INTEGRATED NUTRIENT MANAGEMENT FOR SHORT DURATION CASSAVA IN LOWLANDS

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DECLARATION

I hereby declare that this thesis entitled **"Integrated nutrient management for short duration cassava in lowlands"** 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 of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani
25-10-2003

PAMILA VIMAL RAJ

CERTIFICATE

Certified that this thesis entitled **"Integrated nutrient management for short duration cassava in lowlands"** is a record of research work done independently by Ms. Pamila Vimal Raj under my guidance and supervision and that it has not previously formed the basis for the reward of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

%	Per cent
@	At the rate of
°C	Degree celsius
ANOVA	Analysis of variance
BCR	Benefit cost ratio
Ca	Calcium
CPC	Coir pith compost
CD	Critical difference
cm	Centimetre
CTCRI	Central Tuber Crops Research Institute
$d\ S\ m^{-1}$	Deci Siemens per metre
et al.	And others
Fig.	Figure
FYM	Farmyard manure
g	Gram
ha^{-1}	Per hectare
K	Potassium
KAU	Kerala Agricultural University
kg	Kilogram
LAI	Leaf area index
MAP	Months after planting
Mg	Magnesium
N	Nitrogen
P	Phosphorous
PM	Poultry manure
POP	Package of practices
Rs.	Rupees
S	Sulphur
t	Tonne
UI	Utilization index
TDMP	Total dry matter production
$\mu g\ g^{-1}$	Micro gram per gram
var.	Variety
Zn	Zinc

INTRODUCTION

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) popularly known as tapioca is one of the world's most important staple food crop. It ranks sixth among the major contributors of food in the world, the others being wheat, rice, maize, potato and barley (Ghosh *et al.*, 1988). Approximately 60 per cent of the world's cassava production is used as human food serving as an important staple food for more than 500 million people (Mohankumar *et al.*, 2000). It is a native of Brazil in Latin America and was introduced to India (Kerala) by the Portuguese in the 17th century. Among the different tropical root and tuber crops grown in India, cassava is of significance since it can produce more calories per unit area per unit time. Its importance in tropical agriculture is due to its drought tolerance and wide flexibility to adverse soil, nutrient and management conditions including time of harvest.

The cropping pattern scenario has witnessed change especially in Kerala where plantation crops have started gaining prominence in uplands. Kerala being a food deficit state, cassava assumes importance as supplementary food item and thus provides food security and avoids drain in our economy for import of rice. Besides, cassava holds promise as animal feed and as raw material for industries. But cassava area under traditional upland rainfed situation is declining gradually in Kerala. On the other hand, the area under lowland situation is increasing with the gradual replacement of rice by cassava. Due to the high cost of labour, and lack of timely availability of labour, the farmer has replaced rice with cassava in lowlands. Short duration varieties of cassava are being grown continuously or rotated with banana and vegetables in such lands. Thus there is a need to develop management strategy for cassava in lowland production system.

There are many promising local short duration varieties like Kantharipadappan and Kariyilapothiyan with good cooking quality. There are also early maturing, high yielding varieties like Sree Jaya and Sree Vijaya released from Central Tuber Crops Research Institute (CTCRI) and Nidhi and Kalpaka released from Kerala Agricultural University (KAU). Of these, Sree Vijaya is a selection from indigenous germplasm collection from Kottayam district. It is an early maturing variety (6-7 months) suited for lowlands with excellent cooking quality (CTCRI, 1998a).

An integrated nutrient supply is highly essential to realize higher crop yields as well as to maintain soil productivity. But there is no such Package of Practices (POP) by KAU for short duration varieties of cassava in lowlands. Differential response to nitrogen (N) application was observed for different short duration varieties of cassava which necessitated standardization of N levels. Farmyard manure (FYM) is the most commonly used organic manure. Inadequate availability of FYM has led us to think of alternate sources of organic manure. Poultry manure (PM) is also largely used by cassava farmers especially in lowlands. Coir pith, a byproduct of coir industry can also be used as a potential organic manure after composting with *Pleurotus* sp. This will help to avoid environmental pollution caused by these organic materials.

Keeping these views under consideration, the present investigation entitled, "Integrated nutrient management for short duration cassava in lowlands" was undertaken to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

In Kerala, cassava is being increasingly cultivated in lowlands with gradual replacement of rice. But there is no POP recommendation for nutrient management of short duration varieties of cassava in lowlands. Also the scarcity of FYM, the commonly used organic manure, has led us to think of alternate sources of organic manure. The literature collected on the effect of different organic manures, N levels and integrated nutrient management for cassava in traditional uplands is reviewed hereunder. Wherever pertinent information is lacking in cassava, results of such studies conducted on other related crops are also cited.

2.1. EFFECT OF ORGANIC MANURES

Organic materials are valuable byproducts of farming and allied industries, derived from plant and animal sources. The living phase of the soil is greatly stimulated by the addition of organic materials in the soil. The augmented microbial population helps in organic matter decomposition, N fixation, P solubilization and increases the availability of plant nutrients (Allison, 1973). Addition of organic manures increased the status of organic carbon and available N, P and K status of soil (Srivastava, 1985 and More, 1994).

Organic manure serves as slow release source of N, P and S for plant nutrition and microbial growth. It possess considerable water holding capacity, acts as buffer against changes in pH of the soil and cements clay and silt particles together contributing to crumb structure of the soils. It also binds micronutrient metal ion in the soil that otherwise might be leached out (Rammohan *et al.*, 2002).

Traditionally cassava is fertilized only with organic manures such as FYM and wood ash and even today this is followed by subsistence farmers. This may be of particular importance in sandy soils to improve water and nutrient holding capacity (Mohankumar *et al.*, 2000). Cassava responds to both bulky and concentrated organic manures (Thampan, 1979).

2.1.1. Effect of farmyard manure

Farmyard manure, the most commonly used organic manure is a good source of both macro and micro nutrients. It has both direct and residual effects in plant nutrition .

2.1.1.1. Growth characters

Application of FYM @ 12.5 t ha^{-1} to cassava gave better response in terms of growth characters (Asokan and Sreedharan, 1977).

In a study conducted by Veenavidyadharan (2000) in arrow root revealed that plant height, number of leaves per plant, sucker number per hill and dry matter production were increased by the highest level of FYM tried (20 t ha^{-1}). FYM was found to be the best organic manure for the highest dry matter production irrespective of growth stages of coleus (Archana, 2001).

Increasing rates of FYM increased plant height but had inconsistent effect on the number of main stem per hill in potato (Wildjajanto and Widodo, 1982). Sahota (1983) found that FYM application increased plant height and number of leaves per plant in potato.

2.1.1.2. Yield components and yield

Saraswat and Chettiar (1976) recorded an yield of 32 t ha^{-1} when 66.6 % of N requirement was met by FYM application. Cassava yield was increased over control by 11.8 % when FYM was applied (Gaur *et al.*, 1984). Studies conducted at CTCRI and KAU revealed that basal application of FYM @ 12.5 t ha^{-1} enhanced the yield of cassava (Mohankumar *et al.*, 1976; Ashokan and Sreedharan, 1977; Pillai *et al.*, 1987 and Ravindran and Balanambisan, 1987). KAU (2002) also recommends 12.5 t ha^{-1} of FYM for cassava.

Application of FYM @ 20 t ha^{-1}produced significantly superior tuber yield in *Dioscorea alata* (CTCRI, 1973). But Mohankumar and Nair (1979) suggested that yield increase obtained by the application of FYM @ 20 t ha^{-1} over lower doses (10-15 t ha^{-1}) was not sufficient to compensate the increased cost of FYM and hence 10 t ha^{-1} of FYM is recommended for *Dioscorea alata* to obtain economic returns.

Experiments conducted in Karnataka to find out the response of sweet potato to FYM showed 30.6 % increase over control (Gaur *et al.*, 1984). Studies conducted at CTCRI revealed that basal application of 5 t ha^{-1} of FYM to sweet potato was beneficial in enhancing the yield (Pillai *et al.*, 1987 and Ravindran nd Balanambisan, 1987). The presence of FYM enhanced tuber yield both under lowland and upland situations indicating that FYM is essential for higher tuber production in sweet potato (Ravindran and Balanambisan, 1987).

Application of FYM alone resulted in higher yields in elephant foot yam (Patel and Mehta, 1987).

Maheswarappa *et al.* (1997) found that application of FYM resulted in significantly higher harvest index and number and length of rhizomes in arrow root. Veenavidyadharan (2000) also reported the profound influence of FYM on the number of rhizomes per plant and yield of arrowroot.

Farmyard manure as the source of organic manure for coleus had positive influence on yield and yield components like number and weight of tubers and weight of marketable tubers per plant, as observed by Archana (2001).

2.1.1.3. Quality characters

Kurien *et al.* (1976) found that application of cowdung alone to cassava resulted in an increase in bitterness and cyanogen content of tubers. But a mixture of cowdung and ash tended to reduce cyanogens.

Application of FYM @ 12.5 t ha^{-1} enhanced the quality of cassava tubers as reported by Mohankumar *et al.* (1976) and Pillai *et al.* (1987).

Ravindran and Balanambisan (1987) observed that quality of tubers in sweet potato was not much affected by different doses of FYM.

2.1.2. Effect of coir pith compost

Coir pith is abundantly available in Kerala as a byproduct of coir industry. It is a light fluffy refuse obtained during the separation of coir fibre from coconut husk. This can be used as an organic manure after narrowing down its C:N ratio with *Pleurotus* sp.

Coir pith compost (CPC) has beneficial effect as an organic manure in increasing the yield of crops like turmeric (Selvakumari *et al.*, 1991). But Maheswarappa *et al.*, (1997) observed that application of CPC produced lower values of growth characters, yield and yield components, quality parameters and nutrient uptake by arrow root. Similar effect of CPC was also observed by Archana (2001) in coleus. However, Suja (2001) found that tuber quality of white yam in terms of starch and crude protein contents were markedly improved by CPC application.

Suhurban *et al.* (1997) reported that in a pot culture experiment with bhindi, maximum yield was recorded by the treatment CPC alone followed by the treatment with half the recommended dose of N as coir pith and half as fertilizer. But Arunkumar (2000) reported that amaranthus performed inferior with respect to growth characters like number of leaves and number of branches when CPC was used as organic manure but DMP was superior.

2.1.3. Effect of poultry manure

Poultry manure is another organic manure which is commonly used by farmers especially in lowlands. It is a bulky organic manure which can replace FYM. Singh *et al.*, (1973) attributed the higher efficiency of PM to its narrow C:N ratio and comparatively higher content of mineralizable N. In this manure, 60 % of N is present as uric acid, 30 % as more stable organic N forms and balance as mineral N (Srivastava, 1988). When entire quantity of PM is applied as basal, more than 60 % of its N present as uric acid rapidly changes to ammoniacal form.

Singh *et al* (1973) reported that PM application exhibited better response, than FYM, in yield and growth attributes of potato.

Mina (1986) reported that application of PM alone or in combination with NPK fertilizer mixture, irrespective of the rates, significantly increased the yield of musk melon.

2.1.4. Comparison of different organic manures

Higher efficiency of FYM in producing higher yield of cassava compared to castor oilcake and urea was revealed by Gomes *et al.* (1983). But Ayyaswami *et al.* (1996) observed significant increase in tuber yield due to incorporation of coir waste @ 10 t ha^{-1} compared to FYM @ 12.5 t ha^{-1} and coir waste @ 5 t ha^{-1}. The positive effect of coir waste on yield might be due to its water holding capacity and better nutrient uptake by the crop.

Field experiments undertaken at CTCRI (CTCRI, 1998b) to study the possibility of substituting FYM in cassava production with recently available organic manures like pressmud and CPC indicated that there was no conspicuous yield variation among the various organic manures suggesting the suitability of pressmud or CPC as alternative to FYM for cassava depending upon availability.

According to Maheswarappa *et al.* (1997), application of FYM and vermicompost recorded significantly higher yield of arrowroot compared to CPC application. In general, CPC was found inferior to other organic manures in its effects on growth, yield and quality of arrowroot. Similar results were also reported by Archana (2001) in coleus. CPC as the organic manure recorded lower values of yield components of coleus. The highest tuber yield was produced by FYM and the lowest by CPC. Net income and BCR were maximum when FYM was used as the organic manure. CPC recorded the lowest net income.

Growth response of white yam to various organic manures (Suja, 2001) indicated that application of CPC favoured crop growth condition by producing longer plants and retaining more number of leaves. Higher dry matter accumulation in leaves, vines, tubers and thereby in the whole plant were obtained due to CPC application. Maximum LAI was also obtained in the plot that received CPC. FYM and CPC had similar effects in promoting bulking rate.

weight, length and girth of tubers of white yam. There was no conspicuous variation in tuber yield among FYM and CPC which implies the suitability of CPC as alternative to FYM.

Incorporation of 10 t ha^{-1} of FYM into soil one day prior to transplanting gave the highest fruit yield of tomato (19 t ha^{-1}) followed by 20 t ha^{-1} of coir pith (16 t ha^{-1}) and the lowest in the control plot (11.5 t ha^{-1}) which were treated with neither FYM nor coir pith (Ahmed, 1993).

