	218.375	226.467	224.267	225.283	220.975	224.200	245.925	235.575	239.842	237.350	10.518	NS
At harvest	223.133	231.017	228.908	229.525	225.067	228.733	250.267	240.083	244.483	242.667	10.465	NS

NS - Not significant

M.A.P. - Months After Planting

2. Total number of leaves per plant.

The mean values of the observations taken at monthly intervals are given in Table 2 and the analysis of variance in Appendix III.

It is seen that there was no significant differences between treatments with regard to the total number of leaves throughout the different stages of growth of cassava.

3. Functional leaves per plant.

The mean number of functional leaves per plant taken at monthly intervals are given in Table 3 and the analysis of variance in Appendix IV.

It was observed that the treatments did not differ significantly on their effect on the number of functional leaves produced per plant, through out the growth of cassava.

4. Leaf area index.

The mean values of leaf area index recorded at monthly intervals are presented in Table 4 and the analysis of variance in Appendix V.

Table.2. Total number of leaves of cassava as influenced by planting geometry and intercropping systems.

M.A.P.	Treatments										S.E.	C.D.
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}		
I	11.267	11.867	11.267	11.133	10.733	11.467	11.467	11.467	10.733	10.600	0.427	NS
II	36.667	39.417	39.867	37.822	34.267	36.733	36.767	38.500	39.000	37.833	1.378	NS
III	49.139	56.233	54.167	54.933	55.083	53.583	54.167	54.222	56.333	57.417	1.620	NS
IV	63.528	73.317	67.083	73.183	71.417	72.417	76.250	80.250	76.583	77.000	3.757	NS
V	116.333	133.250	130.733	129.417	127.250	124.333	135.583	131.250	145.250	142.472	6.778	NS
VI	152.517	165.800	165.983	164.850	162.083	159.083	169.067	170.167	180.917	179.200	6.555	NS
VII	176.417	186.733	189.067	186.750	185.417	183.483	194.183	192.800	204.500	204.100	6.030	NS
VIII	188.250	196.133	198.400	196.067	195.850	195.050	203.117	202.067	213.483	213.483	5.861	NS
IX	197.417	204.917	206.417	204.867	204.250	203.283	211.217	210.333	221.567	222.417	5.589	NS
At harvest	205.200	212.467	210.483	211.700	211.467	210.800	218.600	217.600	228.467	229.733	5.583	NS

NS - Not significant

M.A.P. - Months after planting

Table No.3. Number of functional leaves of cassava as influenced by planting geometry and intercropping systems

M.A.P.	Treatments										S.E.	C.D.
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}		
I	11.267	11.867	11.267	11.133	10.733	11.467	11.467	11.467	10.733	10.600	0.427	NS
II	36.667	39.417	39.867	37.822	34.267	36.733	36.767	38.500	39.000	37.833	1.378	NS
III	49.139	56.233	54.167	54.933	55.083	53.583	54.167	54.222	56.333	57.417	1.620	NS
IV	31.694	36.783	34.000	39.000	36.083	37.500	40.333	41.750	38.500	39.583	2.218	NS
V	53.750	59.417	63.117	61.583	62.000	59.583	64.500	62.000	68.500	66.444	3.101	NS
VI	70.167	75.067	75.800	75.683	73.117	72.883	76.333	77.900	81.950	82.033	2.585	NS
VII	74.133	78.400	79.267	78.283	77.467	76.733	81.083	80.917	85.733	85.150	2.512	NS
VIII	66.033	68.200	69.250	68.983	68.183	68.033	71.033	70.133	74.817	74.750	1.967	NS
IX	49.517	50.050	50.783	51.017	50.967	50.750	52.400	52.683	54.667	54.850	1.290	NS
At harvest	41.533	42.183	42.267	42.400	42.467	42.383	44.100	43.550	45.400	45.867	1.074	NS

N.S. - Not significant

M.A.P. - Months after planting

Table.4. Leaf area index of cassava as influenced by planting geometry and intercropping systems

M.A.P.	Treatments										S.E.	C.D.
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}		
I	0.180	0.185	0.185	0.184	0.181	0.182	0.182	0.185	0.180	0.180	0.016	NS
II	1.242	1.482	1.425	1.505	1.405	1.410	1.509	1.524	1.418	1.421	0.082	NS
III	1.688	2.176	2.114	2.252	2.095	2.110	2.234	2.181	2.272	2.320	0.088	0.36
IV	1.119	1.248	1.117	1.363	1.181	1.169	1.364	1.380	1.458	1.497	0.125	NS
V	2.135	2.338	2.321	2.514	2.404	2.445	2.524	2.530	2.738	2.757	0.149	NS
VI	2.428	2.942	2.802	2.959	2.862	2.877	3.040	3.014	3.178	3.210	0.153	NS
VII	2.754	3.161	3.036	3.202	3.125	3.119	3.278	3.244	3.387	3.468	0.154	NS
VIII	2.607	2.712	2.687	2.784	2.664	2.684	2.760	2.717	2.903	2.906	0.081	NS
IX	1.841	1.888	1.887	1.973	1.918	1.933	1.964	1.989	2.131	2.113	0.042	0.17
t har-vest	0.956	0.963	1.001	1.019	1.012	1.017	1.063	1.059	1.103	1.112	0.024	0.10

N.S. - Not significant

M.A.P. - Months after planting.

The results indicated that there was significant difference in leaf area index at third, nineth and tenth month after planting cassava. However, no significant difference was observed at any other stage of crop growth.

The treatment T_{10} recorded the maximum leaf area index at third and tenth month after planting cassava and it was on par with T_9, T_4, T_7, T_8, T_2, T_6 and T_5 at third month of planting cassava and with T_9, T_8, T_7, T_4, T_6 and T_5 at tenth month of planting cassava. The maximum leaf area index after nine months of planting cassava was given by the treatment T_9 and it was on par with T_{10}, T_8, T_4 and T_7. The lowest values of leaf area index at third, nineth and tenth month of planting cassava were recorded by the treatment T_1.

B. Yield attributes and yield

1. Yield attributes

The mean values of yield attributes are presented in Table 5 and the analysis of variance in Appendix VI a.

a. Number of tubers per plant.

It is seen from the data that the treatments differed significantly in their effect on the number of

Table 5. Yield attributes of cassava as influenced by planting geometry and intercropping systems.

Treatment	Number of tuber/plant	Length of tuber (cm)	Girth of tuber (cm)
T_1	5.988	28.770	12.800
T_2	8.123	29.030	12.267
T_3	7.383	28.867	12.700
T_4	8.593	29.200	12.300
T_5	8.728	28.933	12.967
T_6	7.037	28.867	12.700
T_7	8.531	29.067	12.200
T_8	7.679	29.133	12.233
T_9	7.926	28.767	12.700
T_{10}	6.728	28.700	12.833
SE	0.093	0.157	0.229
CD	0.38	NS	NS

NS - Not significant

tubers per plant. The treatment T_5 recorded the maximum number of tubers per plant and it was on par with T_4 and T_7, but differed significantly from other treatments. T_1 recorded the minimum number of tubers per plant and differed significantly from all other treatments.

b. Length of tuber:

The results showed that there was no significant difference between treatments with regard to the length of tuber in cassava.

c. Girth of tuber

It is seen from the results that there was no significant difference between treatments with regard to the tuber girth of cassava.

2. Tuber yield

Table 6 shows the mean values of tuber yield per hectare and Appendix VIa furnishes the corresponding analysis of variance.

The data revealed that there was significant variation between treatments with regard to the tuber yield per hectare.

The highest tuber yield was obtained from the treatment T_4 which differed significantly from all other treatments. The second best tuber yield was given by T_8 and it also differed significantly from all other treatments. The treatment T_{10} recorded the lowest tuber yield and was found to be on par with T_1. The tuber yield of other treatments were in between.

3. Top yield

The mean top yield per hectare is given in Table 6 and the analysis of variance in Appendix VIa.

There was significant difference between treatments with regard to the top yield of cassava. The maximum top yield was obtained from the treatment T_4 which differed significantly from all other treatments except T_8. The treatment T_8 inturn did not significantly differ from T_5, T_7 and T_3. The minimum top yield was recorded by the treatment T_{10} and was found to be on par with T_1, T_2, T_9 and T_6.

4. Utilisation index

The mean values of utilisation index are presented in Table 6 and the analysis of variance in Appendix VIa.

Table.6. Yield and utilisation index of cassava as influenced by planting geometry and intercropping system

Treatments	Tuber yield (t/ha)	Top Yield (t/ha)	Utilisation index
T_1	26.673	18.616	1.434
T_2	28.197	18.702	1.527
T_3	31.398	21.841	1.457
T_4	36.308	27.008	1.347
T_5	31.245	23.853	1.311
T_6	29.874	19.948	1.532
T_7	32.160	22.741	1.420
T_8	34.294	24.310	1.429
T_9	28.197	19.890	1.437
T_{10}	25.911	17.528	1.484
S.E.	0.274	0.762	0.052
C.D.	1.12	3.10	NS

N.S. - Not significant.

The results showed that there was no significant difference between treatments with regard to the utilisation index values.

C. Quality attributes

1. Dry matter content of tuber

The mean values of dry matter percentage of tuber are given in Table 7 and the analysis of variance in Appendix VI b.

The data revealed that there was no significant difference between treatments with regard to the dry matter content of tuber.

2. Crude protein content of tuber

Table 7 furnishes the mean values of crude protein content and Appendix VI b gives the corresponding analysis of variance

The treatments did not register any significant influence on the crude protein content of tuber.

D. Plant analysis

1. Nitrogen content.

The mean values of nitrogen content (per cent) of leaves and stem are given in Table 8 and the analysis of variance in Appendix VII.

Table.7. Drymatter and crude protein contents of cassava tuber as influenced by planting geometry and intercropping systems.

Treatments	Drymatter content	Crude protein content (per cent)
T_1	35.233	2.440
T_2	35.267	2.460
T_3	35.500	2.550
T_4	35.867	2.563
T_5	35.733	2.533
T_6	35.467	2.553
T_7	35.767	2.567
T_8	35.800	2.560
T_9	35.500	2.437
T_{10}	35.100	2.433
S.E.	0.271	0.154
C.D.	NS	NS

NS - Not significant

a. Nitrogen content of leaves.

No significant difference in the nitrogen content of leaves was recorded due to the influence of different treatments.

b. Nitrogen content of stem.

The results showed that there was no significant difference between treatments with regard to nitrogen content of stem of cassava.

2. Phosphorus content.

Table 9 gives the mean values of phosphorus content in cassava as influenced by various treatments. Appendix VII gives the corresponding analysis of variance.

a. Phosphorus content of leaves.

The data revealed that there was no significant difference between treatments with regard to phosphorus content of leaves of cassava.

b. Phosphorus content of stem.

The results showed no significant difference between treatments with regard to phosphorus content of stem of cassava.

Table.8. Distribution of nitrogen (per cent) in cassava as influenced by planting geometry and intercropping systems.

Treatments	Plant parts	
	Leaf	Stem
T_1	2.056	0.610
T_2	1.980	0.613
T_3	1.866	0.622
T_4	1.790	0.620
T_5	2.094	0.617
T_6	1.980	0.618
T_7	2.018	0.623
T_8	1.980	0.622
T_9	1.866	0.615
T_{10}	1.942	0.612
S.E.	0.061	0.014
C.D.	NS	NS

N.B. - Not significant

c. Phosphorus content of tuber.

Significant difference was not observed between treatments with regard to phosphorus content of tuber of cassava.

3. Potassium content.

The mean values of potassium content in cassava as influenced by different treatments are furnished in Table 10 and the analysis of variance in Appendix VII.

a. Potassium content of leaves.