Anitha (1997) reported that in chilli, various growth attributes like plant height, number of branches and DMP were better with PM application as compared to FYM and vermicompost. PM treated chilli plants showed better yield and yield attributing characters as compared to FYM and vermicompost application.

Joseph (1998) observed that growth characters and yield attributing characters of snakegourd were higher in FYM treated plants as compared to PM or vermicompost treated plants. But PM treated plants recorded the highest crude protein content and the lowest fibre content.

Among the different organic manures like vermicompost, neemcake, CPC, FYM and PM tried in amaranthus, FYM and vermicompost performed better in terms of plant height, number of leaves, number of branches and leaf area index (Arunkumar, 2000). Higher yields were obtained from 100, 125 and 150 per cent levels of FYM, vermicompost, PM and neemcake. CPC treatments recorded maximum fibre content but protein and moisture contents were superior.

2.2. EFFECT OF NITROGEN

2.2.1. Growth characters

Higher levels of N invariably favoured the vegetative growth of the plant. Significant increase in plant height, leaf number and leaf retention due to higher rates of N application was reported by Mandal *et al.* (1971). According to Natarajan (1975), N upto 150 kg ha^{-1} enhanced plant height in cassava. Pillai and George (1978) observed increase in plant height and weight in response to higher levels of N in cassava var. M4. Ramanujam and Indira (1979) reported that the rate of leaf production was high under higher levels of N and would produce about 10-12 functional leaves per plant per week. Similar increase in leaf production with incremental dose of N was noticed by Prabhakar *et al.* (1979). Nair (1982), studying the influence of three levels of N (50, 125 and 200 kg ha^{-1}), recorded maximum plant height, number of nodes and number of functional leaves at 200 kg N ha^{-1}. But enhancement in leaf area was attained only upto 125 kg N ha^{-1}.

Increased rates of N application increased the plant height, nodes per plant, functional leaves per plant and leaf area index of cassava when intercropped in coconut garden (Nayar, 1986).

2.2.2. Yield components and yield

There are conflicting reports on the effects of higher levels of N on the yield components of cassava. Vijayan and Aiyer (1969) found that mean number of tuber per plant increased with increase in N application in cassava varieties, M-4 and H-165. Nair (1982) also observed that increase in N level caused significant increase in number and weight of tuber. But Natarajan (1975) and

Ashokan and Sreedharan (1980) stated that N nutrition had no significant effect on yield attributes of cassava.

Increase in tuber yield in response to higher rates of N application in cassava had been reported by many research workers. On acid laterite soils of Kerala, Mandal *et al.* (1971) obtained the highest yield with 100 kg N ha^{-1}. Saraswat and Chettiar (1976) obtained the most economic level of N for maximum tuber production in hybrid was 80 kg ha^{-1} and for local varieties, 40 kg ha^{-1} (Mohankumar and Mandal, 1977). However, the optimum dose was found to vary with location and varieties. According to Ashokan and Sreedharan (1980), cassava responded upto 180 kg N ha^{-1} in sandy loam soils of North Kerala. Studies by Nair (1982) revealed that the high yielding hybrid cassava, Sree Sahya produced significantly higher tuber yield at 125 kg N ha^{-1}.

2.2.3. Quality characters of tuber

Many research workers have reported the beneficial effect of N nutrition in increasing the starch content of cassava tubers (Mandal *et al.*, 1971; Natarajan, 1975; Pillai and George, 1978). However Vijayan and Aiyer (1969) noted a decrease in starch content of tubers with increase in N beyond 75 kg ha^{-1}. Starch content of tuber was not affected by N levels according to Muthuswamy and Rao (1979).

Increase in HCN content of tuber due to increase in N application has been reported by Vijayan and Aiyer (1969), Nair (1982) and Ashokan *et al.* (1988).

2.3. EFFECT OF INTEGRATED NUTRIENT MANAGEMENT

Integrated nutrient management practices will restore, enhance and sustain the productivity of the farm soils even under intensive commercial farming (Badanur and Bellakki, 1997). Studies have shown that combination of organic manure with inorganic fertilizer had a moderating effect on soil reaction particularly under acidic soils and improvement in sustained availability of N, P, K and S and the micronutrients particularly Zn (Nambiar and Abrol, 1989). Organic sources, when applied with chemical fertilizers, improved the efficiency of the latter due to the favourable effects on physical and biological properties of the soil (Singh, 2001)

It was observed that application of 12.5 t ha^{-1} of FYM and 100 kg each of N, P_2O_5 and K_2O ha^{-1} produced the highest tuber yield (Mandal *et al.*, 1973). Similar findings were reported by Mohankumar *et al.*, 1976 and Pillai *et al.*, 1987. Mohankumar *et al.* (1976) observed that the effect of fertilizers and FYM on tuber production was additive. Neither FYM nor any of the nutrients (N, P or K) applied individually could increase yield by more than 4 t ha^{-1} but the combined use of NPK + FYM produced a response four times higher.

Continuous cropping of cassava with only chemical fertilizers decreased the levels of Ca, Mg, Zn and Cu in the soil and lowered the pH (George *et al.*, 2001). Combined application of FYM and NPK fertilizers increased the availability of N, P and K in the soil. Application of FYM alone or in combination with inorganic fertilizers was found to increase the organic carbon status in the soil. The results clearly indicate the need for organic manure application to the soil along with inorganic fertilizers.

For sweet potato under lowland conditions, the combination of FYM @ 10 t ha^{-1} and 75:50:75 kg NPK ha^{-1} recorded maximum yield (19.6 t ha^{-1}) which was significantly superior to control (8.33 t ha^{-1}) and on par with the combination of 5 t ha^{-1} of FYM + 50:25:50 kg NPK ha^{-1} which yielded 17.5 t ha^{-1} of tubers (Ravindran and Balanambisan, 1987).

Nutrient management studies on amorphophallus conducted at CTCRI (CTCRI, 1992) revealed that maximum corm yield, the highest dry matter production as well as the highest nutrient uptake was recorded for the treatment NPK @ 100:50:100 kg ha^{-1} + FYM @ 25 t ha^{-1} than lower levels of N, P and K with and without FYM.

Maheshwarappa *et al.* (1997) noticed that combined application of FYM and NPK fertilizers resulted in highest yield of arrowroot intercropped in coconut garden. Reduction in yield with FYM applied alone was 16.4 to 17.9 %, with NPK alone was 26.9 % and with control was 63.7 % compared to FYM + NPK treatment (Maheshwarappa *et al.*, 1999). Increased yield of arrowroot intercropped in the coconut garden due to combined application of FYM and NPK fertilizers was also reported by Veenavidyadharan (2000).

Preliminary investigation at CTCRI (CTCRI, 2000) indicated that for realizing maximum tuber yield of white yam, both organic manures and inorganic fertilizers were highly inevitable. Application of organic manure alone without chemical fertilizers depressed tuber yield significantly.

According to Suja (2001), application of organic manures like FYM or CPC alone produced lower yields of white yam which resulted in negative net returns and the lowest BCR. Application of CPC @ 5 t ha^{-1} along with 80:60:80 kg NPK ha^{-1} or FYM @ 10 t ha^{-1} along with 80:60:120 kg NPK ha^{-1} produced higher tuber yield of white yam besides generating higher net income and BCR.

Review of literature emphasizes the need for integrated use of organic manure and inorganic fertilizers for achieving higher yields of cassava. In all the studies, whether in upland or lowland, a dose of 12.5 t ha^{-1} of FYM was found beneficial. KAU (2002) also recommends the application of cattle manure or compost @ 12.5 t ha^{-1} for cassava. But we are faced with the problem of availability of sufficient quantity of FYM which necessitates to explore the possibility of substituting FYM with other organic manures like PM, CPC, vermicompost or oilcakes.

A scan of literature also indicates that the response of cassava to fertilizers varies with duration of varieties. Higher yields of short duration varieties of cassava in the uplands of Kuttanad were observed with a NPK dose of 50:50:100 kg ha^{-1} (KAU, 1991). In a rice based cropping system in uplands, Mohankumar *et al* (1996) have recommended a fertilizer dose of 100:25:100 kg NPK ha^{-1} for Sree Prakash, a short duration variety of cassava. CTCRI (1998a) recommends a fertilizer dose of 75:50:100 kg NPK ha^{-1} for the var. Sree Vijaya. KAU (2002) recommends 50:50:50 kg NPK ha^{-1} for the var. M-4 and local varieties, 75:75:75 kg NPK ha^{-1} for the varieties H-97 and H-226 and 100:100:100 kg NPK ha^{-1} for the varieties H-165, Sree Visakham and Sree Sahya. But there is no POP recommendation for short duration varieties of cassava in lowlands. Hence the present investigation was undertaken to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was undertaken to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation. The materials used and the methods adopted for the study are presented in this chapter.

3.1. MATERIALS

3.1.1. Experimental site

The investigation was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani. The college is located at 8.5° N latitude and 76.9° E longitude at an altitude of 29 m above mean sea level.

3.1.2. Soil

The soil of the experimental site is commonly known as brown hydromorphic soil and belongs to the taxonomic class of fine kaolinite isohyperthermic Tropic Fluvaquent. The important physical and chemical properties of the soil are given in Table1. The soil was sandy clay loam in texture and acidic with a pH of 4.4. It had a low cation exchange capacity of 4.5 c mol kg^{-1}. It was medium in organic carbon, low in available N and medium in available P and K contents.

3.1.3. Cropping history of the experimental site

The experimental area was lying fallow for the previous three months after the harvest of a bulk crop of banana.

Table1. Soil characteristics of the experimental field

Characteristics	Value	Method
Mechanical composition		
Clay	27.8 %	International pipette method (Piper, 1966)
Silt	21.4 %	
Finesand	19.2 %	
Coarse sand	31.6 %	
Textural class	Sandy clay loam	
pH	4.4	pH meter with glass electrode (Jackson, 1973)
Electrical conductivity	< 0.05 d S m^{-1}	Conductometry (Jackson, 1973)
Cation exchange capacity	4.5 c mol kg^{-1}	Neutral normal ammonium acetate method (Scholenberger and Dreibelbis, 1930)
Organic Carbon	0.61 %	Wet oxidation method (Walkley and Black, 1934)
Available N	235.20 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5	40.47 kg ha^{-1}	Bray's colorimetric method using ascorbic acid (Bray and Kurtz, 1945)
Available K_2O	138.84 kg ha^{-1}	Neutral normal ammonium acetate method (Hanway and Heidal, 1952)

3.1.4. Season

The investigation was conducted from September 2002 to April 2003. The crop was planted on 26th September and harvested on 24th April 2003.

3.1.5. Weather conditions

Vellayani enjoys a tropical humid climate. Data on maximum and minimum temperatures, relative humidity, rainfall and evaporation during the entire crop season are collected and presented as weekly averages in Appendix I and Fig.1.

3.1.6. Planting material

The short duration varieties used were Sree Vijaya, a high yielding variety released from CTCRI, Sreekariyam, Thiruvananthapuram and Kariyilapothiyan, a local variety with good cooking quality. Sree Vijaya is a selection from indigenous germplasm collection from Kottayam district and is an early maturing variety (6-7 months) suited to lowlands with excellent cooking quality (CTCRI, 1998a). The stems of Sree Vijaya were obtained from CTCRI, Sreekariyam, Thiruvananthapuram and that of Kariyilapothiyan were purchased locally.

3.1.7. Manures and Fertilizers

The organic manures used were FYM containing 0.4 % N, 0.3 % P_2O_5, and 0.3 % K_2O; PM containing 1.0 % N, 1 % P_2O_5 and 0.8 % K_2O and CPC containing 0.83 % N, 0.06 P_2O_5 and 1.1 % K_2O. The fertilizers used were urea (46 % N), Rajphos (20% P_2O_5) and muriate of potash (60 % K_2O).