The different treatments did not show any significant influence on the potassium content of leaves of cassava.

b. Potassium content of stem.

The results showed no significant difference between treatments with regard to potassium content of stem of cassava.

c. Potassium content of tuber.

The different treatments had no significant influence on the potassium content of tuber of cassava.

Observations on intercrops (Groundnut and French beans)

Though horsegram was sown as a second intercrop, the observations were not recorded as the crop failed to

Table.9. Distribution of phosphorus (per cent) in cassava as influenced by planting geometry and intercropping systems.

Treatments	Plant parts		
	Leaf	Stem	Tuber
T_1	0.600	0.297	0.152
T_2	0.602	0.301	0.152
T_3	0.613	0.297	0.149
T_4	0.615	0.302	0.153
T_5	0.618	0.305	0.148
T_6	0.608	0.304	0.152
T_7	0.618	0.305	0.154
T_8	0.617	0.305	0.153
T_9	0.603	0.300	0.152
T_{10}	0.600	0.299	0.153
S.E.	0.007	0.003	0.019
C.D.	NS	NS	NS

NS - Not significant

Table.10. Distribution of potassium (per cent) in cassava as influenced by planting geometry and intercropping systems.

Treatments	Plant parts		
	Leaf	Stem	Tuber
T_1	0.689	0.437	0.715
T_2	0.690	0.437	0.721
T_3	0.696	0.438	0.637
T_4	0.690	0.440	0.857
T_5	0.696	0.442	0.816
T_6	0.695	0.441	0.832
T_7	0.695	0.441	0.810
T_8	0.694	0.441	0.721
T_9	0.689	0.437	0.813
T_{10}	0.690	0.439	0.711
S.E.	0.003	0.003	0.053
C.D.	NS	NS	NS

N S - Not Significant

survive in the interspaces of cassava. As the intercrop of horsegram failed the observations on the sole crop of horsegram (control) was also not recorded.

A. Growth characters.

1. Height of the plant at different growth stages.

The mean values are presented in Tables 11, 12 and 13 and the analysis of variance in Appendix VIII.

a. Groundnut (first intercrop)

The results revealed that there was significant difference between treatments with regard to the height of the plants after 80 and 100 days of planting groundnut and also at harvest.

After 80 days of planting groundnut the treatment T_1 recorded the maximum height which was on par with T_6, T_3 and T_5 and the treatment T_{11} recorded the minimum height. The treatment T_1 recorded the maximum height after 100 days of planting groundnut and at harvest, which was on par with T_6 and T_3 and the treatment T_{11} gave the minimum value which was on par with T_5 and at both stages

Table.11. Height of groundnut (first intercrop) at different growth stages as influenced by the base crop (cassava) and spatrial arrangements (cm).

Treatments	Days after planting					At harvest
	20	40	60	80	100	
T_1	5.667	29.267	44.033	53.333	56.233	58.600
T_3	5.533	27.500	43.600	50.400	53.167	55.700
T_5	5.633	26.800	44.017	49.417	52.253	54.800
T_6	5.600	26.783	43.933	51.673	54.567	56.767
T_{11}	5.500	25.733	41.333	45.710	48.700	52.033
S.E.	0.054	0.776	0.947	0.873	0.805	0.765
C.D.	NS	NS	NS	4.4	3.82	3.63

N.S. - Not significant

T_6 and T_3 was on par with T_5.

b. French beans (first intercrop)

Significant difference between treatments with regard to plant height could not be observed throughout the growth of French beans.

c. French beans (second intercrop)

The results revealed that there was significant difference between treatments with regard to height of plants at all stages of growth of French beans. After 20 days of planting French beans the treatment T_5 recorded the maximum height and was on par with T_7. The treatments T_5 and T_7 gave the maximum height after 40 and 60 days of planting. At all stages of growth the treatment T_{12} recorded the minimum height.

2. Number of branches per plant

The data on the mean number of branches at different growth stages are given in Tables 14,15 and 16 and the analysis of variance in Appendix IX.

a. Groundnut (first intercrop)

The treatments differed significantly with regard to the number of branches per plant after 60,80 and 100 days

Table.12. Height of French beans (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements (cm)

Days after planting	Treatments					S.E.	C.D
	T_2	T_4	T_7	T_8	T_{12}		
20	12.900	12.833	12.867	12.867	12.800	0.111	NS
40	31.467	30.933	30.667	30.800	29.567	0.535	NS
60	36.073	35.833	35.667	35.700	34.600	0.544	NS

NS - Not significant

Table.13. Height of French beans (second intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements (cm)

Due after planting	Treatments			S.E.	C.D.
	T_5	T_7	T_{12}		
20	17.567	17.200	13.523	0.397	2.58
40	36.833	36.833	30.333	0.382	2.49
60	40.267	40.267	34.000	0.265	1.73

of planting groundnut and also at harvest. The highest number of branches per plant after 60 days of planting was recorded by T_3 which was on par with T_{11}, T_5 and T_6. After 80 days of planting and at harvest, highest number of branches per plant was recorded by T_3 and was on par with T_6, T_{11} and T_5. The treatment T_6 gave the highest number of branches per plant after 100 days of planting and was on par with T_3, T_{11} and T_5. The lowest number of branches per plant was recorded by the treatment T_1 after 60,80 and 100 days of planting and also at harvest.

b. French beans (first intercrop)

The treatments did not have any significant influence on the number of branches per plant at any stages of growth.

c. French beans (second intercrop)

The results indicates that there was significant difference between treatments with regard to the number of branches per plant at all stages of growth. The highest number of branches was recorded by the treatment T_{12} and the lowest number of branches was recorded by the treatment T_7 which was on par with T_5.

Table.14. Number of branches per plant of groundnut (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Days after planting					At harvest
	20	40	60	80	100	
T_1	4.300	7.267	6.967	7.167	7.413	7.470
T_3	4.333	7.800	8.833	9.338	9.462	9.575
T_5	4.400	7.767	8.600	9.143	9.350	9.437
T_6	4.467	7.967	8.500	9.267	9.497	9.570
T_{11}	4.067	7.950	8.697	9.190	9.400	9.473
S.E.	0.122	0.314	0.355	0.309	0.306	0.310
C.D.	N.S.	N.S	1.16	1.46	1.45	1.47

N.S. - Not significant

Table.15. Number of branches per plant of French beans (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangement.

Days after planting	Treatments					S.E.	C.D.
	T_2	T_4	T_7	T_8	T_{12}		
20	0.953	0.967	0.963	0.960	0.947	0.020	NS
40	5.967	6.233	6.217	6.217	5.500	0.224	NS
60	6.633	7.067	6.867	6.967	6.333	0.256	NS

NS - Not significant

Table.16. Number of branches per plant of French beans (second intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements

Days after planting	Treatments			S.E.	C.D.
	T_{15}	T_7	T_{12}		
20	0.400	0.333	0.867	0.047	0.14
40	4.100	4.033	5.733	0.084	0.55
60	5.067	5.000	6.133	0.111	0.72

3. Number of functional leaves per plant

The mean number of functional leaves per plant at different growth stages are given in Tables 17, 18 and 19 and the analysis of variance in Appendix X.

a. Groundnut (first intercrop)

No significant difference between treatments was observed with regard to number of functional leaves per plant after 20,40 and 60 days of planting groundnut. But after 80 and 100 days of planting and at harvest, treatments showed significant difference with regard to number of functional leaves per plant. The treatment T_{11} recorded the maximum number of functional leaves per plant after 80 and 100 days of planting and also at harvest and was on par with T_6, T_3 and T_5 whereas treatment T_1 recorded the minimum number of functional leaves per plant at the above stages of growth.

b. French beans (first intercrop)

The treatments did not have any significant influence on the total number of functional leaves per plant at different growth stages except at 20 days after planting

Table.17. Number of functional leaves per plant of groundnut (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Days after planting					
	20	40	60	80	100	At harvest
T_1	16.000	51.867	77.867	73.333	74.533	55.267
T_3	15.700	50.100	84.667	87.047	87.967	67.500
T_5	16.067	48.020	86.000	86.833	87.593	65.713
T_6	17.100	48.067	86.110	88.833	89.533	67.500
T_{11}	16.400	46.600	83.373	90.057	90.647	68.780
S.E.	0.670	2.412	3.646	3.161	3.117	2.562
C.D.	NS	NS	NS	10.31	10.17	8.35

NS - Not significant

Table.18. Number of functional leaves per plant of French beans (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Days after Planting	Treatments					S.E.	C.D.
	T_2	T_4	T_7	T_8	T_{12}		
20	4.733	4.200	4.133	4.233	4.000	0.121	0.39
40	16.033	15.343	15.100	15.143	15.100	0.850	NS
60	11.700	10.567	10.133	10.167	10.100	0.599	NS

NS - Not significant

Table.19. Number of functional leaves per plant of French beans (second intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Days after Planting	Treatments			S.E.	C.D.
	T_5	T_7	T_{12}		
20	3.767	4.000	4.833	0.062	0.41
40	12.467	12.633	15.800	0.221	1.44
60	8.800	8.800	10.367	0.131	0.85

French beans. The treatment T_2 showed the maximum number of functional leaves per plant after 20 days of planting and the treatment T_{12} showed the minimum number which was on par with T_7, T_4 and T_8.

c. French beans (second intercrop)

Significant difference between treatments with regard to number of functional leaves per plant was recorded at all stages of growth. The highest number of functional leaves per plant after 20,40 and 60 days of planting was recorded by the treatment T_{12}. The lowest number of functional leaves per plant after 20 and 40 days of planting was recorded by the treatment T_5 which was on par with T_7. The treatments T_5 and T_7 produced the lowest number of functional leaves per plant after 60 days of planting.

4. Leaf area index

The mean leaf area index values at different growth stages are presented in Tables 20,21 and 22 and the corresponding analysis of variance in Appendix XI.

a. Groundnut (first intercrop)

The results revealed that there was significant difference between treatments with regard to the leaf area index values at all the growth stages of groundnut, from planting till harvest. The treatment T_{11} recorded the maximum leaf area index at all growth stages and differed significantly from all other treatments. After 20 and 100 days of planting and at harvest, T_1 recorded the minimum leaf area index and was on par with T_3, T_5 and T_6. The treatment T_5 showed the minimum leaf area index after 40 days of planting, which was on par with T_6, T_1 and T_3. After 60 and 80 days of planting T_1 recorded the minimum leaf area index and was on par with T_5, T_3 and T_6.

b. French beans (first intercrop)

The different treatments had no significant influence on the leaf area index at any of the growth stages.

c. French beans (second intercrop)

The results indicates that there was significant difference between treatments with regard to the leaf area index at all growth stages. The treatment T_{12} recorded the maximum leaf area index after 20,40 and 60 days of planting. After 20 and 40 days of planting the treatments T_5 and T_7 showed the minimum leaf area index. The treatment T_5 recorded

Table.20. Leaf area index of groundnut (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Days after plant					At harvest
	20	40	60	80	100	
T_1	0.363	2.483	3.384	5.200	5.322	3.037
T_3	0.372	2.540	3.494	5.622	5.740	3.223
T_5	0.377	2.389	3.479	5.601	5.750	3.283
T_6	0.379	2.425	3.701	5.711	5.815	3.373
T_{11}	1.059	6.074	9.699	9.683	9.762	5.947
S.E.	0.015	0.106	0.122	0.128	0.132	0.082
C.D.	0.07	0.50	0.58	0.61	0.63	0.39

Table.21. Leaf area index of French beans (first intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Days after planting	Treatments					S.E.	C.D.
	T_2	T_4	T_7	T_8	T_{12}		
20	0.322	0.306	0.307	0.312	0.271	0.014	NS
40	1.235	1.239	1.186	1.194	1.087	0.039	NS
60	0.957	0.953	0.893	0.917	0.917	0.016	NS

NS - Not significant

Table.22. Leaf area index of French beans (second intercrops) at different growth stages as influenced by the base crop (cassava) and spatial arrangements.