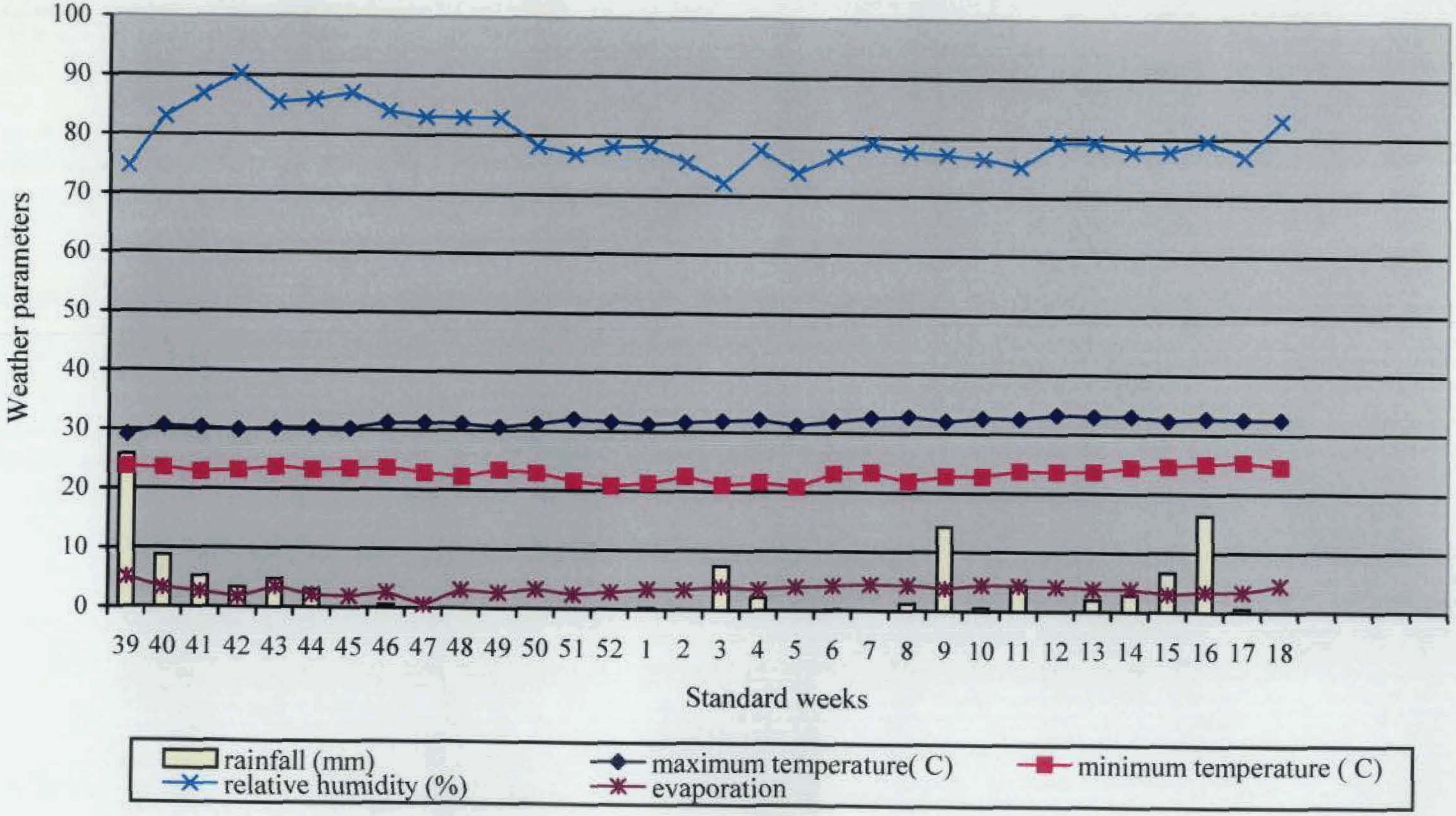

Fig. 1. Weather parameters during the crop growth period

3.2. METHODS

3.2.1. Details of treatments

The treatments consisted of factorial combinations of two varieties of cassava, three sources of organic manure and three levels of nitrogen.

1. Varieties (V)

   v_1 - Sree Vijaya

   v_2 - Kariyilapothiyan

2. Sources of organic manure (M)

   m_1 - FYM

   m_2 - Poultry manure (PM)

   m_3 - Coir pith compost (CPC)

3. Nitrogen levels (N)

   n_1 - 50 kg N ha^{-1}

   n_2 - 75 kg N ha^{-1}

   n_3 - 100 kg N ha^{-1}

The doses of organic manures were fixed to supply N present in 12.5 t ha^{-1} of FYM (KAU,2002). A uniform dose of 50 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} was applied to all plots.

Treatment combinations

$v_1m_1n_1$	$v_2m_1n_1$
$v_1m_1n_2$	$v_2m_1n_2$
$v_1m_1n_3$	$v_2m_1n_3$
$v_1m_2n_1$	$v_2m_2n_1$
$v_1m_2n_2$	$v_2m_2n_2$
$v_1m_2n_3$	$v_2m_2n_3$
$v_1m_3n_1$	$v_2m_3n_1$
$v_1m_3n_2$	$v_2m_3n_2$
$v_1m_3n_3$	$v_2m_3n_3$

3.2.2. Experimental design and layout

The field experiment was laid out in a 3^2 x 2 asymmetrical confounded factorial design confounding VMN in Replication I and MN in Replication II.

The procedure followed for the allocation of various treatments to different plots was in accordance with Yates (1937). The lay out plan is depicted in Fig.2.

The details of the lay out are furnished below.

Treatment combinations	:	18
Replications	:	2
No.of blocks per replication	:	3
No.of plots per block	:	6
Gross plot size	:	4.5 x 4.5 m
Net plot size	:	2.7 x 2.7 m
Spacing	:	90 x 90 cm

3.2.3. Details of cultivation

3.2.3.1. Field preparation

The experimental area was dug twice and weeds and stubbles were removed. The field was laid out into blocks and plots. Dried and powdered FYM, PM and CPC were applied to the plots as per the treatment schedule and then mounds were taken in each plot.

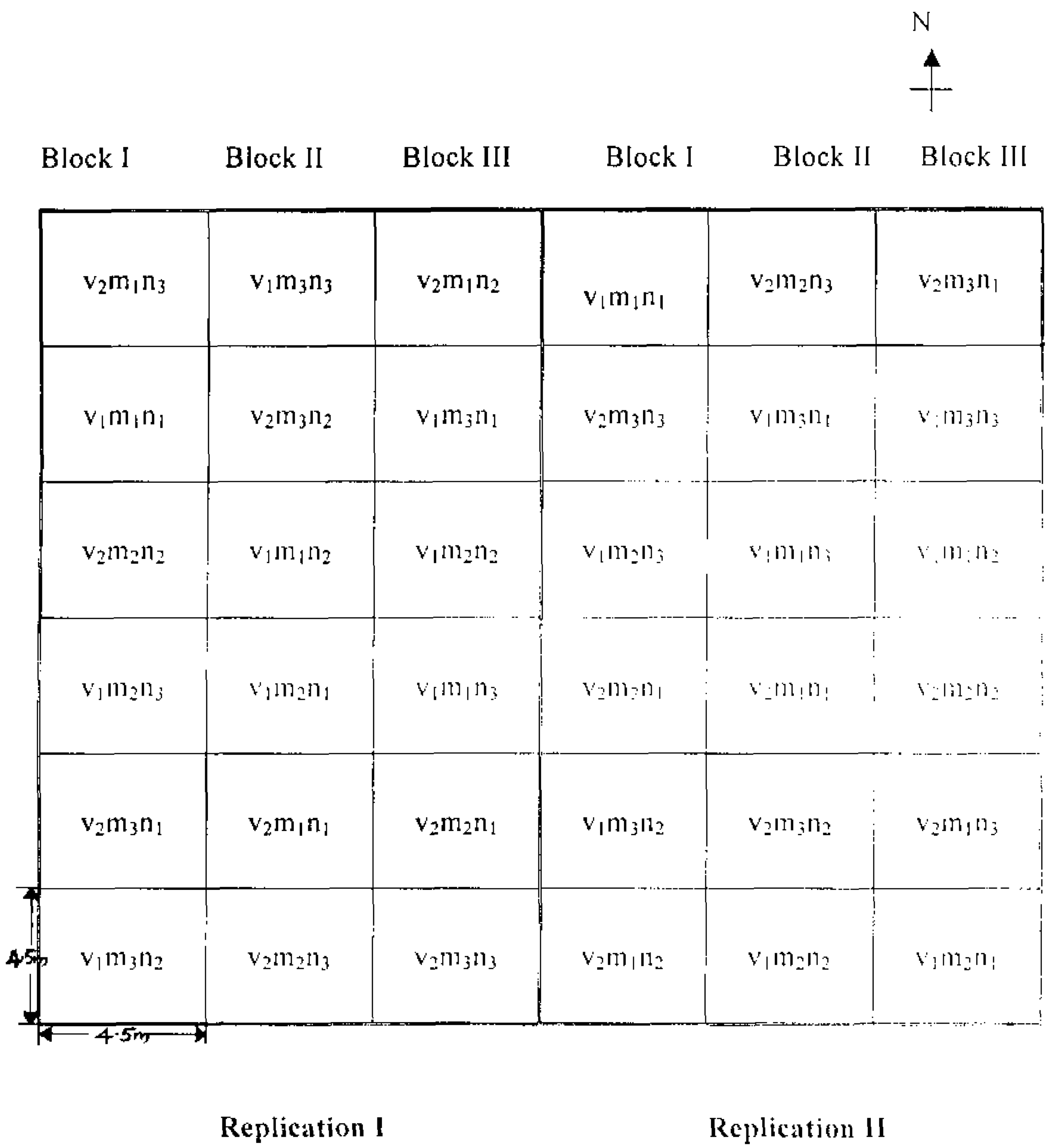

Fig. 1. Layout plan of the experiment

3.2.3.2. Fertilizer application

The different nutrients N, P and K were applied to the plots in the form of urea, Rajphos and muriate of potash respectively in appropriate quantities according to the treatment schedule. Full dose of P and half dose each of N and K were applied as basal dose. Half each of N and K were applied 45 days after planting.

3.2.3.3. Planting

Setts of about 20 cm length were cut from the stems. The setts were planted on the top of the mounds taken at a spacing of 90 x 90 cm, inserting 4 cm of setts below soil.

3.2.3.4. After cultivation

Dried and unsprouted setts were removed and gap filling with setts of longer size (about 40 cm) was done ten days after planting. Excess sprouts were removed one month after planting (MAP) after retaining two healthy sprouts. Shallow digging and weeding were done 45 days after planting along with top dressing of the fertilizers followed by light earthing up. A light raking, second weeding and earthing up were done two months later.

3.2.3.5. Harvest

The crop was ready for harvest at about seven months after planting. Harvesting was done by digging out the tubers and pulling out the stem. The tubers were separated from the shoot. The border rows and sample plants were harvested separately from each plot. The tubers and shoot portions from the net plot were weighed separately and the weights were recorded.

3.3. BIOMETRIC OBSERVATIONS

Single line of plants all round in each plot were left out as border rows. Three plants remaining diagonally in the same direction were selected at random, from each net plot as sample plants for taking biometric observations. Average of the observations were used for statistical analysis.

3.3.1. Growth characters

3.3.1.1. Height of the plants

Height of the tallest of stem of each plant was measured from the base of the sprout to the terminal bud at bimonthly intervals.

3.3.1.2. Total number of leaves per plant

The total number of leaves were recorded at bimonthly intervals by counting the number of fully opened leaves as well as the leaf scars from the base to the tip of both the stems.

3.3.1.3. Number of functional leaves per plant

The number of fully opened leaves present in the plant at each observation was counted at bimonthly intervals.

3.3.1.4. Leaf area index (LAI)

The total leaf area of each sample plant was calculated at bimonthly intervals adopting the non-destructive method suggested by Ramanujam and Indira (1978) and LAI was worked out using the following formula developed by Watson (1947).

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

3.3.1.5. Total dry matter production (TDMP)

The sample plants uprooted prior to general harvest were used for computing dry matter production. These plants were separated out into stem, leaves, tuber rind and flesh. Fresh weights of each part were recorded and sub-samples were taken for estimating the dry weight. The sub-samples were dried in an oven at 70 °C to constant dry weight. Then the dry weight of each part as well as the TDMP at harvest were computed in t ha^{-1}.

3.3.2. YIELD COMPONENTS AND YIELD

3.3.2.1. Number of tubers per plant

The total number of tubers from the sample plant was counted and average per plant was worked out.

3.3.2.2. Weight of tubers per plant

The total weight of tubers from the sample plants were recorded and the average value was expressed as weight of tubers per plant.

3.3.2.3. Length of tuber

The average length of tubers was worked out by measuring the length of medium sized tubers from the sample plants.

3.3.2.4. Girth of tuber

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

3.3.2.5. Tuber yield

After the harvest of the crop, the tubers were separated, the soil adhering to the tubers were removed and the fresh weight of the tuber from the net plot was recorded and expressed as t ha^{-1}.

3.3.2.6. Top yield

The total weight of the stem and leaves of the plants from the net plot was taken at the time of harvest and converted to t ha^{-1}.

3.3.2.7. Utilization index (UI)

It is the ratio of the root weight to the top weight (stem and leaves) and is an important yield determinant in cassava. (Obigbesan, 1973).

3.3.3. Quality characters of tuber

3.3.3.1. Starch content

Starch content of the flesh was estimated by using Potassium ferricyanide method (Aminoff *et al.*, 1970). The values were expressed as % on fresh weight basis.

3.3.3.2. Protein content

The N content of oven dried samples of tuber flesh from each plot was estimated by colorimetric method. The N values were multiplied by the factor 6.25 to get the crude protein content of tuber (A.O.A.C, 1969).

3.3.3.3. Hydrocyanic acid (HCN) content

The HCN content of fresh tuber samples were estimated by the colorimetric method suggested by Indira and Sinha (1969).

3.3.3.4. Cooking quality

The cooking quality of the tuber was assessed by a taste panel based on taste, texture and appearance. The taste was assessed on a discrete scale with five points (Prema *et al.*, 1975). The best taste was described as sweet and was allotted a score of 4. The other scores in the decreasing order of taste were watery sweet (3), starchy (2), bitter (1) and watery bitter (0).The cooking quality was rated as good, medium or poor based on texture, appearance and overall acceptability.

3.4. CHEMICAL ANALYSIS

3.4.1. Plant analysis

Samples of stem, leaves and tuber rind and flesh collected for chemical analysis were dried separately in an air oven at 70 °C and ground to pass through 0.5 mm mesh in a Willey mill.

The N content of the samples was determined by modified micro kjeldahl method (Jackson, 1973). The P content was estimated colorimetrically (Jackson, 1973) and K content by flame photometric method (Piper, 1966).

3.4.2. Uptake studies

The total uptake of N, P, and K at harvest were calculated based on the respective nutrient contents in the stem, leaves and tuber rind and flesh and their corresponding dry weights. The uptake was expressed in kg ha^{-1}.

3.5. SOIL ANALYSIS

Soil samples were taken from the experimental area before and after the study. The composite sample from the experimental area before the study was analysed for physical and chemical properties as given in Table 1. After the experiment, composite samples were collected from each plot, air dried, powdered and passed through 2 mm sieve and analysed for available N, P and K using the methods given in Table1.

3.6. ECONOMICS OF CULTIVATION

The economics of cultivation of the crop was worked out and net income and benefit-cost ratio (BCR) were calculated as follows.

$$\text{Net income (Rs.ha}^{-1}) = \text{Gross income} - \text{Cost of cultivation}$$

$$BCR = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.7. STATISTICAL ANALYSIS

The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) for 3^2 x 2 asymmetrical confounded factorial experiment and the significance was tested by F test (Cochran and Cox, 1965). Wherever F test was significant in ANOVA, the critical difference (CD) is provided. The results and discussion are based on 5 % level of significance.

RESULT

4. RESULT

A field investigation was conducted at the Instructional farm, College of Agriculture, Vellayani from September 2002 to April 2003 to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation. The study was laid out in asymmetrical confounded factorial with 18 treatments in three blocks of six plots each per replication and two replications. The experimental data was statistically analysed and the results are presented in this chapter.

4.1. GROWTH CHARACTERS

4.1.1. Height of the plant

The data on the effect of varieties, organic manures and N levels on plant height at different stages of growth are presented in Table 2.

There was significant difference in plant height between varieties at 2 MAP and v_2 was superior to v_1 but this significant difference was not noted at later stages.

Different organic manures had significant influence on plant height. At all stages of growth, m_1 produced taller plants while the effects of m_2 and m_3 were on par.

Levels of N showed significant influence on plant height. Maximum response was shown by n_2 at all stages of growth which was on par with n_3 but superior to n_1. A quadratic nature of response was observed at the highest N dose.

The interactions among the various factors were not significant at any stage of growth.

Table 2. Effect of varieties, organic manures and N levels on plant height (cm)

Treatments	2 MAP	4 MAP	Harvest
Varieties (V)			
v_1	68.78	137.93	225.37
v_2	87.70	145.66	231.78
$F_{1, 13}$	19.145**	1.374	6.445*
CD	9.425	--	18.950
Organic manures (M)			
m_1	90.29	153.12	247.22
m_2	74.18	130.31	214.48
m_3	70.26	141.95	224.03
$F_{2, 13}$	8.038**	3.990*	5.000*
CD	11.543	17.601	23.209
N levels (N)			
n_1	69.09	128.45	209.86
n_2	87.17	156.42	248.06
n_3	78.47	140.51	227.81
$F_{2, 13}$	5.828*	6.036*	6.445*
CD	11.543	17.601	23.209

* Significant at 5 % level

** Significant at 1 % level

4.1.2. Total number of leaves per plant

The effect of treatments and their interactions on total number of leaves per plant are presented in Table 3a and 3b.

Varieties showed significant difference in total number of leaves at all growth stages (Table 3a) and v_2 produced more number of leaves than v_1 at all stages of growth.

The different organic manures had significant influence on the total number of leaves only at 2 MAP and 4 MAP. FYM (m_1) treated plots were found to be superior both at 2 MAP and 4 MAP. The effect of m_2 was superior to m_3 at 2 MAP but both were on par at 4 MAP.

Significant difference was noted between the N levels at all growth stages. The treatment n_2 produced higher number of leaves at all stages and was significantly superior to n_1 and n_3 which were on par.

The interaction between varieties and organic manures were not significant whereas interaction between varieties and N showed significant influence at 2 MAP and at harvest. (Table 3b). In case of v_1 the response was high at higher doses of N while v_2 responded better at n_1 level. This result was observed both at 2 MAP and at harvest. The interaction between different organic manures and levels of N were significant only at harvest. The treatment m_1n_2 showed superior response than other treatments followed by m_3n_2 and m_2n_2. All sources of organic manure produced higher number of leaves at n_2 level and reduced number at n_3 level.

4.1.3. Number of functional leaves per plant

The data pertaining to the effect of treatments and their interactions on number of functional leaves per plant at different growth stages are given in Table 4a and 4b.

Table 3a. Effect of varieties, organic manures and N levels on total number of leaves per plant.

Treatments	2 MAP	4 MAP	Harvest
Varieties (V)			
v_1	68.26	110.67	191.59
v_2	82.57	128.40	214.89
$F_{1, 13}$	98.825**	29.739**	55.728**
CD	3.138	7.086	6.804
Organic manures (M)			
m_1	79.93	128.18	207.47
m_2	75.51	114.63	197.88
m_3	70.80	115.79	204.38
$F_{2, 13}$	13.397**	7.117**	3.279
CD	3.843	8.679	--
N levels (N)			
n_1	68.58	108.33	191.53
n_2	87.38	135.58	225.17
n_3	70.28	114.70	193.03
$F_{2, 13}$	69.53**	25.621**	49.433**
CD	3.843	8.679	8.333

** Significant at 1 % level

Table 3b. Interaction effect of varieties, organic manures and N levels on total number of leaves per plant

Treatments	2 MAP	4 MAP	Harvest
v_1m_1	71.62	117.62	197.67
v_1m_2	88.23	139.23	217.27
v_1m_3	68.95	104.18	183.62
v_2m_1	82.07	125.08	212.13
v_2m_2	64.20	110.70	196.48
v_2m_3	77.40	120.88	215.27
$F_{2,13}$	0.642	1.359	0.739
v_1n_1	56.48	93.22	175.45
v_1n_2	80.68	123.45	207.60
v_1n_3	82.45	129.65	209.98
v_2n_1	92.30	141.50	240.35
v_2n_2	65.83	109.15	189.33
v_2n_3	74.72	120.25	196.72
$F_{2,13}$	11.834**	3.705	6.529*
CD	5.435	--	11.785
m_1n_1	73.93	112.15	190.08
m_1n_2	88.68	149.15	238.90
m_1n_3	77.18	123.25	193.43
m_2n_1	63.85	102.38	181.18
m_2n_2	88.75	127.50	215.45
m_2n_3	73.93	114.03	197.00
m_3n_1	67.98	110.48	203.33
m_3n_2	84.70	130.08	221.15
m_3n_3	59.73	106.83	188.65
$F_{4,13}$	1.483	2.537	7.434**
CD	--	--	14.433

* Significant at 5 % level

** Significant at 1 % level

Varieties showed significant difference at all stages of growth and v_2 produced more number of functional leaves than v_1 at all stages (Table 4a).

Organic manures produced significant differences in number of functional leaves at 2 MAP. The treatment m_1 was superior to m_2 and m_3 but m_2 was superior to m_3 in its effect. But this type of response was not observed later.

Significant difference in number of functional leaves was noted at all growth stages due to the effect of N levels. Plants treated with n_2 produced more number of functional leaves than n_1 and n_3 treated plants.

Significant difference in number of functional leaves was observed only at 2 MAP due to VxM interaction. At 2 MAP v_1 was found to respond better at m_2 and v_2 fared well with m_1. However no interaction was observed during later stages (Table 4b). VxN interaction was present at all stages, v_1 responding well with n_2 and n_3, while v_2 recorded more functional leaves with n_1 level. MxN interaction was significant at 2 MAP. Whatever be the manure, more functional leaves was seen at n_2 level.

4.1.4. Leaf area index

The data on LAI as influenced by treatments and their interactions at different stages of growth are given in Table 5a and 5b.

Varieties showed significant difference in LAI (Table 5a) only at 2 MAP and 4 MAP and v_2 was found superior at both stages. Although v_2 recorded higher LAI at harvest, the difference between varieties was not significant.

Significant difference in LAI was recorded by sources of organic manure. LAI was more or less similar and high for the plants treated with m_1 and m_2 at all growth stages.

Table 4a. Effect of varieties, organic manures and N levels on number of functional leaves per plant

Treatments	2 MAP	4 MAP	Harvest
Varieties (V)			
v_1	62.03	97.21	97.21
v_2	75.92	110.88	110.91
$F_{1,13}$	511.698**	19.771**	20.047**
CD	1.337	6.705	6.669
Organic manures (M)			
m_1	73.86	109.81	109.87
m_2	69.23	100.55	100.53
m_3	63.83	101.77	101.78
$F_{2,13}$	89.110**	3.563	3.661
CD	1.638	--	--
N levels (N)			
n_1	62.62	92.92	92.92
n_2	81.20	120.11	120.17
n_3	63.11	99.11	99.08
$F_{2,13}$	396.971**	28.633**	29.102**
CD	1.638	8.212	8.168

** Significant at 1 % level

Table 4b. Interaction effect of varieties, organic manures and N levels on number of functional leaves per plant

Treatments	2 MAP	4 MAP	Harvest
v_1m_1	65.10	101.28	101.28
v_1m_2	82.62	118.33	118.45
v_1m_3	63.30	92.61	92.61
v_2m_1	75.17	108.50	108.45
v_2m_2	57.00	97.73	97.73
v_2m_3	69.97	100.93	105.82
$F_{2,13}$	8.798**	0.836	0.857
CD	2.317	--	--
v_1n_1	50.13	79.78	79.78
v_1n_2	75.10	106.05	106.05
v_1n_3	75.32	114.56	114.56
v_2n_1	87.08	125.67	125.78
v_2n_2	60.65	97.28	97.28
v_2n_3	65.56	100.93	100.88
$F_{2,13}$	91.907**	4.677*	4.736*
CD	2.317	11.614	11.551
m_1n_1	66.58	94.75	94.75
m_1n_2	85.00	132.50	132.68
m_1n_3	70.00	102.18	102.18
m_2n_1	57.45	89.68	89.68
m_2n_2	82.33	110.42	110.42
m_2n_3	67.93	101.57	101.49
m_3n_1	63.83	94.33	94.33
m_3n_2	76.28	117.42	117.43
m_3n_3	51.40	93.58	93.58
$F_{4,13}$	22.57**	2.811	2.856
CD	2.838	--	--

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

Plots treated with n_2 recorded higher LAI at all stages.

Among interactions (Table 5b), only organic manures x N levels showed significant influence at 2 MAP and 4 MAP. With any organic manure, LAI increased with increase in N level from n_1 to n_2 and decreased at n_3 level. At 2 MAP, the effects of the treatment combinations m_1n_2, m_2n_2 and m_3n_2 were on par but superior to others. At 4 MAP, m_1n_2 produced the highest index.

4.1.5. Total dry matter production

Table 6 revealed significant difference in TDMP among N levels. Total dry matter production increased with N level up to 75 kg ha^{-1} (n_2) and decreased at higher level.

Interaction effects were not significant with respect to this character.

4.2. YIELD COMPONENTS AND YIELD

The data on the effect of treatments on yield components are given in Table 7. Table 8a and 8b indicate the data on yield as influenced by the treatments and their interactions.

4.2.1. Number of tubers per plant

From the results in Table 7, it is seen that varieties or sources of organic manure did not produce any significant variation in number of tubers per plant. But tuber number significantly increased when the N level was increased from n_1 to n_2 but decreased at n_3 level.

Significant effect of interactions were also absent.

Table 5a. Effect of varieties, organic manures and N levels on leaf area index

Treatments	2 MAP	4 MAP	Harvest
Varieties (V)			
v_1	1.13	2.11	2.48
v_2	1.45	2.32	2.64
$F_{1,13}$	36.406**	62.90**	1.171
CD	0.115	0.146	--
Organic manures (M)			
m_1	1.37	2.38	2.82
m_2	1.33	2.24	2.63
m_3	1.17	1.89	2.23
$F_{2,13}$	5.411*	6.408*	10.646**
CD	0.141	0.179	0.283
N levels (N)			
n_1	1.07	1.83	2.24
n_2	1.63	2.70	3.04
n_3	1.17	1.99	2.40
$F_{2,13}$	41.745**	18.69**	20.97**
CD	0.141	0.179	0.283

* Significant at 5 % level

** Significant at 1 % level

Table 5b. Interaction effect of varieties, organic manures and N levels on leaf area index

Treatments	2 MAP	4 MAP	Harvest
V_1m_1	1.24	2.25	2.85
v_1m_2	1.50	2.50	2.78
v_1m_3	1.17	2.05	2.64
v_2m_1	1.48	2.44	2.62
v_2m_2	0.98	1.75	1.95
v_2m_3	0.37	2.03	2.51
$F_{2,13}$	0.463	0.380	3.740
V_1n_1	0.89	1.58	2.06
v_1n_2	1.24	2.07	2.43
v_1n_3	1.49	2.57	3.02
v_2n_1	1.77	2.82	3.06
v_2n_2	1.01	1.90	2.37
v_2n_3	1.34	2.08	2.43
$F_{2,13}$	0.152	1.874	1.025
M_1n_1	1.01	1.76	2.32
m_1n_2	1.70	3.09	3.29
m_1n_3	1.40	2.26	2.84
m_2n_1	1.11	1.94	2.37
m_2n_2	1.61	2.75	3.24
m_2n_3	1.26	2.05	2.28
m_3n_1	1.08	1.76	2.03
m_3n_2	1.56	2.25	2.58
m_3n_3	0.87	1.65	2.08
$F_{4,13}$	4.168*	4.256*	1.170
CD	0.244	0.311	--

* Significant at 5 % level

Table 6. Effect of varieties, organic manures and N levels on total dry matter production (t ha^{-1})

Treatments	TDMP (t ha^{-1})
Varieties (V)	
v_1	10.72
v_2	11.51
$F_{1,13}$	1.945
Organic manures (M)	
m_1	10.94
m_2	11.90
m_3	10.52
$F_{2,13}$	2.071
N levels (N)	
n_1	9.90
n_2	13.09
n_3	10.37
$F_{2,13}$	12.289**
CD	1.514

** Significant at 1 % level

4.2.2. Weight of tubers per plant

Table 7 revealed that there was no significant variation between varieties in weight of tubers per plant.