Days after planting	Treatments			S.E.	C.D.
	T_5	T_7	T_{12}		
20	0.286	0.286	0.356	0.007	0.04
40	0.811	0.811	1.161	0.004	0.03
60	0.605	0.607	0.940	0.009	0.06

which was on par with T_7.

B. Yield and yield attributes.

1. Pod number per plant.

Groundnut (first intercrop)

The data on the mean number of pods per plant are given in Table 23 and the analysis of variance in Appendix XII.

The treatments differed significantly with regard to the number of pods per plant. The maximum number of pods per plant was recorded by the treatment T_{11} which was on par with T_6. The minimum number of pods per plant was recorded by T_1 which was found to be on par with T_5 and T_3. The treatment T_6 in turn was found to be on par with T_3, T_5 and T_1.

2. Pod yield

The mean values of pod yields are given in Tables 23, 24 and 25 and the analysis of variance in Appendix XII.

a. Groundnut (first intercrop)

There was significant difference between treatments with regard to the pod yield. The highest pod yield was

Table.23. Pod number and yield of groundnut (first intercrops) as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Pod number per plant	Pod yield Kg/ha	Bhusa yield Kg/ha
T_1	26.867	417.333	8540.653
T_3	29.667	502.667	9033.385
T_5	29.237	510.000	9296.173
T_6	30.983	508.667	9131.930
T_{11}	36.050	1895.667	42547.998
S.E.	1.093	9.005	696.551
C.D.	5.19	42.72	3304.92

given by the treatment T_{11} and it differed significantly from all other treatments. The next best yield was given by the treatment T_5 which was on par with T_6 and T_3. The lowest yield was given by T_1 which was significantly inferior to all other treatments.

b. French beans (first intercrop)

Significant difference was observed between treatments with regard to the green pod yield of french beans. The treatment T_{12} recorded the highest green pod yield which was significantly superior to all other treatments. The lowest green pod yield was recorded by T_2 which was on par with T_7, T_4 and T_8.

c. French beans (second intercrop)

The treatments were found to differ significantly with regard to the green pod yield.

The highest green pod yield was recorded by the treatment T_{12} and the lowest green pod yield by T_7 which was on par with T_5.

3. Bhusa yield.

The mean values of the observations on bhusa

Table.24. Yield of french beans (first intercrops) as influenced by the base crop (cassava) and spatial arrangements.

Yield	Treatments					S.E.	C.D.
	T_2	T_4	T_7	T_8	T_{12}		
Green pod yield (Kg/ha)	4600.333	4763.00	4708.334	4785.334	12046.000	362.197	1718.51
Bhusa yield (Kg/ha)	5318.834	5614.500	5686.166	5685.166	8093.268	362.131	1718.20

Table.25. Yield of French beans (second intercrops) as influenced by the base crop (cassava) and spatial arrangements.

Yield	Treatments			S.E.	C.D.
	T_5	T_7	T_{12}		
Green pod yield (Kg/ha)	1544.333	1494.667	13013.333	129.769	844.75
Bhusa yield (Kg/ha)	4441.334	4440.200	7824.868	54.772	356.55

yield are presented in tables 23,24 and 25 and the analysis of variance in Appendix XII.

a. Groundnut (first intercrop)

Bhusa yield of groundnut differed significantly between treatments. The treatment T_{11} recorded the maximum bhusa yield and it was significantly superior to all other treatments. The minimum bhusa yield was recorded by T_1 and it was on par with T_3, T_6 and T_5.

b. French beans (first intercrop)

Significant difference was noticed between treatments with regard to the bhusa yield. The maximum yield was recorded by the treatment T_{12} and the minimum yield by T_2 which was on par with T_4, T_8 and T_7.

c. French beans (second intercrop)

There was significant difference between treatments with regard to the bhusa yield. The treatment T_{12} recorded the maximum yield and was significantly superior to the other two treatments. The minimum yield was recorded by T_7 and was on par with T_5.

C. Plant analysis

Bhusa of groundnut and French beans were analysed for nitrogen, phosphorus and potassium contents. The mean values of nitrogen, phosphorus and potassium contents of bhusa are given in Tables 26, 27 and 28 and their respective analysis of variance in Appendix XIII.

1. Nitrogen content of bhusa

a. Groundnut (first intercrop)

The different treatments had no significant influence on the nitrogen content of bhusa.

However, highest value of nitrogen content in bhusa was recorded by the treatment T_3 and the lowest value by T_1.

b. French beans (first intercrop)

No significant difference between treatments was observed with regard to the nitrogen content of bhusa.

However, the treatment T_{12} recorded the highest value of nitrogen content in bhusa and T_7 recorded the lowest value.

c. French beans (second intercrop)

There was significant difference between treatments with regard to the nitrogen content of bhusa.

The highest value of nitrogen content in bhusa,

was recorded by the treatment T_{12} and was on par with T_5 The treatment T_7 recorded the lowest value of nitrogen content in bhusa. However T_5 was on par with T_7.

2. Phosphorus content of bhusa

a. Groundnut (first intercrop)

There was no significant difference between treatments with regard to phosphorus content of bhusa.

However, the maximum value of phosphorus content in bhusa was showed by the treatment T_1 and minimum values by the treatment T_5 and T_6.

b. French beans (first intercrop)

The phosphorus content of bhusa was not significantly influenced by the various treatments.

However the treatment T_{12} recorded the highest phosphorus content in bhusa and the lowest phosphorus content was recorded by T_2.

c. French beans (second intercrop)

The different treatments had no significant influence on the phosphorus content of bhusa.

However, the highest value of phosphorus content in bhusa was recorded by the treatment T_{12} and the lowest value by the treatment T_5.

3. Potassium content of bhusa.

a. Groundnut (first intercrop)

Potassium content of bhusa was not significantly influenced by various treatments.

However, the maximum potassium content in bhusa was recorded by the treatment T_3 and the minimum potassium content by T_1.

b. French beans (first intercrop)

Significant difference was observed between treatments with regard to potassium content of bhusa.

The highest value of potassium content in the bhusa was showed by the treatment T_{12} which was on par with T_7. The treatment T_2 showed the lowest value of potassium content in the bhusa and was on par with T_4 and T_8. The treatment T_7 in turn, was on par with T_8 and T_4.

c. French beans (second intercrop)

There was significant difference between treatments with regard to potassium content in the bhusa.

The maximum potassium content in the bhusa was recorded by the treatment T_{12} and the minimum potassium content by T_5 which was on par with T_7.

Table.26 Distribution of nitrogen, phosphorus and potassium (per cent) in the bhusa of groundnut (first intercrops) as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Nitrogen	Phosphorus	Potassium
T_1	1.034	0.127	1.100
T_3	1.082	0.121	1.178
T_5	1.064	0.119	1.133
T_6	1.073	0.119	1.111
T_{11}	1.058	0.126	1.144
S.E.	0.035	0.009	0.036
C.D.	NS	NS	NS

NS - not significant

Table.27 Distribution of nitrogen, phosphorus and potassium (per cent) in the bhusa of French beans (first intercrops) as influenced by the base crop (cassava) and spatial arrangements

Nutrients	Treatments					S.E.	C.D.
	T_2	T_4	T_7	T_8	T_{12}		
Nitrogen	1.257	1.295	1.252	1.295	1.409	0.035	NS
Phosphorus	0.105	0.109	0.114	0.114	0.129	0.008	NS
Potassium	1.233	1.300	1.327	1.300	1.400	0.028	0.09

NS= - Not significant

Table.28 Distribution of nitrogen, phosphorus and potassium (per cent) in the bhusa of French beans (second intercrops) as influenced by the base crop and spatial arrangements.

Nutrients	Treatments			S.E.	C.D.
	T_2	T_7	T_{12}		
Nitrogen	1.274	1.265	1.408	0.022	0.08
Phosphorus	0.104	0.113	0.123	0.007	NS
Potassium	1.293	1.313	1.397	0.012	0.08

NS - Not significant

D. Quantity of nutrients incorporated by the intercrops.

The mean values of nitrogen, phosphorus and potassium incorporated to the soil through the bhusa of intercrops are given in Table 29 and the analysis of variance in Appendix XIV.

1. Quantity of nitrogen incorporated by the intercrops.

Significant difference was observed between the first intercrops (groundnut and French beans) and second intercrops (French beans) with regard to the quantity of nitrogen incorporated to the soil.

The bhusa of first intercrops (groundnut and French beans) incorporated significantly higher quantities of nitrogen when compared to the second intercrops (French beans). Treatment T_5 was the superior treatment but was on par with all other first intercrops.

2. Quantity of phosphorus incorporated by the intercrops.

The quantity of phosphorus incorporated to the soil through bhusa was also significantly influenced by the intercrops.

Table 29 Quantity of nitrogen, phosphorus and potassium incorporated by the intercrops (Kg/ha) as influenced by the base crop (cassava) and spatial arrangements.

Treatments	Nitrogen			Phosphorus			Potassium		
	Groundnut	French beans (I intercrop)	French beans (II intercrop)	Groundnut	French beans (I intercrop)	French beans (II intercrop)	Groundnut	French beans (I intercrop)	French beans (II intercrop)
T_1	28.691	-	-	3.484	-	-	30.340	-	-
T_3	31.536	-	-	3.498	-	-	34.344	-	-
T_5	31.868	-	-	3.542	-	-	34.003	-	-
T_6	31.035	-	-	3.514	-	-	32.872	-	-
T_2	-	26.556	-	-	2.207	-	-	26.268	-
T_4	-	29.128	-	-	2.478	-	-	29.046	-
T_7	-	28.610	-	-	2.598	-	-	30.109	-
T_8	-	29.455	-	-	2.579	-	-	29.451	-
T_5	-	-	22.683	-	-	1.852	-	-	22.948
T_7	-	-	22.510	-	-	2.014	-	-	23.295
S.E.		2.118			0.230			2.142	
C.D.		6.29			0.93			6.37	

Bhusa of groundnut (first intercrop) added significantly higher amounts of phosphorus compared to bhusa of french beans (first and second intercrops). The treatment T_5 (with groundnut as first intercrop) was the superior treatment but was on par with all other treatments having groundnut as first intercrop. There was no significant difference between treatments containing French beans as first and second intercrops, with regard to the quantity of phosphorus added to soil through the bhusa. However among French beans, the first intercrops of French beans recorded the highest values and the second inter crops of french beans recorded the lowest values.

3. Quantity of potassium incorporated by the intercrops.

Similar to the quantity of nitrogen incorporated, quantity of potassium incorporated to the soil was also found to be significantly influenced by the intercrops.

The treatments with groundnut and French beans as first intercrops incorporated significantly higher amounts of potassium to soil through the bhusa, compared to the bhusa of second intercrops of French beans. There was no significant difference among the first intercrops with

regard to quantity of potassium added to soil through bhusa and the superior treatment was T_3 which was on par with all other first intercrops.

Land Equivalent Ratio (LER)

The mean values of LER are presented in Table 30 and the analysis of variance in Appendix XV.

The various treatments recorded significantly different values of land equivalent ratio (LER).

The treatment T_4 recorded the highest value of LER which was on par with T_7 and T_8 and differed significantly from all other treatments. The next best value of LER was given by T_5 which was on par with T_3. followed by T_6 which was on par with T_2. The treatment T_3 in turn, was on par with T_6 and T_2. The lowest value of LER was recorded by T_1 and was significantly inferior to all other treatments.

Soil analysis after the experiment

The mean values of the nutrient contents of soil after the experiment are presented in Table 31 and Appendix XVI gives the analysis of variance.

Table.30 Land equivalent ratios of the cassava based intercropping systems as influenced by planting geometry and intercrops.

Treatments	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	S.E.	C.D.
L.E.R.	1.165	1.385	1.477	1.802	1.596	1.421	1.753	1.728	0.030	0.13

L.E.R - Land Equivalent Ratio

1. Total nitrogen content of the soil

It was observed that the treatments had no significant effect on the total nitrogen content of the soil.

2. Available phosphorus content of the soil

The results revealed that there was no significant difference in the available phosphorus content of soil due to different treatments.

3. Available potassium content of the soil

No significant difference was indicated due to different treatments with regard to the available potassium content of the soil.

Economics of intercropping in cassava.

The economics of intercropping in cassava as influenced by planting geometry, intercrops (groundnut and french beans) and double intercropping are presented in Table 32.

Table.31. Distribution of nitrogen, phosphorus and potassium in the soil after the experiment, as influenced by intercropping systems.

Nutrients	Treatments											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	S.E.	C.D
otal Nitrogen percent)	0.084	0.085	0.084	0.085	0.085	0.085	0.086	0.087	0.084	0.084	0.001	NS
vailable hosphorus kg/ha)	40.667	40.600	40.833	40.800	41.000	40.633	40.933	41.000	40.633	40.650	0.213	NS
vailable otassium kg/ha)	78.467	78.733	78.833	78.600	78.833	78.867	78.167	78.100	78.033	78.133	0.340	NS

S - Not significant

Table. 32. Economics of intercropping in cassava as influenced by planting geometry, intercrops and double intercropping

Cost of cultivation Rs. Ps.	Yield: Cassava t/ha	Yield: I intercrop kg/ha	Yield: II intercrop Kg/ha	Value of produce: Cassava Rs. Ps.	Value of produce: I intercrop Rs. Ps.	Value of produce: II intercrop Rs. Ps.	Total income Rs. Ps.	Profit Rs. Ps.
8089.75	26.673	417.333*	-	13336.50	2295.33*	-	15631.83	7542.08
9037.50	28.197	4600.333**	-	14098.50	11500.83**	-	25599.33	16561.83
8089.75	31.398	502.667*	-	15699.00	2764.67*	-	18463.67	10373.92
9037.50	36.308	4763.000**	-	18154.00	11907.50**	-	30061.50	21024.00
9464.75	31.245	510.000*	1544.333**	15622.50	2805.00*	3860.33**	22288.33	12823.58
8739.75	29.874	508.667*	***	14937.00	2797.67*	***	17734.67	8994.92
10412.50	32.160	4708.334**	1494.667**	16080.00	11770.84**	3736.67**	31587.50	21175.00
9687.50	34.294	4785.334**	***	17147.00	11963.34**	***	29110.34	19422.84
6837.50	28.197	-	-	14098.50	-	-	14098.50	7261.00
6837.50	25.911	-	-	12955.50	-	-	12955.50	6118.00

ndnut ** French beans

csegram which was not successful as II intercrop.

Price of cassava - Rs.50/-Quintal
Price of groundnut- Rs.5.50/Kg.
Price of French beans - Rs.2.50/Kg

Discussion

DISCUSSION

An investigation was carried out at the College of Agriculture, Vellayani during 1983-84 to study the possibility of raising a second intercrop in sequence, immediately after the harvest of the first intercrop, in a cassava based intercropping system and to identify the most suitable planting geometry. The observations on growth characters, yield attributes and yield were recorded. Chemical analyses of soil and plant samples were done and data recorded. The results obtained from the study are discussed hereunder.

Main crop (Cassava)

A. Growth Characters

1. Height of the Plant

The results (Table 1) revealed that there was no significant influence of the treatments on the height of plants throughout the growth period of cassava. As cassava was planted on mounds its canopy was always held at a higher level, than the canopy of intercrops which were planted in

the interspace between the cassava mounds. Thus the competition for solar radiation never occured in the intercropping system between the main crop and the intercrops. Similarly, due to the uniform distribution of rainfall during the period when intercrops were being raised, the competition for water between the main crop and intercrops was also absent. The application of required doses of fertilizer nutrients to both main crop and intercrops resulted in lesser competition between main crop and intercrops for nutrition.

Thus the absence of competition for solar energy, water and nutrients, resulted in uniform growth of cassava plants throughout the growing period.

2. Total number of leaves per plant

It is seen that there was no significant influence of treatments on the total number of leaves per plant, at all stages of growth of cassava (Table 2). As in the case of plant height, the absence of competition for factors such as solar energy, water and nutrients created uniform growth conditions for cassava plants in all the treatments and as such there occured no significant difference between treatments with regard to the total number of leaves produced per plant.

3. Number of functional leaves per plant.

From the results obtained (Table 3) it is seen that there was no significant difference between treatments regarding the number of functional leaves per plant, throughout the growth of cassava. As there was little competition for solar energy, water and nutrients there was no significant difference between the number of functional leaves per plant in the different treatments as in the case of total number of leaves per plant.

4. Leaf area index

A critical analysis of the data on leaf area index (Table 4) revealed that there was significant difference between different treatments regarding the leaf area index after third, nineth and tenth month of planting cassava.

The cassava plants in ordinary method of planting with groundnut as intercrop (T_1) gave the lowest value for leaf area index after third, nineth and tenth months of planting cassava. This may be due to the reason that T_1 recorded lowest values for total number of leaves as well as number of functional leaves per plant, though not significantly different from other treatments. Similarly, due to the higher values for total number of leaves and number of

functional leaves per plant recorded after third, nineth and tenth months of planting cassava, by the cassava plants in pure cropped plots, there occured higher leaf area index values in those treatments.

B. Yield attributes and yield

1. Number of tubers per plant.

The results (Table 5) revealed that there was significant difference between treatments with regard to the number of tubers per plant. The treatment (T_5) in which groundnut and French beans were raised in sequence as first and second intercrops with cassava planted in paired row system produced maximum number of tubers per plant and was on par with treatments (T_4 and T_7) in which French beans was raised as intercrop with cassava planted in paired row system. This might be attributed to the beneficial effects of French beans as an intercrop and also due to the fact that in the above treatments cassava was planted in paired rows which had additional advantage of 'border effect'.

The lowest number of tubers per plant was produced by the treatment in which groundnut was raised as intercrop with cassava planted in ordinary system, and this is due to the comparitively higher competition by groundnut as intercrop with cassava planted in ordinary method and is

evident from the fact that cassava in the above treatment recorded minimum height, minimum number of functional leaves and minimum leaf area index at all stages of growth. The minimum number of functional leaves and minimum leaf area index indicates the poor development of the photosynthetic apparatus which in turn might have reduced the carbohydrate supply for initiating secondary thickening of roots for tuber development.

2. Length of tuber

The results (Table 5) showed no significant difference between treatments with regard to the length of tubers. However, it could be seen that length of tuber was maximum in treatments in which French beans was raised as first intercrop with cassava planted in both paired row system and ordinary method of planting. This is due to the fact that French beans might have put forth their tap roots to deeper layers and the uprooting of intercrops resulted in a loosened soil condition around the tapioca plants. This condition would have helped the growing tubers to penetrate easily through the loose soil at the time of tuberisation resulting in an increase in the length of

tubers in the French beans intercropped plots. Similar findings were reported by Sheela (1981) and Anil Kumar (1984) in studies with cowpea as intercrop of cassava.

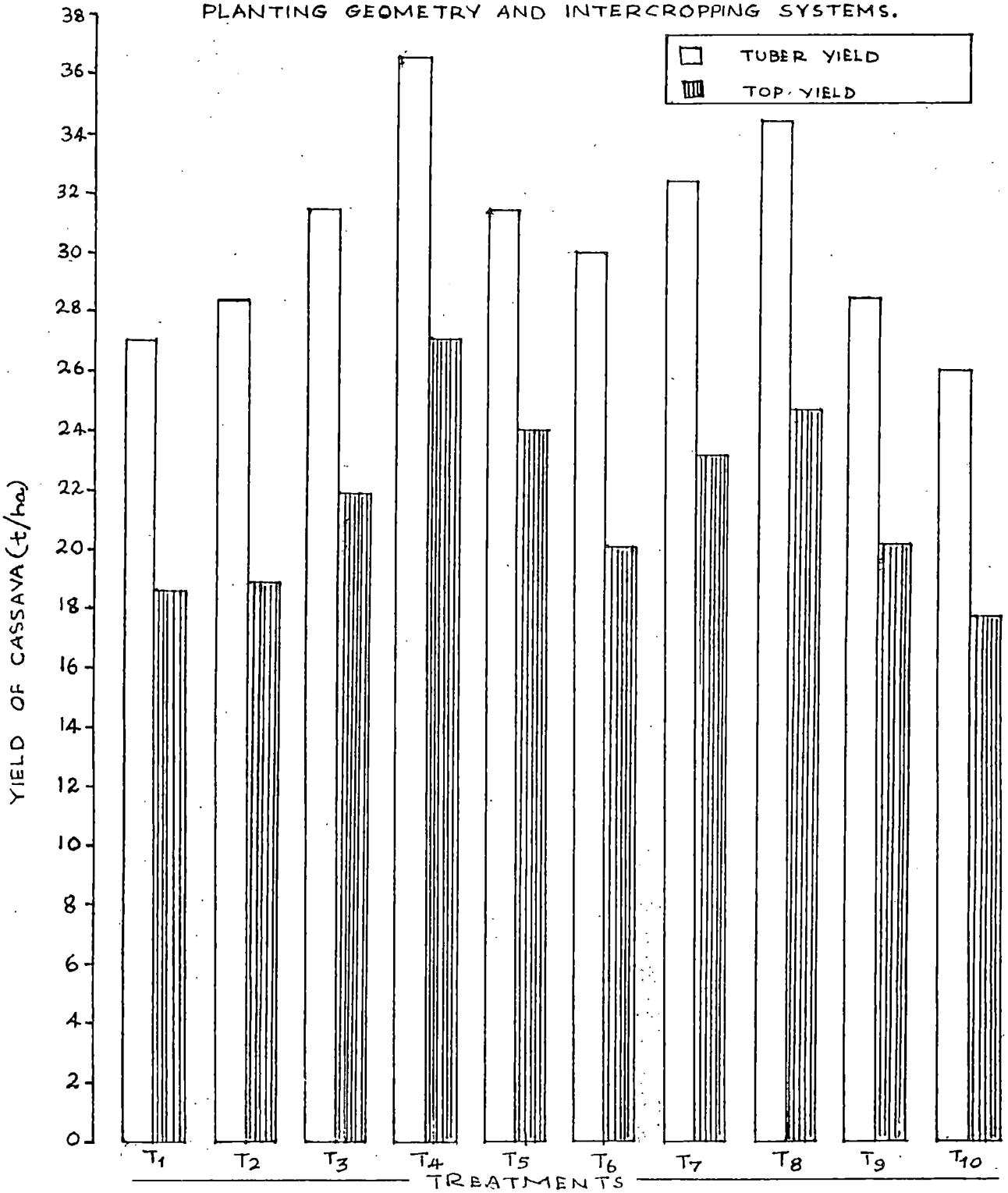
3. Girth of tuber

The data (Table 5) showed that there was no significant difference in tuber girth due to treatment effects. However, the data revealed that the treatment which showed the higher values for length of tuber recorded the lower values for girth of tuber. This is due to the fact that use of assimilates for building up the length of productive roots might have caused a reduction in availability of assimilates for increasing the girth of the tubers.