The tuber weight per plant varied significantly with the source of organic manure. PM (m_2) gave superior response than FYM (m_1) and CPC (m_3). The effects of FYM and CPC were on par.

Significant increase in weight of tuber was seen with n_2 treated plants.

Interaction effects were not significant for this character.

4.2.3. Length of tuber

Table 7 indicated that the improved variety (v_1) produced significantly longer tubers than the local variety (v_2).

Length of tuber was not influenced by the source of organic manure, but n_2 treated plants produced longer tubers

Interaction effects were absent.

4.2.4. Girth of tuber

The results (Table 7) showed that varieties or source of organic manure did not have any significant effect on girth of tuber.

Plants treated with n_2 registered longer tubers than n_3 treated plants but on par with n_1 treated plants.

No interaction effects were observed on tuber girth.

Table 7. Effect of varieties, organic manures and N levels on yield components

Treatments	Number of tubers per plant	Weight of tubers per plant (kg)	Length of tuber (cm)	Girth of tuber (cm)
Varieties (V)				
v_1	6.78	1.49	20.82	13.12
v_2	7.53	1.48	18.23	13.55
$F_{1,13}$	3.025	0.844	13.460**	1.57
CD	--	--	1.536	--
Organic manures (M)				
m_1	7.00	1.34	19.53	13.16
m_2	7.38	1.71	19.20	13.63
m_3	7.08	1.40	19.83	13.21
$F_{2,13}$	0.29	19.650**	0.270	0.752
CD	--	0.136	--	--
N levels (N)				
n_1	6.25	1.39	19.16	13.43
n_2	8.55	1.75	21.03	13.95
n_3	6.67	1.31	18.36	12.62
$F_{2,13}$	10.612**	27.609**	5.023*	4.902*
CD	1.159	0.136	1.882	0.929

* Significant at 5 % level

** Significant at 1 % level

4.2.5. Tuber yield

The mean yield presented in Table 8a clearly pointed out that the tuber yield did not vary between the varieties tested.

Among organic manures, PM treated plants recorded the highest tuber yield which was on par with those treated with FYM but superior to CPC treated plants. At the same time, no significant difference in yield was seen with FYM and CPC.

Tuber yield significantly increased with increase in N level from 50 (n_1) to 75 kg ha^{-1} (n_2) but decreased with further increase in N level. Maximum yield was obtained with n_2 level.

Tuber yield was not influenced by any type of interaction between the tested factors (Table 8b).

4.2.6. Top yield

Neither varietal difference nor manurial source yield any significant difference in top yield as evident from Table 8a, but an increasing trend in top yield was seen when N was increased from n_1 to n_2 which was on par with n_3 level.

The interaction between treatments (Table 8b) showed significant effect on top yield. Regarding VxM interaction, v_2 combined with FYM and PM produced higher top yield than v_1 combined with these organic manures. Both varieties produced higher top yield with PM than with other organic manures. With respect to VxN interaction, the response of v_1 was observed upto n_3 level while v_2 responded better at n_2 level. Considering MxN interaction, FYM and PM responded better at higher levels of N, while the response of CPC was higher at n_2 level.

Table 8a. Effect of varieties, organic manures and N levels on yield of cassava

Treatments	Tuber yield (t ha^{-1})	Top yield ((t ha^{-1})	Utilization index
Varieties (V)			
v_1	18.36	26.06	0.73
v_2	18.35	25.70	0.72
$F_{1,13}$	0.00	0.216	0.50
Organic manures (M)			
m_1	17.88	25.08	0.72
m_2	20.05	25.98	0.80
m_3	17.14	26.60	0.65
$F_{2,13}$	4.043*	1.308	21.415**
CD	2.317	--	0.005
N levels (N)			
n_1	16.33	24.26	0.70
n_2	22.00	26.13	0.85
n_3	16.73	27.26	0.62
$F_{2,13}$	17.730**	5.189*	47.03**
CD	2.317	2.054	0.005

* Significant at 5 % level

** Significant at 1 % level

Table 8b. Interaction effect of varieties, organic manures and N levels on yield of cassava

Treatments	Tuber yield (t ha^{-1})	Top yield ((t ha^{-1})	Utilization index
v_1m_1	16.05	23.40	0.78
v_1m_2	16.62	26.75	0.67
v_1m_3	22.02	25.62	0.84
v_2m_1	21.99	26.34	0.76
v_2m_2	17.02	29.17	0.57
v_2m_3	16.45	24.02	0.72
$F_{2,13}$	0.143	10.638**	20.483**
CD	--	2.906	0.007
v_1n_1	18.09	22.63	0.75
v_1n_2	17.65	25.88	0.65
v_1n_3	20.42	27.32	0.82
v_2n_1	19.68	24.95	0.87
v_2n_2	16.56	28.24	0.61
v_2n_3	17.72	26.29	0.63
$F_{2,13}$	0.462	5.503*	6.051*
CD	--	2.906	0.007
M_1n_1	15.90	22.85	0.71
m_1n_2	20.68	25.70	0.81
m_1n_3	17.05	26.70	0.66
m_2n_1	17.21	22.30	0.81
m_2n_2	23.69	24.92	0.95
m_2n_3	19.25	30.71	0.64
m_3n_1	15.90	27.62	0.58
m_3n_2	21.64	27.78	0.78
m_3n_3	13.89	24.38	0.56
$F_{4,13}$	0.959	5.579**	4.238*
CD	--	3.559	0.008

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

4.2.7. Utilization index

As shown in Table 8a, UI was not influenced by varietal difference.

The organic manures varied significantly in their effects on the utilization index. The highest UI was registered by PM followed by FYM and the lowest UI was registered by CPC.

As in the case of tuber yield, UI was maximum at 75 kg N ha^{-1} (n_2) which was superior to n_1 level and it decreased at higher N level.

The effect of VxM interaction (Table 8b) showed that higher values of UI were recorded when different organic manures were applied to v_1 than to v_2. The improved variety (v_1) recorded the highest UI with m_3 and the local variety (v_2) recorded the highest UI with m_1. In the case of VxN interaction, v_1 combined with n_3 and v_2 combined with n_1 recorded higher utilization index. With any organic manure, UI increased with increase in N level from n_1 to n_2 but declined at n_3 when MxN interaction is considered. FYM and PM in combination with N levels showed higher UI than CPC with N levels.

4.3. QUALITY CHARACTERS OF TUBER

Table 9a and 9b show the data on the quality characters of tuber namely starch, protein and HCN contents and cooking quality as affected by the treatments and their interactions.

4.3.1. Starch content

Neither varieties nor sources of organic manure produced any significant variation in starch content of the tuber (Table 9a), but n_2 treated plants produced tubers with higher starch content.

Among interactions (Table 9b), only MxN interaction was significant. The treatment combination m_3n_2 produced the highest starch content which was on par with m_2n_2. With any organic manure, starch content increased with increase in N level from n_1 to n_2 but declined at n_3 level.

4.3.2. Protein content

The treatments differed significantly with respect to protein content of tuber (Table 9a).

The local variety (v_2) registered higher protein content than the improved variety (v_1).

Protein content of tuber from plants treated with PM recorded significantly higher value than those with FYM and CPC. FYM and CPC produced the same protein content.

With regard to N levels, tubers of plants treated with n_2 were found to have more protein than those treated with n_1 and n_3 levels.

All the interactions were significant with respect to this character (Table 9b). In the case of VxM interaction, the local variety (v_2) registered higher protein content with different sources of organic manure compared to the improved variety (v_2) combined with different organic manures. When different levels of N were applied to v_1, the highest protein content was registered at n_3 level whereas v_2 registered the highest protein content at n_1 level Considering MxN interaction, the organic manures FYM and CPC recorded higher protein contents at n_2 level while PM recorded higher protein content at n_1 level.

Table 9a. Effect of varieties, organic manures and N levels on quality characters of tuber

Treatments	Starch content (%)	Protein content (%)	HCN content (μg g^{-1})	Scores for taste
Varieties (V)				
v_1	41.14	2.02	16.59	2.59
v_2	39.31	2.14	13.17	2.46
$F_{1,13}$	2.230	11.768**	78.457**	7.234*
CD	--	0.007	0.840	0.103
Organic manures (M)				
m_1	41.14	2.01	16.27	2.47
m_2	39.56	2.22	9.18	2.58
m_3	39.97	2.01	19.19	2.53
$F_{2,13}$	0.597	16.021**	237.477**	2.010
CD	--	0.009	1.029	--
N levels (N)				
n_1	36.03	2.01	11.88	2.51
n_2	47.21	2.16	15.81	2.64
n_3	37.43	2.07	16.96	2.43
$F_{2,13}$	32.934**	6.211*	63.66**	7.056**
CD	2.672	0.009	1.029	0.126

* Significant at 5 % level

** Significant at 1 % level

Table 9b. Interaction effect of varieties, organic manures and N levels on quality characters of tuber

Treatments	Starch content (%)	Protein content (%)	HCN content ($\mu g\ g^{-1}$)	Scores for taste
v_1m_1	42.49	2.10	13.05	2.50
v_1m_2	39.79	1.93	10.70	2.60
v_1m_3	39.03	2.10	17.50	2.67
v_2m_1	40.08	2.33	14.12	2.57
v_2m_2	41.90	1.87	19.22	2.38
v_2m_3	38.05	2.16	14.69	2.72
$F_{2,13}$	1.454	18.636**	3.740*	0.854
CD	--	0.128	1.456	--
v_1n_1	35.39	2.04	13.05	2.55
v_1n_2	36.66	1.98	10.71	2.68
v_1n_3	48.53	2.10	17.50	2.53
v_2n_1	45.90	2.22	14.12	2.47
v_2n_2	39.50	1.93	19.22	2.60
v_2n_3	35.37	2.22	14.69	2.32
$F_{2,18}$	1.719	8.828**	2.685	0.876
CD	--	0.128	--	--
m_1n_1	37.23	1.84	10.88	2.50
m_1n_2	43.40	2.28	18.12	2.63
m_1n_3	42.80	1.93	19.81	2.28
m_2n_1	37.87	2.36	8.03	2.58
m_2n_2	49.03	2.01	9.41	2.70
m_2n_3	31.78	2.28	10.12	2.48
m_3n_1	32.98	1.84	16.72	2.45
m_3n_2	49.22	2.19	19.90	2.60
m_3n_3	37.72	2.01	20.94	2.53
$F_{4,18}$	7.497**	9.119**	6.109**	0.837
CD	5.670	0.157	1.456	--

* Significant at 5 % level

** Significant at 1 % level

4.3.3. HCN content

As presented in Table 9a, the HCN content of the tuber of the local variety (v_2) was lower than the improved variety (v_1).

HCN content of tubers from plants treated with PM registered significantly lower HCN content than those treated with FYM and CPC.

The content of HCN in tuber increased significantly with increase in N level though it was within the permissible limits.

The effects of interactions VxM and MxN were significant (Table 9b). Among VxM interaction, v_1 recorded the lowest HCN content when combined with PM and v_2 combined with FYM recorded lower HCN content. With regard to MxN interaction, the HCN content increased with increase in N level in combination with any organic manure. In general, interaction between PM and N levels registered lower HCN contents.

4.3.4. Cooking quality

It is seen from Table 9a that the improved variety (v_1) obtained higher scores for taste than the local variety (v_2).

The taste of the tuber was not affected by the source of organic manure.

Levels of N showed significant change in the score obtained for taste of the tuber. Maximum score was recorded by n_2 which was superior to n_1 and n_3 levels.

In general, the cooking quality of the tuber of both varieties was rated as good based on texture and appearance. The improved var. Sree Vijaya was observed to cook well in lesser time than the local variety.

4.4. UPTAKE OF NUTRIENTS

Nutrient uptake in terms of, N, P and K uptake (kg ha^{-1}) as affected by treatments are presented in Table 10a and their interaction effects in Table 10 b.

4.4.1 N uptake

Uptake of N (Table 10a) was significantly influenced only by N level. The level n_2 recorded the highest uptake of N which was superior to n_1 and n_3 levels.