4. Tuber yield

The data (Table 6 and Fig. 4) revealed that the treatments differed significantly with regard to the tuber yield. The treatment (T_4) in which French beans was raised as intercrop with cassava planted in paired row system recorded the maximum tuber yield followed by a treatment (T_8) in which French beans was raised as first intercrop and horsegram as second intercrop (which perished at early stages of growth) with cassava in paired row system. In all the above treatments French beans was raised as first intercrop between cassava

FIG.4. TUBER AND TOP YIELDS OF CASSAVA AS INFLUENCED BY PLANTING GEOMETRY AND INTERCROPPING SYSTEMS.



TREATMENTS

T_1 - ORDINARY METHOD OF PLANTING CASSAVA + GROUNDNUT
T_2 - ORDINARY METHOD OF PLANTING CASSAVA + FRENCH BEANS
T_3 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + GROUNDNUT
T_4 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + FRENCH BEANS
T_5 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + (GROUNDNUT + FRENCH BEANS)
T_6 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + (GROUNDNUT + HORSE GRAM)
T_7 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + (FRENCH BEANS + FRENCH BEANS)
T_8 - PAIRED ROW SYSTEM OF PLANTING CASSAVA + (FRENCH BEANS + HORSE GRAM)
T_9 - PURE CROP OF CASSAVA IN ORDINARY METHOD OF PLANTING
T_{10} - PURE CROP OF CASSAVA IN PAIRED ROW SYSTEM OF PLANTING

planted in paired row system and the beneficial effect of French beans in tuber development of cassava at the time of tuber initiation might have resulted in the higher tuber yield of cassava. The beneficial effects of French beans is evident from the higher number of tubers per plant and maximum length of tubers in the above treatments. This is in conformity with the finding which revealed that cassava grown alone gave tuber yields of 12.9 t/ha while it was 13.2 t/ha when intercropped with French beans (Anon., 1975). According to Neumann (1984) also higher cassava yield was obtained when intercropped with French beans.

5. Top yield.

The mean values of top yield (Table 6 and Fig. 4) revealed that top yield was significantly influenced by treatment effects. The treatments which gave higher tuber yields recorded higher values for top yield also. This might be attributed to the beneficial effects of French beans as intercrop in stimulating growth of cassava which resulted in better growth and canopy build up.

6. Utilisation index.

The results (Table 6) showed that there was no significant difference between treatments with regard to

the utilisation index. Though there was significant difference between treatments with regard to tuber yield and top yield, the values of their ratio need not necessarily vary significantly. This shows that the cassava plants in different treatments were having equal capacity for translocating carbohydrates from the source to the sink.

C. Quality attributes

Dry matter and crude protein contents of tuber.

From the results (Table 7) it is observed that quality attributes like drymatter and crude protein contents of cassava tuber were not significantly influenced by treatment effects. This is due to the reason that the treatments did not include variations in nutrient applications and varieties, which would have influenced the above quality attributes. This in conformity with the findings of Anilkumar (1984)

D. Plant analysis

Nitrogen content of leaf and stem and phosphorus and potassium contents of leaf, stem and tubers.

No significant difference was observed in the nitrogen content (Table 8) of cassava leaf and stem. Phosphorus (Table 9) and potassium (Table 10) contents of leaf, stem and tuber were also not significantly influenced by different

treatment effects. It clearly shows that groundnut and french beans as intercrops did not have any influence on the nitrogen, phosphorus and potassium contents of cassava. Since cassava and intercrops were given seperate adequate doses of nitrogen, phosphorus and potassium in all the treatments, significant variation in nitrogen, phosphorus and potassium contents of cassava plant parts need not be expected also.

Intercrops

A. Growth characters.

1. Height of plant.

a. Groundnut (first intercrop).

The results (Table 11) revealed that there was significant difference between treatments with regard to the height of the plant after 80 and 100 days of planting and at harvest. Groundnut planted in interspaces of cassava planted in ordinary method (T_1) recorded the maximum height at all the above stages and this may be attributed to the shading of groundnut by vigorous vegetative growth of cassava which in turn might have produced longer internodes for intercepting more of sunlight with the result that the height of groundnut increased. At all the above stages the pure crop of groundnut recorded the minimum height due to

the absence of shading.

After 80 days of planting height of groundnut planted in interspaces of cassava planted in ordinary method was on par with height of all groundnut intercrops planted with cassava planted in paired row system and this might be due to the fact that cassava canopy started building up to shade the interspaces to some extent even in cassava planted in paired rows. After 100 days of planting and at harvest, two treatments (T_6 and T_3) in which groundnut was planted with cassava in paired row system was on par with T_1 and one treatment T_5 in which groundnut was planted with cassava in paired row system was on par with pure crop of groundnut (T_{11}). The treatment T_6 inturn was on par with T_3 and T_5. Thus it is seen that as far as intercropped groundnut with cassava planted in paired row is concerned there was a tendency to show lesser heights. This may be attributed to reduction in shading effect of cassava as is evident from lesser number of functional leaves and lesser leaf area index after 100 days of planting cassava (Tables 3 and 4), resulting in reduced shading of groundnut intercrops planted with cassava planted in paired rows compared to groundnut intercropped with cassava planted in ordinary method.

b. French beans (first intercrop)

The mean values of height of French beans (Table 12) indicated that there was no significant difference between treatments throughout the growth of French beans. This may be due to the fact that shading effect of cassava was not so pronounced at early stages of growth of cassava as seen in the case of groundnut intercrops also and French beans being a crop with shorter duration (60 days) was not affected by shading from cassava.

c. French beans (second intercrop)

It is seen that there was significant difference in the height of French beans at all stages of growth (Table 13). French beans planted in sequence as second intercrop after the harvest of first intercrops experienced shading in all intercropped plots as the canopy build up of cassava grown in paired rows tended to shade interspaces of paired rows to some extent. This shading resulted in increased internodal lengths of French beans in intercropped plots and a higher value for height was recorded, compared to the pure crop of French beans.

2. Number of branches per plant.

a. Groundnut (first intercrop).

The mean values of number of branches of groundnut (Table 14) indicated that there was significant difference between treatments from 60 days after planting of ground till harvest. The treatment in which groundnut was planted in the interspaces of cassava planted in ordinary method was found to record the minimum number of branches. The cassava planted in paired rows offered only little competition for sunlight with groundnut as the interspaces were not as much covered by the canopy of cassava as in ordinary method of planting cassava. Groundnut planted in the interspaces of paired rows of cassava thus experienced an almost similar condition as that in a pure crop of groundnut with regard to availability of solar radiation. So the groundnut in the above treatments recorded higher number of branches which were not significantly different from that of a pure crop of groundnut.

b. French beans (first intercrop).

The results (Table 15) revealed no significant difference between treatments with regard to the number of branches per plant at all growth stages. There was practically zero competition between the intercrop of

French beans and main crop of cassava for solar energy, nutrients and water. In the case of intercrop of groundnut also it was seen that competition was experienced only after 60 days of planting and as duration of French beans was only 60 days it was free from competition and was comparable to growth conditions available to a pure crop of French beans.

c. French beans (second intercrop)

From the results (Table 16) obtained it is seen that the number of branches of second intercrop of French beans was significantly influenced by treatment effects at all stages of growth. Intercrops of French beans recorded minimum number of branches through out the growth period and were significantly inferior to the pure crop of French beans. This is due to the reduced availability of solar radiation as the build up of canopy of cassava planted in paired rows tended to shade the interspaces to some extent.

3. Number of functional leaves per plant.

a. Groundnut (first intercrop)

Mean values of number of functional leaves of groundnut (Table 17) indicated that there was significant difference between treatments from 80 days after planting till harvest. The treatment in which groundnut was planted

in the interspaces of cassava planted in ordinary method recorded minimum number of functional leaves at the above stages of growth. This is attributed to the competition for sunlight offered by increased shading by cassava in ordinary method due to closeness to intercrop of groundnut. In paired row cassava interspaces were free from much shading and so competition for solar radiation was lesser, and so number of functional leaves per plant of groundnut intercrops in those treatments were on par with that of pure crop of groundnut.

b. French beans (first intercrop)

It is seen that there was significant difference in the number of functional leaves per French beans plant at 20th day of planting (Table 18). The French beans planted in interspaces of cassava planted in ordinary method recorded the maximum number of functional leaves. This can be attributed to the fact that French beans being a fast growing crop might have extracted more nutrients and water applied to cassava mounds due to the proximity to cassava crop. At 40th and 60th days of planting, cassava root system might have established well thus preventing the French beans

intercrop from tapping the nutrients added to mounds of cassava. So there was no significant difference between treatments with regard to number of functional leaves of French beans at 40th and 60th days of planting.

c. French beans (second intercrop)

Significant difference between treatments was observed with regard to the number of functional leaves at all stages of growth of second intercrop of French beans (Table 19). As in the case of height and number of branches, the French beans intercrops recorded significantly lower values compared to pure crop. This might be attributed to competition for sunlight caused by shading of interspaces to some extent due to build up of canopy of cassava planted in paired rows.

4. Leaf area index

a. Groundnut (first intercrop)

The results (Table 20) revealed significant difference between treatments with regard to leaf area index of groundnut at all growth stages. The pure crop of groundnut was significantly superior to groundnut intercrops. Though the height of plant, number of branches and number of functional leaves were not much affected by competition

from cassava, the groundnut plants in intercropped plots might have experienced competition for nutrients and water resulting in production of minimum leaf area index.

b. French beans (first intercrop)

Mean values of leaf area index (Table 21) showed no significant difference between treatments at all stages of growth of French beans. This is due to the absence of competition for solar radiation, nutrients and water between the intercropped French beans and cassava.

c. French beans (second intercrop)

From the results obtained (Table 22) it is seen that the leaf area index of French beans was significantly influenced by treatment effects. The pure crop of French beans recorded significantly higher values of leaf area index at all stages of growth compared to French beans intercrops. This is attributed to the fact that the intercrops experienced competition for solar radiation due to shading by cassava to some extent and is evident from lesser number of branches per plant and lesser number of functional leaves per plant recorded by French beans intercrop.

B. Yield and yield attributes

1. Pod number per plant

Groundnut (first intercrop)

Mean values of pod number per plant (Table 23) recorded significant difference between treatments. The pure crop of groundnut gave maximum value and minimum value was recorded by groundnut intercropped with cassava in ordinary method and was on par with all other groundnut intercrops. The cassava plants offered competition with regard to availability of solar radiation and nutrient availability at later stages of growth of groundnut when pod formation started, which resulted in the decreased pod number of groundnut intercrops.

2. Pod yield

a. Groundnut (first intercrop)

From the results obtained (Table 23) it is seen that pod yield of groundnut was significantly influenced by treatment effects. The pure crop of groundnut recorded superior value for pod yield compared to all the groundnut intercrops. This is due to the higher plant population in the pure cropped plot of groundnut. Among the groundnut intercrops, the groundnut planted in the interspaces of cassava planted in ordinary method recorded significantly lower value for pod yield compared to groundnut intercropped

with cassava in paired row system. The competition effect of cassava on the above intercrop is evident from the lower growth character values and so the lowest pod yield was recorded by that treatment.

b. French beans (first intercrop)

The mean values of green pod yield of french beans (Table 24) recorded significant difference between treatments. The pure crop of French beans recorded significantly higher green pod yield due to increased plant population compared to French beans intercrops. The green pod yields of French beans intercrops did not vary significantly. This is due to the fact that there was lesser competition with cassava in all intercropped plots and so all intercrops of French beans experienced similar growth conditions.

c. French beans (second intercrop)

The results (Table 25) revealed significant difference between treatments with regard to the green pod yield of French beans. Pure crop of French beans recorded significantly superior value for green pod yield compared to all French beans intercrops due to the higher plant population of pure crop. The green pod yields

of French beans intercrops did not vary significantly as growth conditions were similar. Compared to first inter crop, green pod yield of second intercrop was much lesser than expected due to reduced plant population of second intercrop, and this might be attributed to the competition offered by cassava to second inter crop as is evident from the significantly lower values obtained for growth characters of second intercrop such as the number of branches per plant, number of functional leaves per plant and leaf area index.

3. Bhusa yield

a. Groundnut (first intercrop)

Mean values of bhusa yield of groundnut (Table 23) indicated that there was significant difference due to treatment effects. As in the case of pod yield, here also highest value was recorded by pure crop of groundnut due to higher plant population and among intercrops the bhusa yield did not vary significantly. However, lowest value was recorded by groundnut intercropped with cassava in ordinary method due to competition with cassava.

b. French beans (first intercrop)

The results (Table 24) revealed that treatments differed significantly with regard to bhusa yield of french beans. Similar to green pod yield, pure crop of French beans recorded highest value of bhusa yield due to higher plant population and French beans intercrops did not vary significantly with regard to bhusa yield due to the fact that similar growth conditions were experienced by all the intercrops. However, French beans intercropped with cassava in ordinary method gave the lowest value, possibly due to comparatively greater competition offered by cassava due to proximity of the intercrop to cassava plants.

c. French beans (second intercrop)

It is seen that there was significant difference in the bhusa yield of French beans (Table 25). As in the case of green pod yield, here also highest value was recorded by pure crop of French beans due to the higher plant population. The intercrops did not vary significantly with regard to bhusa yield due to the similar growth conditions experienced by them.

C. Plant Analysis

1. Nitrogen content of bhusa

a. Groundnut (first intercrop)

Results (Table 26) revealed that treatments did not vary significantly with regard to nitrogen content of bhusa of groundnut. This is due to the fact that as nutrients were supplied separately to intercrops and main crop in required doses, only little competition was experienced by intercrops for availability of nutrients.

b. French beans (first intercrop)

Mean values of nitrogen content in bhusa of French beans (Table 27) did not vary significantly due to treatment effects. This is due to absence of competition for the nutrient between the intercrop and main crop.

c. French beans (second intercrop)

It is seen that there was significant difference in nitrogen content of bhusa of French beans due to treatment effects (Table 28). The highest value was recorded by pure crop of French beans and lowest value by the intercrops. This is due to the competition offered by

cassava to some extent as far as the availability of nitrogen to the intercrop is concerned. Any way one of the intercrop treatments was on par with the pure crop treatment indicating that the degree of competition offered by cassava was not much.

2. Phosphorus content of bhusa

a. Groundnut (first intercrop)

No significant difference was seen between treatments with regard to phosphorus content of bhusa (Table 26), and the reason being little competition as seen in the case of nitrogen.

b. French beans (first intercrop)

Mean values of phosphorus content in bhusa of French beans (Table 27) indicated no significant difference due to treatment effects. This is comparable to the nitrogen content in bhusa.

c. French beans (second intercrop)

The results (Table 28) revealed no significant difference between treatments with regard to phosphorus content of French beans. This is due to absence of competition offered by cassava with regard to availability of phosphorus to intercrops.

3. Potassium content of bhusa.

a. Groundnut (first intercrop)

No significant difference was seen between treatments with regard to potassium content of bhusa of groundnut (Table 26). This is comparable to absence of competition for other two nutrients between main crop of cassava and groundnut intercrops.

b. French beans (first intercrop)

Results (Table 27) revealed significant difference in potassium content in bhusa of French beans due to treatment effects. The pure crop of French beans recorded highest value and French beans intercropped with cassava in ordinary method recorded lowest value. The higher competition offered by cassava in ordinary method due to proximity to intercrop might have resulted in lowest potassium content, as cassava needs higher amounts of potassium for proper tuber development.

c. French beans (second intercrop)

Mean values of potassium content in bhusa of French beans (Table 28) indicates significant difference due to treatment effects. The pure crop of French beans

recorded the highest value due to absence of competition and the lower values by intercrope due to competition with cassava for potassium in soil, as more potassium is needed by cassava for proper tuber development.

D. Quantity of nutrients incorporated by intercrops into soil.

1. Quantity of nitrogen incorporated by the intercrops.

The data (Table 29) on the amount of nitrogen incorporated into the soil by the intercrops revealed significant difference due to various treatments.

The bhusa of first intercrops (groundnut and French beans) incorporated significantly higher amounts of nitrogen when compared to the second intercrops (French beans). Though first intercrop of groundnut produced larger quantities of bhusa than first intercrop of French beans, the nitrogen content in bhusa was higher in French beans compared to groundnut. So the first intercrops did not differ in the amount of nitrogen added to soil through bhusa.

The second intercrop of French beans produced lesser amounts of bhusa and so added lesser amounts of nitrogen to soil. However, the second intercrops of French beans was on par with one treatment involving a first intercrop of groundnut (T_1) and two treatments involving first intercrop of French beans (T_7 and T_2).

2. Quantity of phosphorus incorporated by the intercrops.

From the results obtained (Table 29) it is seen that quantity of phosphorus added to soil by intercrops differed significantly. Bhusa of groundnut (first intercrop) added significantly higher amounts of phosphorus to soil compared to bhusa of French beans (both first and second intercrops). This is due to the larger quantities of bhusa produced by groundnut and also the higher content of phosphorus in the bhusa of groundnut compared to french beans. Though there was no significant difference between first and second intercrops of French beans with respect to quantity of phosphorus added to soil, the first intercrop, of French beans recorded highest values as the quantity of bhusa produced by the first intercrops of French beans was higher compared to the second intercrops of French beans.

3. Quantity of potassium incorporated by the intercrops.

The results (Table 29) revealed significant difference due to various treatments with regard to quantity of potassium incorporated in to the soil by intercrops. Similar to the quantity of nitrogen incorporated into the soil by the intercrops, the first

intercrops of groundnut and French beans added higher amounts of potassium in to the soil through bhusa compared to second intercrops of French beans. Here also, although the first intercrop of groundnut produced larger quantities of bhusa, potassium content in the bhusa was lesser compared to that of French beans and therefore was on par with first intercrop of French beans, with regard to quantity of potassium added to soil.

Land Equivalent Ratio (LER)

Mean values of LER (Table 30) revealed significant difference between treatments. The highest LER value was recorded by treatment T_4 which was on par with T_7 and T_8 in which treatments French beans was raised as first intercrop. This is due to the comparatively good yields produced by the French beans intercrops and also due to higher yield of cassava compared to its sole crop. This shows that French beans is a more efficient intercrop with cassava compared to groundnut. The lowest value of LER was recorded by the treatment in which groundnut was raised as intercrop with cassava in ordinary planting (T_1) and was significantly inferior to all other treatments.

This is due to lower yields of cassava compared to its sole crop in ordinary method of planting and also due to lower yield of groundnut compared to other groundnut intercrops with cassava in paired row system of planting. This indicates that groundnut is more efficient as an intercrop with cassava, when cassava is planted in paired row system.

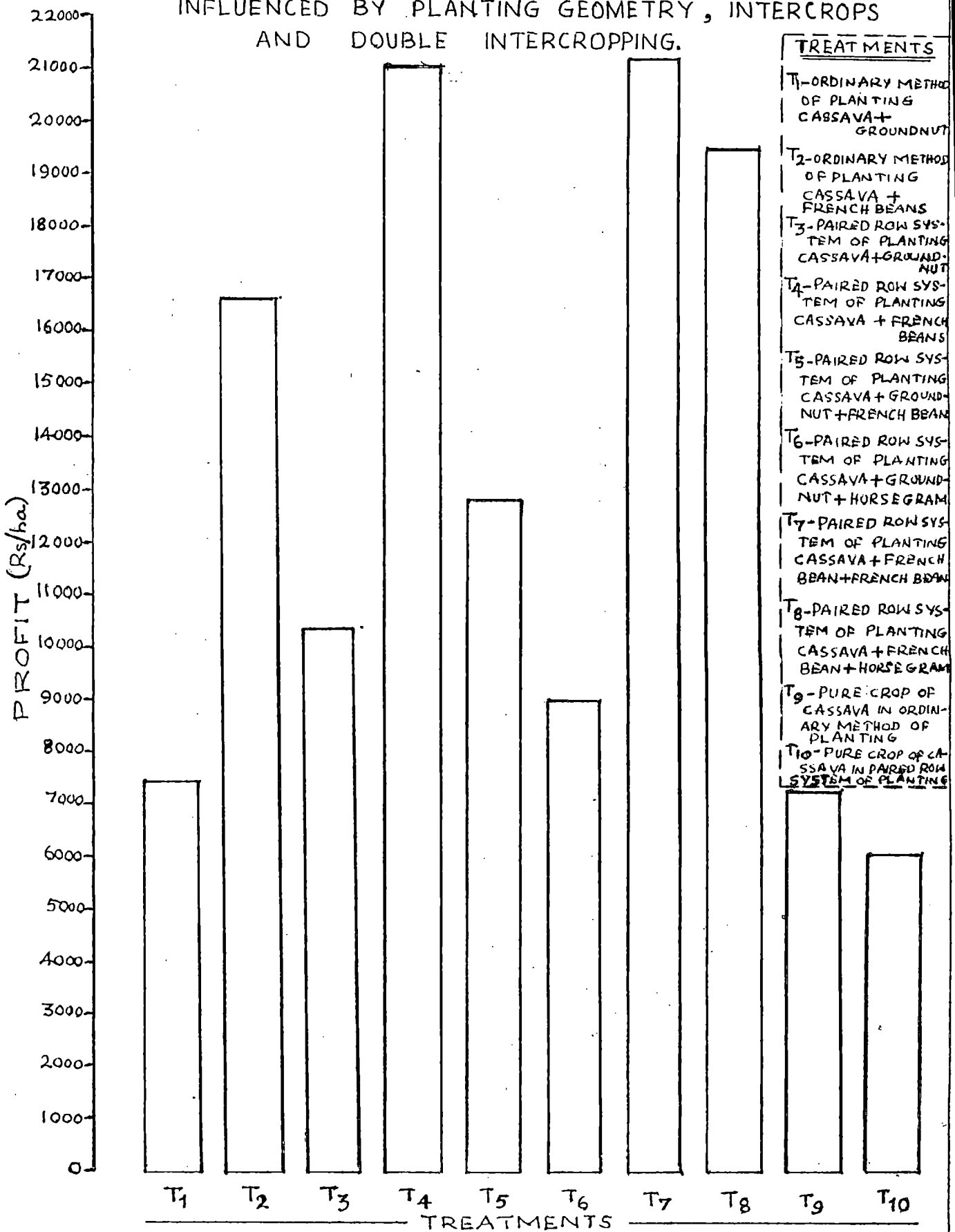
Soil analysis after the experiment:

Chemical analysis of soil for major plant nutrients (Table 31) revealed that there was no significant difference in nitrogen, phosphorus and potassium contents of soil after the experiment.

Economics of cassava based intercropping system.

The results (Table 32 and Fig. 5) indicated that raising two intercrops of French beans in sequence with cassava planted in paired row system was the most profitable cassava based intercropping system. The intercropping system, in which a single intercrop of French beans was raised with cassava planted in paired rows gave much higher profits compared to groundnut raised as intercrops with cassava planted in paired row system. The intercropping system

FIG. 5. ECONOMICS OF INTERCROPPING IN CASSAVA AS INFLUENCED BY PLANTING GEOMETRY, INTERCROPS AND DOUBLE INTERCROPPING.



in which a single intercrop of groundnut was raised with cassava in ordinary method of planting gave lesser profit compared to the system in which groundnut was raised with cassava in paired row system of planting. Again, the intercropping system in which a single intercrop of French beans was raised with cassava in ordinary method of planting gave higher profit even when compared to groundnut raised with cassava in paired row system of planting.