No significant interaction between treatments (Table 10b) was observed with respect to N uptake.

4.4.2 P uptake

It is evident form Table 10a that the var. Sree Vijaya (v_1) recorded significantly higher uptake of P than the local variety (v_2).

Different organic manures did not register any significant difference in P uptake.

Uptake of P increased with increase in N level form n_1 to n_2 and declined at n_3 level.

Significant interactions were observed with respect to P uptake (Table 10b). Regarding VxM interaction, the effects of all the combinations were on par except $v_2m_1$and v_2m_3. The local variety (v_2) registered lower P uptake with different organic manures, compared to the improved variety (v_1). The combinations of v_1 with n_3 and v_2 with n_1 registered higher uptake of P in the case of VxN interaction. Among MxN interaction, the highest P uptake was registered by m_2n_2 which was superior to other

Table 10a. Effect of varieties, organic manures and N levels on uptake of nutrients (kg ha^{-1})

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Varieties (V)			
v_1	109.61	34.97	98.01
v_2	110.97	31.59	101.36
$F_{1,13}$	0.148	17.654**	0.612
CD	--	1.756	--
Organic manures (M)			
m_1	104.70	33.98	97.80
m_2	111.27	32.73	102.66
m_3	114.90	33.13	98.60
$F_{2,13}$	2.844	0.835	0.491
N levels (N)			
n_1	100.32	29.32	92.09
n_2	128.03	39.58	110.32
n_3	102.51	30.93	96.65
$F_{2,13}$	25.275**	62.555**	6.515*
CD	9.447	2.151	11.457

* Significant at 5 % level

** Significant at 1 % level

Table 10b. Interaction effect of varieties, organic manures and N levels on uptake of nutrients (kg ha^{-1})

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
v_1m_1	99.74	34.15	90.69
v_1m_2	100.91	33.81	93.48
v_1m_3	132.41	36.06	107.71
v_2m_1	123.66	29.40	112.93
v_2m_2	96.67	34.71	95.61
v_2m_3	108.34	31.55	97.68
$F_{2,13}$	2.774	5.146*	0.004
CD	--	3.042	--
v_1n_1	104.39	29.39	92.63
v_1n_2	105.01	29.25	102.97
v_1n_3	112.61	44.66	106.05
v_2n_1	109.93	34.51	99.27
v_2n_2	111.83	30.87	95.34
v_2n_3	117.97	30.99	101.85
$F_{2,13}$	0.528	17.590**	1.462
CD	--	3.042	--
m_1n_1	101.12	32.64	97.54
m_1n_2	115.45	38.37	97.61
m_1n_3	97.52	30.93	98.25
m_2n_1	102.74	27.53	90.38
m_2n_2	133.14	42.52	117.25
m_2n_3	97.92	28.13	100.35
m_3n_1	97.11	27.79	88.35
m_3n_2	135.51	37.86	116.10
m_3n_3	112.08	33.73	91.34
$F_{4,13}$	2.539	8.780**	0.820
CD	--	3.726	--

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

combinations. In general, the combinations of any organic manure with n_2 level recorded higher P uptake than with n_1 or n_3 level.

4.4.3 . K uptake

The effect of treatments on K uptake (Table 10a) followed the same trend as that of N uptake. Uptake of K varied significantly only with N levels and the highest uptake was obtained at n_2 level of N.

The interaction effects on K uptake were not significant (Table 10b).

4.5. SOIL NUTRIENT STATUS AFTER THE EXPERIMENT

Available N, P_2O_5 and K_2O contents of the soil after the experiment as influenced by the treatments and their interactions are given in Table 11a and 11b respectively.

4.5.1. Available Nitrogen

No significant variation in available N status of the soil was observed due to neither varietal difference nor the N levels (Table 11a).

Available N status of soil varied significantly with the source of organic manure. FYM registered superior status of available N in the soil while the effects of PM and CPC were on par.

Interaction effects were absent (Table 11b).

4.5.2 Available phosphorous

Varieties showed significant difference in available P status (Table 11a). The improved variety (v_1) gave a better response than local variety (v_2).

Table 11a. Effect of varieties, organic manures and N levels on nutrient status after the experiment (kg ha^{-1})

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
Varieties (V)			
v_1	234.33	33.51	223.16
v_2	249.78	30.82	217.12
$F_{1,13}$	2.058	11.876**	0.845
CD	--	1.702	--
Organic manures (M)			
m_1	268.30	31.40	231.27
m_2	228.41	31.42	208.76
m_3	229.45	33.69	220.40
$F_{2,13}$	5.947*	3.785	3.922*
CD	28.747	--	17.525
N levels (N)			
n_1	233.37	31.99	217.15
n_2	245.65	37.27	216.82
n_3	247.14	27.23	226.45
$F_{2,13}$	0.656	55.174**	0.924
CD	--	2.084	--

* Significant at 5 % level

** Significant at 1 % level

Different organic manures did not produce any variation in the available P status.

Post harvest available P content in the soil was maximum at n_2 level in comparison with n_1 and n_3 levels.

The interactions VxM and MxN were found to have significant effects on available P_2O_5 status (Table 11b). Considering VxM interaction, the treatment combination v_1m_3 and v_2m_3 were superior to other combinations in their effects. Higher available P status was observed in CPC applied plots in the case of both varieties. In the case of MxN interaction, the effects of the treatment combinations m_1n_2, m_2n_2 and m_3n_2 were on par but they registered significantly higher status than other combinations. Whatever be the manure, higher status of available P in the soil was observed in n_2 treated plots.

4.5.3 Available potassium

It is observed from Table 11a that varieties and N levels did not produce any significant variation in the available K content but there was significant difference among organic manures in their effects. Available K content was high with FYM in comparison with PM but similar with CPC.

Significant effects of interaction of varieties with organic manures as well as with N levels was observed (Table 11b). With respect to VxM interaction, the effects of v_1m_1, v_1m_2 and v_2m_2 were on par and were superior to other combinations. Higher available K status was observed with PM in combination with v_1 or v_2 and lower K status was observed with CPC combined with both varieties. The interaction between varieties and N levels showed that v_2n_2 registered the highest value followed by v_2n_1 which were on par but superior to others. Post harvest available K

Table 11b. Interaction effect of varieties, organic manures and N levels on soil nutrient status after the experiment (kg ha^{-1})

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
v_1m_1	207.50	31.80	219.27
v_1m_2	259.24	30.99	243.27
v_1m_3	249.31	35.99	216.15
v_2m_1	241.99	26.85	201.37
v_2m_2	246.18	32.75	234.07
v_2m_3	248.10	34.63	206.74
$F_{2,13}$	2.902	18.080**	5.538*
CD	--	2.948	24.784
v_1n_1	257.15	32.32	212.56
v_1n_2	279.46	31.68	221.75
v_1n_3	233.63	39.32	201.59
v_2n_1	223.18	35.22	232.06
v_2n_2	212.20	38.90	255.34
v_2n_3	246.70	25.56	197.56
$F_{2,13}$	1.553	1.802	16.410**
CD	--	--	24.784
m_1n_1	261.85	30.85	219.38
m_1n_2	282.24	36.93	223.10
m_1n_3	260.82	26.42	251.34
m_2n_1	205.41	34.88	207.64
m_2n_2	217.17	36.16	215.30
m_2n_3	262.64	23.13	203.25
m_3n_1	232.85	30.27	224.45
m_3n_2	237.55	38.73	211.99
m_3n_3	217.95	32.06	224.77
$F_{4,13}$	1.469	5.431**	1.216
CD	--	3.610	--

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

status increased with increase in N level from n_1 to n_2 but decreased at n_3 level in the case of both varieties.

4.6 Economics of cultivation

The economics of cultivation as influenced by the treatments is presented in Table 12. Cost of cultivation included the cost of labour, planting material, P @ 50 kg P_2O_5 ha^{-1} and K @ 100 kg K_2O ha^{-1} applied uniformly to all the plots and the additional cost due to treatments ie, sources of organic manure and N levels. Gross income was worked out considering the income from the sale of tuber. Net income and BCR were calculated from the gross income and the cost of cultivation.

It is evident from Table 12 that both varieties recorded higher net income when PM was used as the source of organic manure. But higher BCR were recorded when FYM was used as the organic manure. Lower net income and BCR were recorded when CPC was used as the organic source. With any organic manure, higher net income and BCR were noticed at n_2 level (75 kg N ha^{-1}) than at n_1 or n_3 level in the case of both varieties. The treatment combination involving CPC as the organic manure and n_3 level of N resulted in negative net income and BCR less than one with both varieties. The treatment combination $v_1m_2n_2$ registered the highest net income followed by $v_2m_2n_2$ whereas the treatment combination $v_1m_1n_2$ registered the highest BCR followed by $v_2m_1n_2$. Maximum net income was obtained for both the varieties from plots treated with PM combined with 75 kg N ha^{-1}. However, both varieties recorded higher BCR when treated with FYM and 75 kg N ha^{-1}.

Table 12. Economics of cultivation as affected by varieties, organic manures and N levels

Treatments	Additional cost due to treatments ($Rs.ha^{-1}$)	Cost of cultivation ($Rs.ha^{-1}$)	Tuber yield ($t\ ha^{-1}$)	Gross income ($Rs.ha^{-1}$)	Net income ($Rs.ha^{-1}$)	BCR
$v_1m_1n_1$	3492	34852	15.74	62960	28108	1.81
$v_1m_1n_2$	3769	35129	21.14	84560	49431	2.41
$v_1m_1n_3$	4047	35407	17.41	69640	34233	1.97
$v_1m_2n_1$	10555	41915	16.51	66040	24125	1.58
$v_1m_2n_2$	10832	42192	23.77	95080	52888	2.25
$v_1m_2n_3$	11109	42469	20.99	83960	41491	1.98
$v_1m_3n_1$	30555	61915	15.90	63600	1685	1.03
$v_1m_3n_2$	30832	62192	21.14	84560	22368	1.36
$v_1m_3n_3$	31109	62469	12.65	50600	-11869	0.81
$v_2m_1n_1$	3492	34852	16.05	64200	29348	1.84
$v_2m_1n_2$	3769	35129	20.22	80880	45751	2.30
$v_2m_1n_3$	4047	35407	16.70	66800	31393	1.89
$v_2m_2n_1$	10555	41915	17.90	71600	29685	1.71
$v_2m_2n_2$	10832	42192	23.61	94440	52248	2.24
$v_2m_2n_3$	11109	42469	17.52	70080	27611	1.65
$v_2m_3n_1$	30555	61915	15.90	63600	1685	1.03
$v_2m_3n_2$	30832	62192	22.14	88560	26368	1.42
$v_2m_3n_3$	31109	62469	15.12	60480	-1989	0.97

Cost of cultivation per ha
excluding the treatments = Rs. 31360
Cost of 1 t FYM = Rs. 235
Cost of 1 t PM = Rs. 2000

Cost of 1 t CPC = Rs. 5000.00
Cost of 1 kg N = Rs. 11.09
Price of 1 kg tuber = Rs. 4.00

DISCUSSION

5. DISCUSSION

The results of the study conducted to develop an integrated nutrient schedule for short duration cassava in lowlands are discussed in this chapter.

5.1. Growth characters

The data in Table 2 pointed out the significant effect of varieties on plant height during the early stage of growth. Although the local var. Kariyilapothiyan produced taller plants than the improved var. Sree Vijaya during the initial stage, both varieties produced plants of similar height at later stages. The data in Table 3a and 4a revealed that the local variety produced significantly higher number of leaves and retained higher number of leaves at all growth stages. A general observation is that both varieties retained considerable number of leaves even at harvest. It is noteworthy that LAI of both varieties increased throughout the growth stages upto harvest (Table 5a). Between the two varieties, the local variety registered significantly higher LAI at 2 MAP and 4 MAP. No significant variation in LAI was observed at harvest. Although the local variety was found superior in terms of plant height, leaf number and LAI, there was no variation in total drymatter (Table 6) produced by both the varieties.

Farmyard manure treated plants were significantly taller when compared to PM and CPC treated plants (Table 2). Significantly higher number of leaves was produced upto 4 MAP by FYM treated plants followed by PM and CPC treated plants. But significant difference in number of functional leaves per plant was noticed only at 2 MAP and FYM applied plots produced the highest number. But significant difference in LAI was observed with different sources of organic manure. The organic sources, FYM and PM were superior to CPC at all stages. Growth promoting effect of FYM in cassava has been reported by Ashokan and

Sreedharan (1977). The higher efficiency of FYM in promoting the growth characters, when compared to other organic manures, has been reported by Veenavidyadharan (2000) in arrowroot and Archana (2001) in coleus. Arunkumar (2000) has also reported the inferior effect of CPC on growth characters and positive effect of CPC on TDMP of amaranthus. However, in the present study, the TDMP did not vary with the source of organic manure as shown in Table 6 .

Higher levels of N invariably favoured the vegetative growth of the plant (Mandal *et al.*, 1971; Pillai and George., 1978 ; Nair, 1982 and Nayar, 1986). In the present study, application of N @ 75 kg ha^{-1} was found sufficient for better expression of growth characters of short duration cassava in low lands (Table 2, 3a, 4a and 5a). The TDMP was influenced only by N levels as evidenced from Table 6. Application of 75 kg N ha^{-1} was found to be the optimum dose which might be due to the favourable effect of 75 kg N ha^{-1} on growth characters.