When considering the economy of intercropping system, all the french bean intercropped treatments recorded higher profits as compared to groundnut and was found to be superior to the cassava intercropping system in which groundnut was raised as intercrop.

Future line of work:

From the present study it is seen that French beans raised as a second intercrop in sequence gave better returns than a single intercrop of groundnut, in a cassava based intercropping system. But, when compared to first intercrop of French beans, the second intercrop of French beans with cassava in paired row system of

planting gave only lesser returns. Though complete filling in of interspace by canopy of cassava was absent at its rank growth stage in cassava planted in paired rows, partial shading caused comparatively poor performance by second intercrop of French beans. Horse gram tried as a second intercrop in this system could not survive due to the shading. Alternative suggestions that may be proposed are reducing the plant population of the second intercrop thus confining the intercrop rows to the central portion of the interspace where shading will be absent and trying other leguminous crops like cowpea as a second intercrop.

Summary

SUMMARY

An experiment was conducted at the College of Agriculture, Vellayani during 1983-84 to study the possibility of raising a second intercrop in sequence, immediately after the harvest of the first intercrop, in a cassava based intercropping system and to identify the most suitable planting geometry.

The experiment with thirteen treatments (six treatments consisting of base crop of cassava in ordinary and paired row methods of planting with and without intercrops of groundnut and french beans during the first season; four treatments consisting of cassava in paired rows intercropped with groundnut followed by French beans, groundnut followed by horsegram, French beans followed by French beans and French beans followed by horsegram in sequence; and three treatments consisting of sole crops of groundnut, French beans and horsegram) was carried out in randomised block design with three replications under rainfed conditions. The results obtained are summarised below.

1. Growth characters of cassava like height, number of functional leaves and total number of leaves were not affected by intercropping throughout the growth of cassava. Only leaf area index showed significantly lower values in intercropped plots after third, nineth and tenth month of planting cassava.

2. Among the various treatments cassava planted in paired rows, with groundnut and french beans as first and second intercrops respectively, recorded the maximum number of tubers per plant. The minimum number off tubers per plant was produced by cassava planted in ordinary method with groundnut as intercrop.

3. No significant variation was observed in the length of tubers of cassava. However, length of tuber was maximum in treatments in which french beans was raised as first intercrop with cassava planted both in paired row system and ordinary method.

4. There was no significant difference in tuber girth of cassava due to treatments. However, the treatments which showed the higher values for length of tubers recorded lower values for girth of tubers.

5. Cassava in paired rows with french beans as intercrop recorded highest tuber yield and it differed significantly from all other treatments.

6. The treatment in which french beans was raised as intercrop with cassava in paired rows gave significantly higher value for top yield of cassava compared to other treatments.

7. There was no significant difference in the utilisation index value due to treatments.

8. Quality attributes like dry matter and crude protein contents of cassava tuber were not significantly influenced by treatments.

9. No significant difference was observed in the nitrogen content of cassava leaf and stem. Phosphorus and potassium contents of leaf, stem and tuber also showed no significant variation.

10. Groundnut intercropped with cassava planted in ordinary method recorded maximum height after 80 and 100 days of planting and at the time of harvest.

11. No significant difference could be observed in the height of French beans (first intercrop) throughout its growth. But French beans raised as second intercrop showed significantly higher values for height, at all stages of growth, compared to the corresponding sole crop of french beans.

12. Highest number of branches was produced by groundnut intercropped with cassava planted in paired rows after 60,80 and 100 days of planting and at harvest. Lowest number of branches at the above stages was produced by groundnut raised in the interspaces of cassava in ordinary method of planting.

13. French beans raised as first intercrop showed no significant difference in the number of branches produced through out its growth, due to treatment effects, while French beans raised as second intercrop produced significantly lower number of branches at all stages of growth, compared to the corresponding sole crop of french beans.

14. Groundnut raised in the interspaces of cassava planted in ordinary method, recorded lowest number of functional leaves per plant after 80 and 100 days of planting and at harvest.

15. With regard to first intercrop of French beans, after 20 days of planting, maximum number of functional leaves per plant was produced by French beans raised with cassava planted in ordinary method. However no significant difference could be observed after 40 and 60 days of planting French beans (first intercrop). French beans raised as second intercrop produced significantly lower number of functional leaves per plant at all stages of growth, compared to the corresponding sole crop of French beans.

16. The sole crop of groundnut recorded highest values for leaf area index at all stages of growth compared to the groundnut intercropped with cassava.

17. No significant difference between treatments with respect to leaf area index of French beans (first intercrop) was observed. However, sole crop of French beans recorded significantly higher values of leaf area index at all stages of growth compared to French beans raised as second intercrops.

18. The maximum number of pods per plant was recorded by pure crop of groundnut and minimum number of pods by groundnut intercropped with cassava planted in ordinary method.

19. The pure crop of groundnut recorded significantly higher value for pod yield. Among the groundnut intercrops, groundnut planted in the interspaces of cassava planted in ordinary method recorded significantly lower value for pod yield.

20. Significantly higher green pod yield was recorded by sole crop of French beans and among French beans raised as first intercrop there was no significant difference in green pod yield. Similarly among French beans raised as second intercrop there was no significant difference in green pod yield and the corresponding sole crop of french beans recorded significantly higher value for green pod yield.

21. Significantly higher bhusa yield was recorded by pure crop of groundnut. However, among groundnut intercrops there was no significant difference with regard to bhusa yield.

22. Sole crop of French beans produced significantly higher bhusa yield compared to all French beans intercrops, while there was no significant difference among the various French bean intercrops, during the first season. Similar results were obtained in the case of sole crop and intercrop of French beans during the second season also.

23. No significant difference was observed with respect to nitrogen, phosphorus and potassium contents of bhusa of groundnut.

24. There was no significant difference due to treatments with respect to nitrogen and phosphorus contents of bhusa of French beans raised as first intercrop. However, maximum potassium content was observed in the bhusa of sole crop of French beans and minimum potassium content in the bhusa of French beans raised in interspaces of cassava planted in ordinary method.

25. Sole crop of French beans recorded significantly higher values for nitrogen and potassium content of bhusa compared to that of French beans raised as second intercrop. However there was no significant difference due to treatments with respect to phosphorus content of bhusa.

26. French beans bhusa was rich in nitrogen and potassium when compared to groundnut bhusa.

27. The bhusa of first intercrops (groundnut and French beans) incorporated larger quantities of nitrogen and potassium into the soil compared to second intercrops of French beans raised after groundnut and French beans respectively. However, with respect to quantity of phosphorus incorporated into soil, bhusa of groundnut recorded higher value compared to bhusa of French beans (both first and second intercrops).

28. The highest values for land equivalent ratio (LER) were recorded by treatments in which French beans were raised as first intercrops with cassava planted in paired rows. The lowest value for LER was recorded by the treatment in which groundnut was raised as intercrop with cassava planted in ordinary method and was significantly inferior to all other treatments.

29. Total nitrogen, available phosphorus and available potassium contents of soil after the experiment were not significantly influenced by any of the treatments.

30. The highest profit (Rs.21175/-) was obtained from the treatment in which two intercrops of French beans were raised in sequence in the interspaces of cassava planted in paired rows.

31. The intercropping system in which a single intercrop of French beans was raised with cassava planted in paired row system, gave much higher profit compared to the one in which groundnut was raised with cassava planted in paired row system.

32. Higher net returns was given by the system in which groundnut was intercropped with cassava planted in paired rows compared to the system in which groundnut was intercropped with cassava planted in ordinary method.

33. The intercropping system in which a single intercrop of French beans was raised with cassava planted in ordinary method gave higher profit even when compared to the system in which groundnut was raised with cassava planted in paired row system.

34. The results indicated that French beans was the most profitable intercrop in cassava.

35. The results also indicated that paired row planting of cassava with two intercrops of French beans raised in sequence in the interspaces was the most profitable system.

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Appendices

APPENDIX - I

Weather data during the crop period in comparison with the corresponding average values for the past 25 years.

Month	Rainfall (mm)		Average temperature °C				Average R.H.(per cent)	
			Maximum		Minimum			
	Crop period (total)	Past 25 years (average)	Crop period	Past 25 years	Crop period	Past 25 Years	Crop period	Past 25 years
June	154.00	307.09	31.30	30.37	23.10	23.86	79.00	85.05
July	121.00	213.20	30.50	29.75	22.90	23.40	83.00	87.19
August	217.20	151.47	28.40	29.78	22.80	23.13	83.00	86.41
September	133.40	153.14	29.40	30.11	23.10	23.24	83.00	85.92
October	50.60	263.91	31.20	29.75	23.40	23.63	79.00	87.49
November	152.30	206.64	30.90	29.99	21.60	23.70	80.00	87.15
December	108.20	67.44	31.20	30.65	23.40	23.09	71.00	84.15
January	35.60	31.91	31.20	30.99	23.60	22.32	73.00	79.47
February	85.00	33.18	32.50	31.29	25.30	22.70	72.00	81.80
March	46.40	18.24	32.20	32.26	23.50	23.26	78.00	84.29
April	191.00	58.28	32.40	32.78	19.20	24.48	75.50	85.12

APPENDIX - II

Abstract of analysis of variance table for the height of cassava at different growth stages.

Source	df	Mean squares				
		1 M.A.P	2 M.A.P	3 M.A.P	4 M.A.P	5 M.A.P.
Block	2	21.100**	610.586**	2960.156**	5814.125**	4019.563**
Treatments	9	3.230	74.651	473.101	369.062	431.431
Error	18	3.060	49.723	221.661	226.465	394.837

Source	df	Mean squares				
		6 M.A.P	7 M.A.P	8 M.A.P	9 M.A.P.	At harvest
Block	2	3526.063**	3333.375**	3273.500**	3348.250**	3337.750**
Treatments	9	284.778	272.125	248.486	251.042	255.194
Error	18	353.278	354.396	355.153	331.903	328.569

M.A.P. - Months After Planting

** - Significant at 1% level

APPENDIX - III

Abstract of analysis of variance table for the total number of leaves of cassava at different growth stages

Source	df	Mean squares				
		1 M.A.P.	2 M.A.P.	3 M.A.P.	4 M.A.P.	5 M.A.P.
Block	2	4.672**	8.945	23.387	324.992**	1590.438**
Treatments	9	0.489	8.221	15.090	73.191	211.191
Error	18	0.548	5.700	7.874	42.353	137.837

Source	df	Mean squares				
		6 M.A.P.	7 M.A.P.	8 M.A.P.	9 M.A.P.	At harvest
Block	2	1722.594**	1758.062**	1614.000**	1535.000**	1405.125**
Treatments	9	220.167	234.417	196.639	191.125	192.583
Error	18	128.924	109.090	103.049	93.694	93.514

M.A.P. - Months After Planting

** - Significant at 1% level

APPENDIX - IV

Abstract of analysis of variance table for the number of functional leaves of cassava at different growth stages.