Interaction effect between treatments were absent in the case of height of the plant. There was no marked variation in leaf number and LAI due to the interaction between varieties and source of organic manure as revealed from Table 3b, 4b and 5b. Significant effect of interaction between varieties and N levels was observed in total number of leaves and number of functional leaves (Table 3b and 4b) which indicated the sufficiency of 75 kg N ha^{-1} (n_2) for the improved variety (v_1) and 50 kg ha^{-1} (n_1) for the local variety (v_2) for higher leaf production and retention. But TDMP was not significantly influenced by the varieties or N levels or their interaction. With any organic manure, better expression of growth characters was observed at 75 kg ha^{-1} than other N levels.

5.2. Yield components

The data on yield components in Table 7 indicated that there was no significant variation between varieties in yield components except length of tuber. The var. Sree Vijaya produced longer tubers than the local variety.

The yield components except tuber weight per plant were not influenced by the source of organic manure. In the case of tuber weight per plant, PM treated plants registered superior response than FYM and CPC treated plants. But the effects of FYM and CPC were on par. Comparable effects of FYM and CPC on weight of tubers per plant of white yam has been reported by Suja (2001).

As in the case of growth characters, N @ 75 kg ha^{-1} recorded higher values of yield components.

5.3. Tuber yield and utilization index

The results of the study revealed similar performance of both varieties in terms of tuber yield as depicted in Fig. 3. The average yield recorded by the improved var. Sree Vijaya and the local var. Kariyilapothiyan were 18.36 and 18.35 t ha^{-1} respectively (Table 8a).

Different organic manures significantly influenced the tuber yield as shown in Table 8a. The highest tuber yield of 20.05 t ha^{-1} was produced by PM (Fig. 3). Corroboratory results have been reported by Singh *et al.* (1973) in potato and Anitha (1997) in chilli. Among organic manures, PM produced maximum weight of tubers per plant which might have led to the increase in tuber yield in PM applied plots. The effect of PM was found was on par with FYM but superior to CPC. The higher efficiency of PM nay be attributed to its narrow C:N ratio and comparatively higher content of mineralisable N as pointed out by Singh *et al.* (1973). No significant difference in the yield was observed between FYM and CPC indicating the possibility of substitution of FYM with CPC. Similar effect of CPC was reported by CTCRI (1998b) in cassava and Suja (2001) in white yam.

Tuber yield increased from 16.33 t ha^{-1} to 22 t ha^{-1} when the dose of N was increased from 50 to 75 kg ha^{-1} (Table 8a). But the yield decreased to 16.73 t ha^{-1} with increase in N level from 75 to 100 kg ha^{-1}. The effect of N levels on yield components (Table 7) pointed out the sufficiency of moderate N nutrition. Hence the optimum dose of N for higher tuber yield of both varieties can be fixed at 75 kg ha^{-1} (Fig. 3).

Among the treatments, only N levels had significant effect on top yield as seen from Table 8a. Top yield increased with increase in N level from 50 to 75 kg ha^{-1} which was on par with 100 kg ha^{-1}. The higher quantity of photosynthates produced when the N level was increased from 75 to 100 kg ha^{-1} might have been utilized for top growth resulting in reduction in tuber yield at the highest level of N tried .

Utilization index did not vary between varieties (Table 8a), the values being 0.73 and 0.72 for the varieties, Sree Vijaya and Kariyilapothiyan respectively. No variation in tuber and top yields was observed between varieties which resulted in similar values of UI for the varieties. As in the case of tuber yield, the source of organic manure influenced utilization index. The highest UI of 0.8 was registered by PM (Table 8a) followed by FYM (0.72) and the lowest (0.65) by CPC treated plants. The effects of N levels on UI were similar to their effects on tuber yield. There was marked increase in UI when N level was increased from 50 to 75 kg but it decreased at higher N level of 100 kg ha^{-1}. It is evident from Table 8a that the tuber yield was

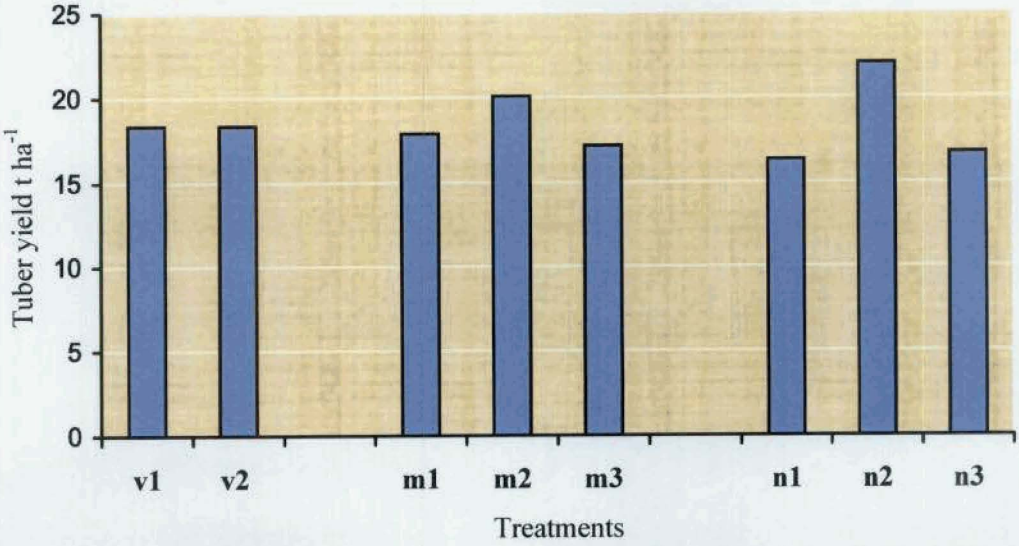

Fig. 3. Effect of varieties, organic manures and N levels on yield of cassava

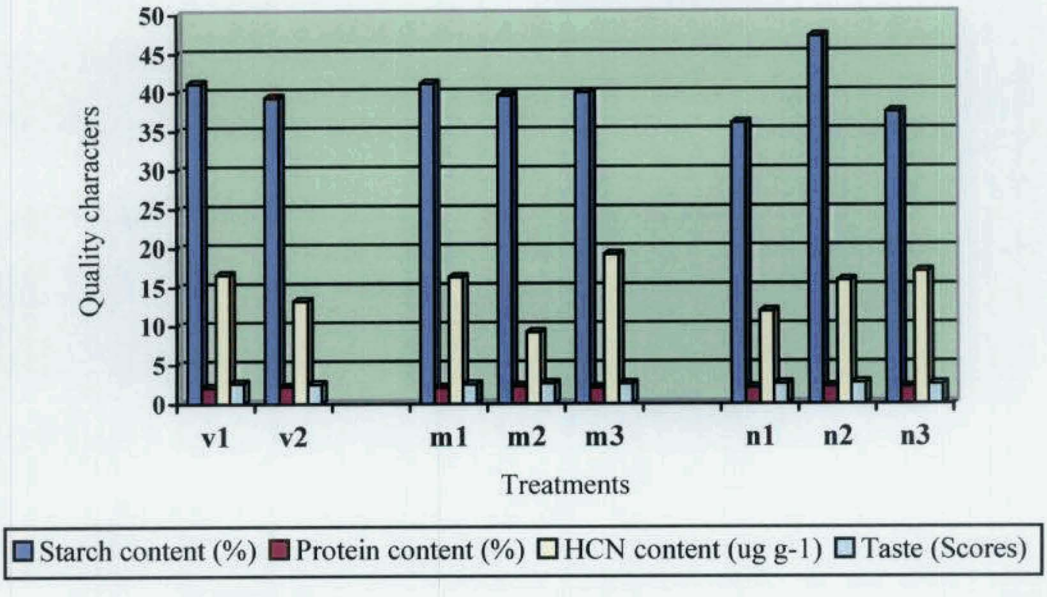

Fig.4 Effect of varieties, organic manures and N levels on quality characters of tuber

maximum at 75 kg N ha^{-1} but top yield increased with increase in N level from 75 to 100 kg ha^{-1}. Hence application of 75 kg N ha^{-1} showed the highest utilization index.

The interaction effects of treatments on UI (Table 8b) reflected the trend of the main effects. Higher values of UI were recorded by the improved variety (v_1) than the local variety (v_2) when different organic manures were applied. Both varieties in combination with 75 kg N ha^{-1} (n_2) produced higher UI than with 50 kg N ha^{-1} (n_1) and lower UI with 100 kg N ha^{-1} (n_3). Whatever be the source of organic manure, UI increased with increase in N level from 50 to 75 kg but declined at 100 kg N ha^{-1}. It is also noticed that FYM and PM in combination with N levels showed higher UI than CPC with N levels which might be due to the significant effect of the source of organic manure on utilization index.

5.4. Quality characters

Regarding the quality of tuber (Table 9a), varieties were on par in the starch content of their tubers. But tuber of the local variety contained higher protein and lower HCN contents. In general, the cooking quality of the tuber of both varieties was judged as good based on texture, appearance and overall acceptability. The improved var. Sree Vijaya was observed to cook well in lesser time when compared to the local variety and obtained highest scores for the taste (Table 10) indicating its excellent cooking quality as reported by CTCRI (1998a).

The source of organic manure influenced only the protein and HCN contents (Table 9a). Poultry manure treated plants recorded the highest protein content. This is in agreement with the findings of Joseph (1998) in snakeguard. FYM and CPC treated plants produced the same content of protein. But PM applied plots showed the lowest HCN content followed by plots treated with FYM and CPC applied plots showed the highest content but within permissible limits. However, the source of organic manure did not produce any variation in the taste of the tuber. The study revealed no marked variation in the quality of tuber due to source of organic manure suggesting the suitability of PM and CPC as alternate organic manures.

The starch content of the tuber increased when N level was increased from 50 to 75 kg ha^{-1} but decreased with further increase in N level. As the availability of N increases there is a tendency for decrease in carbohydrates in plants (Black, 1973). This may be due to increased rate of protein synthesis and consequent increase in vegetative growth triggered by higher N supply with corresponding decrease in starch content. Decrease in starch content of the tuber at higher levels of N has been reported by Vijayan and Aiyer (1969) and Nayar (1986) in cassava and Suja (2001) in white yam. The protein content of the tuber also exhibited similar trend showing the sufficiency of 75 kg N ha^{-1} for higher protein content of the tuber.

Significant increase in the HCN content of the tuber with increase in N levels was observed though it was within the permissible limits. But the scores obtained for taste of the tuber was maximum with 75 kg N ha^{-1} compared to lower or higher N level. A high level of N application results in a high content of cyanogenic gluocosides in the tuber (Sinha, 1969) which upon hydrolysis releases the toxic hydrocyanic acid. Several scientists have earlier reported increase in HCN content due to higher rates of N fertilization (Indira *et al.*, 1972; Mohankumar and Maini, 1977; Nair, 1982 and Nayar, 1986). The result of the present study pointed out the need for application of only 75 kg N ha^{-1} for lower HCN content and better taste of the tuber.

The interaction between varieties and sources of organic manure showed significant difference on protein and HCN contents. The improved variety registered higher protein content with FYM and CPC but registered lower HCN content with PM. The local variety showed the highest protein content and the lowest HCN content with FYM. But the interaction between varieties and N levels was significant with respect to protein content only. Higher protein content was shown by the improved variety when fertilized with 100 kg N ha^{-1} whereas the local variety showed the highest protein content when fertilized with 50 kg N ha^{-1}. The quality characters except the taste of tuber were significantly influenced by the interaction between sources of organic manure and N levels. With any organic manure, starch content increased with increase in N level from 50 to 75 kg ha^{-1} but declined at 100 kg ha^{-1}. The organic manures FYM and CPC registered higher protein contents at 75 kg N ha^{-1} while PM registered the highest protein content at 50 kg N ha^{-1}. The HCN content increased with the increase in N level in combination with all sources of organic manure. In general, the interaction between PM and N levels produced lower HCN contents.

5.5 Uptake of nutrients

Uptake of N and K was not influenced by varieties as shown in Table 10a which meant that both varieties were equally efficient in absorption and utilization of these nutrients. But the var. Sree Vijaya registered higher P uptake than the local variety.

The source of organic manure did not produce any appreciable effect on nutrient uptake. Nutrient uptake is a function of dry matter production. There was also no significant variation in TDMP due to source of organic manure as evident from Table 6.

Uptake of N, P and K increased with increase in N level upto 75 kg ha^{-1} but declined at higher N level. Moderate N nutrition at 75 kg ha^{-1} was sufficient for higher nutrient uptake which resulted in higher values of growth characters, yield components, tuber yield, UI and quality characters at this N level.

The data given in Table 10b indicated significant interactions between the treatments with respect to P uptake only. The local variety registered lower P uptake than the improved variety, when combined with different organic manures. Increase in P uptake was observed with increasing N levels in the case of improved variety while the local variety registered higher P uptake at 50 kg N ha^{-1} only. The interaction of any organic manure with 75 kg N ha^{-1} recorded higher P uptake than with lower or higher N level.