Source	df	Mean squares				
		1 M.A.P.	2 M.A.P.	3 M.A.P.	4 M.A.P.	5 M.A.P.
Block	2	4.672**	8.945**	23.387	65.232*	391.766**
Treatments	9	0.489	8.221	15.090	27.383	50.056
Error	18	0.548	5.700	7.874	14.759	28.849

Source	df	Mean squares				
		6 M.A.P.	7 M.A.P.	8 M.A.P.	9 M.A.P.	At harvest
Block	2	336.336**	306.523**	197.328**	121.641**	60.002**
Treatments	9	42.837	39.385	24.852	10.122	6.470
Error	18	20.040	18.936	11.606	4.996	3.464

M.A.P. - Months After Planting

* - Significant at 5% level ** - Significant at 1% level

APPENDIX - V

Abstract of analysis of variance table for the leaf area index of cassava of different growth stages.

Source	df	Mean squares				
		1.M.A.P.	2 M.A.P.	3 M.A.P.	4 M.A.P.	5 M.A.P.
Block	2	0.012**	0.053	0.104*	0.918**	0.463**
Treatments	9	0.000	0.020	0.094**	0.059	0.107
Error	18	0.001	0.020	0.023	0.047	0.067

Source	df	Mean squares				
		6 M.A.P.	7 M.A.P	8 M.A.P.	9 M.A.P.	At harvest
Block	2	0.473**	0.409*	0.272**	0.116**	0.028**
Treatments	9	0.145	0.116	0.029	0.027**	0.008**
Error	18	0.071	0.071	0.020	0.005	0.002

M.A.P. - Months After Planting
* - Significant at 5% level
** - Significant at 1% level

APPENDIX - VI

a. Abstract of analysis of variance table for yield attributes and yield of cassava.

Source	df	Mean squares					
		Number of tubers Per plant	Length of tuber	Girth of tuber	Tuber yield	Top yield	Utilisation index
Block	2	0.214**	2.822**	1.081**	22.254**	62.513**	0.156**
Treatments	9	2.395**	0.086	0.249	32.966**	27.440**	0.015
Error	18	0.026	0.074	0.158	0.226	1.743	0.008

b. Abstract of analysis of variance table for quality attributes of cassava

Source	df	Mean squares	
		Dry matter content	Crude protein content
Block	2	14.074**	0.427
Treatments	9	0.211	0.010
Error	18	0.221	0.007

** - Significant at 1% level

APPENDIX-VII

Abstract of analysis of variance table for the distribution of nutrients in cassava.

Source	df	Mean squares							
		Nitrogen		Phosphorus			Potassium		
		Leaf	Stem	Leaf	Stem	Tuber	Leaf	Stem	Tuber
Block	2	0.000	0.008**	0.002**	0.001**	0.000	0.000**	0.000**	0.023
Treatments	9	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.015
Error	18	0.011	0.000	0.000	0.000	0.001	0.000	0.000	0.008

** - Sifnificant at 1 % level

APPENDIX - VIII

a. Abstract of analysis of variance table for the height of groundnut at different growth stages.

Source	df	Mean squares					
		20 D.A.P.	40 D.A.P.	60 D.A.P.	80 D.A.P.	100 D.A.P.	At harvest
Block	2	0.145**	32.410**	39.444**	20.869**	18.938**	15.158*
Treatments	4	0.014	5.133	4.031	24.568**	23.985**	17.798**
Error	8	0.009	1.808	2.688	2.288	1.943	1.754

b. Abstract of analysis of variance table for the height of french beans (first intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.413*	0.421	0.532
Treatments	4	0.004	1.452	0.967
Error	8	0.037	0.858	0.889

c. Abstract of analysis of variance table for the height of french beans (second intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P	40 D.A.P.	60 D.A.P.
Block	2	2.207	4.164*	4.955**
Treatments	2	15.000**	42.250**	39.272**
Error	4	0.472	0.438	0.211

D.A.P. - Days After Planting

* - Significant of 5% level

** - Significant of 1% level

APPENDIX - IX

a. Abstract of analysis of variance table for the number of branches of groundnut at different growth stages.

Source	df	Mean squares					
		20 D.A.P.	40 D.A.P.	60 D.A.P.	80 D.A.P.	100 D.A.P.	At harvest
Block	2	0.181	4.431**	1.800*	0.395	0.342	0.347
Treatments	4	0.069	0.242	1.761*	2.582**	2.443**	2.517
Error	8	0.045	0.297	0.378	0.286	0.281	0.289

b. Abstract of analysis of variance table for the number of branches of french beans (first intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.005	1.029*	0.833
Treatments	4	0.000	0.297	0.259
Errror	8	0.001	0.151	0.196

c. Abstract of analysis of variance table for the number of branches of french beans (second intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.054 *	0.014	0.013
Treatments	2	0.254**	2.781**	1.213**
Error	4	0.007	0.021	0.037

D.A.P. - Days After Planting

* - Significant at 5 % level
** - Significant at 1 % level

APPENDIX - X

a. Abstract of analysis of variance table for the number of leaves of groundnut at different growth stages.

Source	df	Mean squares					
		20 D.A.P.	40 D.A.P.	60 D.A.P.	80 D.A.P.	100 D.A.P.	At harvest
Block	2	3.881	24.756	112.406	93.590	89.980	69.838
Treatments	4	0.858	12.746	34.590	137.758*	128.961*	91.519*
Error	8	1.348	17.460	39.870	29.972	29.156	19.685

b. Abstract of analysis of variance table for the number of leaves of french beans (first intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.052	3.344	2.349
Treatments	4	0.234*	0.476	1.383
Error	8	0.044	2.168	1.468

c. Abstract of analysis of variance table for the number of leaves of french beans (second intercrop) at difference growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.063	2.003*	0.191**
Treatments	2	0.943**	10.583**	2.454
Error	4	0.012	0.147	0.051

D.A.P. - Days after planting

* - Significant at 5% level

** - Significant at 1% level

APPENDIX - XI

a. Abstract of analysis of variance table for the leaf area index of groundnut at different growth stages.

Source	df	Mean squares					
		20 D.A.P.	40 D.A.P.	60 D.A.P.	80 D.A.P.	100 D.A.P.	At harvest
Block	2	0.005*	0.172*	0.177	0.388*	0.395*	0.136*
Treatments	4	0.283**	7.849**	22.992*	10.447**	10.228**	4.476**
Error	8	0.001	0.034	0.045	0.049	0.052	0.020

b. Abstract of analysis of variance table for the leaf area index of french beans (first intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.AP.	60 D.A.P.
Block	2	0.003*	0.029*	0.002
Treatments	4	0.001	0.011	0.002
Error	8	0.001	0.004	0.001

c. Abstract of analysis of variance table for the leaf area index of french beans (second intercrop) at different growth stages.

Source	df	Mean squares		
		20 D.A.P.	40 D.A.P.	60 D.A.P.
Block	2	0.000	0.000*	0.001
Treatments	2	0.005**	0.123**	0.111**
Error	4	0.000	0.000	0.000

D.A.P. - Days after Planting

* - Significant at 5% level

** -

APPENDIX - XII

a. Abstract of analysis of variance table for the pod number of groundnut and yield of groundnut and french beans (first intercrop).

Source	df	Mean squares				
		Groundnut			French beans (first intercrop)	
		Number of Pods	Pod yield	Bhusa yield	Green pod yield	Bhusa yield
Block	2	27.406*	6338.000**	4351232.051	740992.021	1528736.114
Treatments	4	34.882**	1199109.439**	675497436.523**	32268078.327**	3870223.999**
Error	8	3.587	243.250	1455552.005	393560.009	393416.004

b. Abstract of analysis of variance table for yield of french beans (second intercrop).

Source	df	Mean squares	
		Green pod yield	Bhusa yield
Block	2	68112.006	301535.987**
Treatments	2	132110059.261**	11452127.695**
Error	4	50520.005	9000.000

* - Significant at 5% level

** - Significant at 1% level

APPENDIX - XIII

a. Abstract of analysis of variance table for the distribution of nutrients in the bhusa of groundnut and french beans (first intercrop).

Source	df	Mean squares					
		Groundnut			French beans (first intercrop)		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Block	2	0.000	0.000	0.000	0.023*	0.000	0.004
Treatments	4	0.001	0.000	0.003	0.012	0.000	0.011*
Error	8	0.004	0.000	0.004	0.004	0.000	0.002

b. Abstract of analysis of variance table for the distribution of nutrients in the bhusa of french beans (second intercrop).

Source	df	Mean squares		
		Nitrogen	Phosphorus	Potassium
Block	2	0.015*	0.000	0.003*
Treatments	2	0.019*	0.000	0.009**
Error	4	0.001	0.000	0.000

* - Significant at 5% level

** - Significant at 1% level

APPENDIX - XIV

Abstract of analysis of variance table for the quantity of nutrients incorporated into the soil by bhusa of intercrops.

Source	df	Mean squares		
		Nitrogen	Phosphorus	Potassium
Block	2	72.100*	0.994**	37.964
Treatments	9	33.663*	1.358**	49.241*
Error	18	13.464	0.158	13.770

*-Significant at 5% level

** - Significant at 1 % level

APPENDIX - XV

Abstract of analysis of variance table for Land Equivent Ratio (LER).

Source	df	Mean squares
Block	2	0.013*
Treatments	7	0.144**
Error	14	0.003

* - Significant at 5% level

** - Significant at 1% level

APPENDIX - XVI

Abstract of analysis of variance table for total nitrogen, available phosphorus and available potassium content of the soil after the experiment.

Source	df	Mean squares		
		Total Nitrogen	Available Phosphorus	Available potassium
Block	2	0.000**	7.093**	2.903**
Treatments	9	0.000	0.076	0.347
Error	18	0.000	0.136	0.347

** - Significant at 1% level

PLANTING GEOMETRY AND DOUBLE INTERCROPPING IN CASSAVA

BY

BIJU.L.

ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

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ABSTRACT

An experiment was conducted at the College of Agriculture, Vellayani, during 1983-84 to study the possibility of raising a second intercrop in sequence in a cassava based intercropping system and to identify the most suitable planting geometry. The experiment with thirteen treatments was carried out in RBD with three replications under rainfed conditions.

Among the growth characters of cassava only leaf area index showed significantly lower values in intercropped plots at certain stages of growth.

Among the yield attributes only number of tubers per plant was influenced by planting geometry and intercrops. Though the above practices influenced tuber yield and top yield, utilisation index was not affected by treatments.

Dry matter and crude protein contents of tubers and distribution of nutrients in cassava remained unaffected by the treatments.

Leaf area index in groundnut and height, number of branches, number of functional leaves and leaf area index

in French beans raised as second intercrop were influenced significantly by spatial arrangements at all stages of growth.

Pod number and Pod yield of groundnut and green pod yield of French beans were affected by spatial arrangements.

Spatial arrangements had no effect on the distribution of nitrogen, phosphorus and potassium in the bhusa of groundnut and nitrogen and phosphorus in the bhusa of French beans (first intercrop) and phosphorus in the bhusa of French beans (second intercrop). However, potassium content in the bhusa of French beans (first intercrop) and nitrogen and potassium contents in the bhusa of French beans (second intercrop) were affected by spatial arrangements.

The bhusa of first intercrops (groundnut and French beans) incorporated larger quantities of nitrogen and potassium into the soil compared to second intercrops (French beans). Bhusa of groundnut (first intercrop) incorporated larger quantities of phosphorus into the soil compared to bhusa of French beans (both first and second intercrops).

No significant difference was observed on the total nitrogen, available phosphorus and potassium contents of the soil after the experiment.

The treatments in which French beans were raised as first intercrops with cassava in paired rows recorded highest values for land equivalent ratio, and the treatment in which groundnut was raised as intercrop with cassava in ordinary method recorded lowest value for LER.

The highest profit was obtained from the treatment in which two intercrops of French beans were raised in sequence in the interspaces of cassava in paired rows.

The results indicated that French beans was the most profitable intercrop in cassava.