5.6 Soil nutrient status after the experiment

Available N status of the soil after the experiment was maintained at the initial level of 235.2 kg ha^{-1} (Table 11a). The content of available P in the soil was lowered after the experiment compared to the original value of 40.47 kg P_2O_5 ha^{-1}. But post harvest available K content was drastically increased above the original content of 138.84 kg ha^{-1}.

No significant variation in available N and K status of soil was observed due to varieties. But the improved variety registered higher status of available P in the soil after the experiment.

Among organic manures, FYM applied plots registered significantly higher status of N and K in the soil while PM and CPC were similar in their effects. Enhancement in post harvest available N status of the soil due to FYM application for arrow root has been documented by Veenavidyadharan (2000). But available P status was not influenced by the source of organic manure.

Available N status of the soil increased with increase in N level though the effect was not significant. An increase in the available N content of the soil due to higher levels of N fertilisation for cassava has been reported by Nayar (1986). Post harvest available P content in the soil was maximum at 75 kg N ha^{-1}. Available P status was considerably reduced when 100 kg N ha^{-1} was applied. No marked variation in the available K content of the soil was observed due to application of N at different levels.

Interaction effects were not significant with respect to post harvest available N status of the soil. But higher available P status and lower K status were observed in CPC applied plots in the case of both varieties. The interaction between varieties and N levels had significant effect on available K status only. Post harvest available K status was maximum when both varieties were fertilized with 75 kg N ha^{-1} compared to lower or higher N level. Whatever be the source of organic manure, higher status of available P in the soil was observed in plots treated with 75 kg N ha^{-1}. But MxN interaction had no marked effect on available N and K contents in the soil.

5.7. Economics of cultivation

The economics of cultivation was worked out in terms of net income and BCR (Table 12). No marked variation in net income and BCR was observed between the varieties as depicted in Fig 5 and 6.

The treatments involving PM as the source of organic manure and 75 kg N ha^{-1} produced higher net income in the case of both varieties. The organic source PM recorded the highest tuber yield (Table 8a and Fig. 3) than other organic manures which might have resulted in higher net income from PM applied plots. However, FYM as the source of organic manure recorded higher BCR compared to other organic sources. Though PM recorded higher net income, its higher cost (Rs. 2000 t^{-1}) compared to FYM (Rs. 235 t^{-1}) has resulted in lower BCR than with FYM. CPC as organic manure registered lower values of net income and BCR compared to FYM and PM. The organic sources FYM and CPC produced almost equal tuber yield (17.88 and 17.14 t ha^{-1} respectively). But higher cost of CPC (Rs. 5000 t^{-1}), compared to FYM and

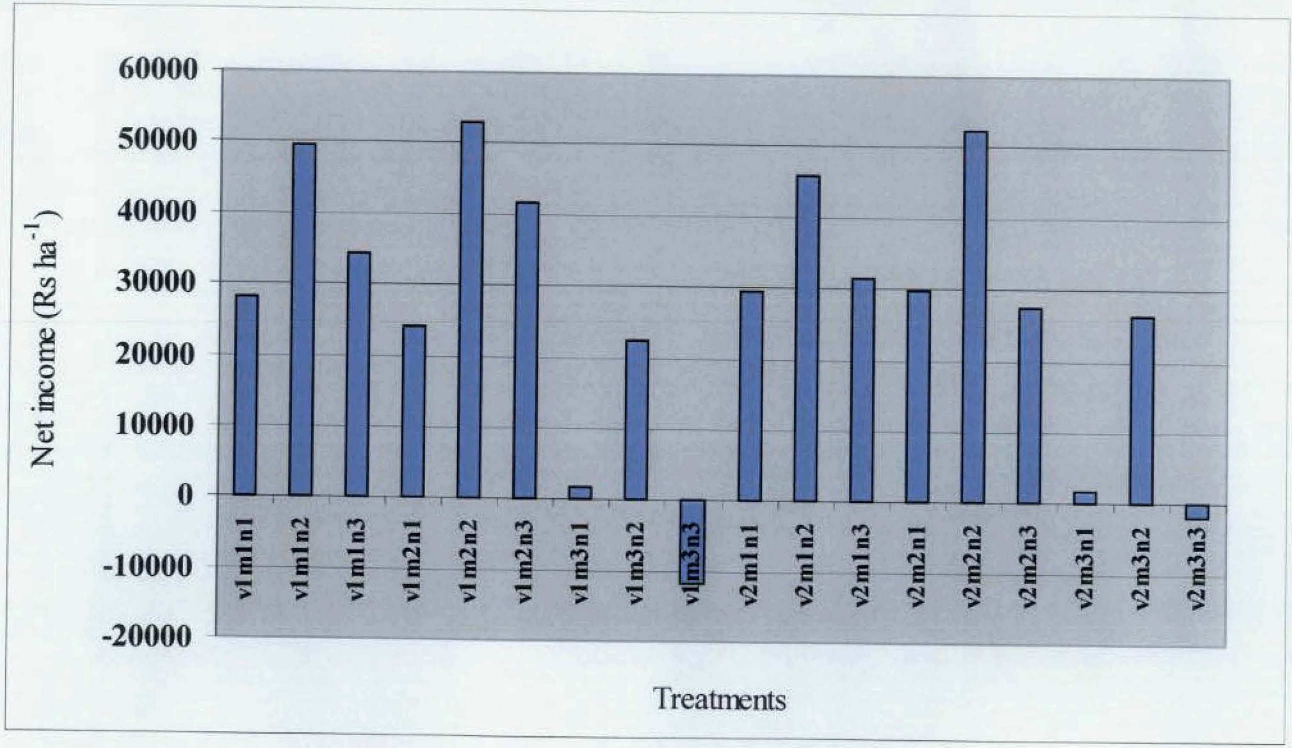

Fig. 5 Effect of varieties, organic manures and N levels on net income

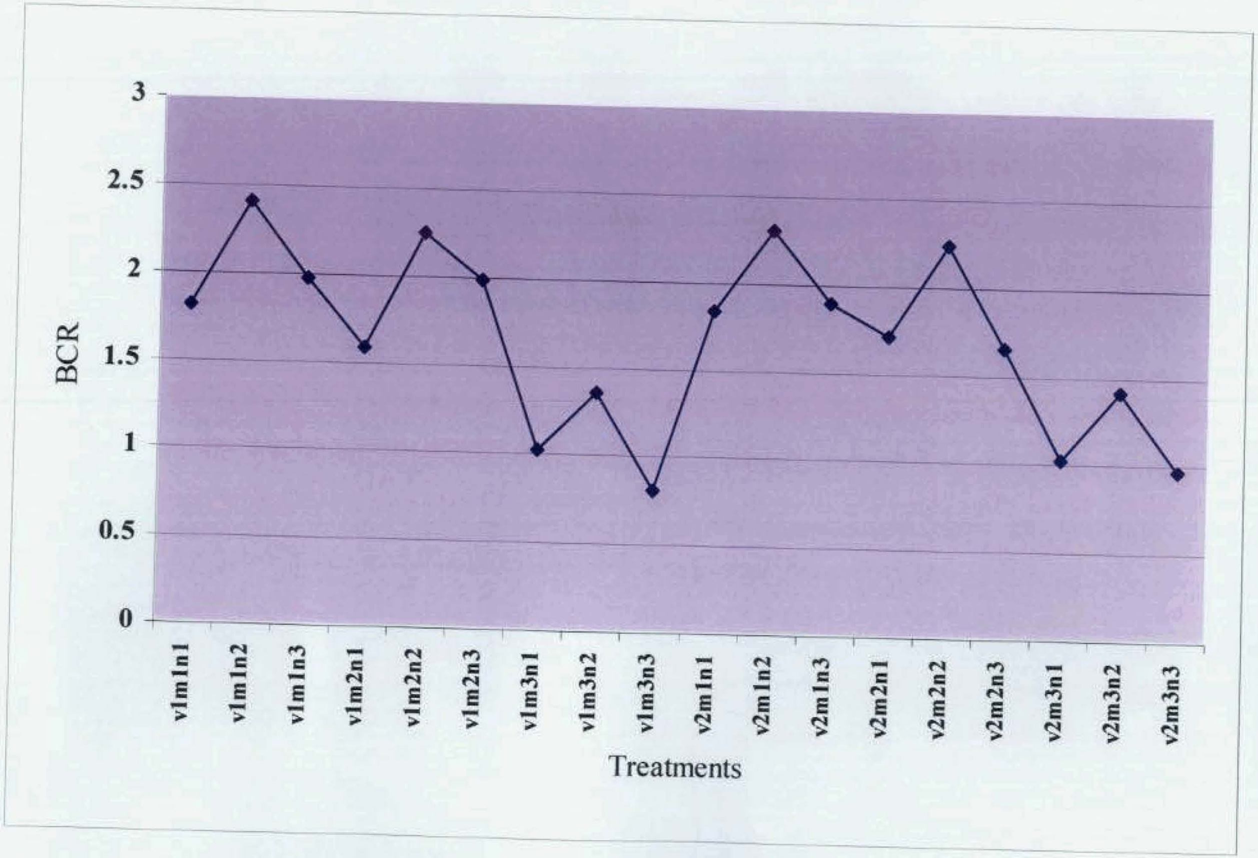

Fig.6 Effect of varieties, organic manures and N levels on BCR

PM, had produced lower values of net income and BCR with CPC. Hence it is evident from the results that FYM can be substituted with PM but not with CPC due to the high cost of CPC.

Application of moderate level of N (75 kg ha^{-1}) compared to lower (50 kg ha^{-1}) or higher level (100 kg ha^{-1}) resulted in higher profit from cultivation of short duration varieties of cassava in low lands. The superior effect of 75 kg N on the yield of cassava had reflected in higher net income and BCR at this level of N as illustrated in Fig. 5 and 6.

Application of PM @ 5 t ha^{-1} and 75 kg N ha^{-1} to the improved var. Sree Vijaya recorded the highest net income of Rs. 52888 (BCR of 2.25). This was followed by PM @ 5 t ha^{-1} and 75 kg N ha^{-1} to the local var. Kariyilapothiyan which recorded net income of Rs. 52248 (BCR of 2.24). But the highest BCR of 2.41 was obtained by the application of FYM @ 12.5 t ha^{-1} and 75 kg N ha^{-1} to the improved variety followed by the application of FYM @ 12.5 t ha^{-1} and 75 kg N ha^{-1} to the local variety (2.30). The study clearly pointed out the need for application of FYM @ 12.5 t ha^{-1} or PM @ 5 t ha^{-1} along with 75:50:100 kg NPK ha^{-1} for obtaining higher returns from both varieties.

SUMMARY

6. SUMMARY

An investigation entitled "Integrated nutrient management for short duration cassava in lowlands" was undertaken at College of Agriculture, Vellayani to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation. The field study was conducted in the Instructional farm attached to the college from September 2002 to April 2003. The treatments consists of factorial combinations of two varieties of cassava (Sree Vijaya and Kariyilapothiyan), three sources of organic manure (FYM, PM and CPC) and three levels of N (50, 75 and 100 kg ha^{-1}). The trial was laid out in 3^2 x 2 asymmetrical confounded factorial design with two replications confounding VMN in replication I and MN in replication II. A uniform dose of 50 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} was applied to all the plots. The salient findings of the study are summarized below.

Although the local variety was found taller than the improved variety during early stage of growth, no significant difference in plant height was noticed between varieties during later stages. The source of organic manure significantly influenced plant height. The organic manure, FYM was found superior to PM and CPC, the effects of which were on par. Nitrogen @ 75 kg ha^{-1} produced taller plants at all stages.

The local var. Kariyilapothiyan produced more number of leaves and retained more number of functional leaves at all growth stages. Plants treated with FYM produced significantly higher number of leaves and retained

significantly higher number of leaves during early stages but there was no marked variation in leaf number and retention due to source of organic manure during later stages. Application of 75 kg N ha^{-1} recorded the highest number of leaves at all stages. Significant effects of VxN and MxN interactions revealed that N @ 75 kg ha^{-1} is sufficient for both varieties and also with any source of organic manure tried.

Leaf area index was found to vary between varieties at 2 MAP and 4MAP and the local variety registered higher index. No marked variation in LAI was observed at harvest between varieties. FYM and PM treated plants produced significantly higher LAI throughout the growth period, when compared to CPC treated plants. The LAI increased with increase in N level from 50 to 75 kg ha^{-1} but decreased at higher level. The interaction MxN was significant at 2 MAP and 4 MAP and the combination of any organic manure with 75 kg N ha^{-1} produced superior values.

Total dry matter production was influenced only by N levels and 75 kg N ha^{-1} produced the highest dry matter.

There was no significant variation between varieties on yield components like number and weight of tubers per plant and girth of tuber. But the improved var. Sree Vijaya produced longer tubers than the local var. Kariyilapothiyan. Among the yield components, only weight of tubers per plant varied with source of organic manure. Poultry manure exhibited superior response than FYM and CPC whereas the effects of FYM and CPC were on par. Nitrogen @ 75 kg ha^{-1} recorded higher values of yield components.

Tuber yield produced by both varieties were almost equal. Among organic manures, the highest tuber yield was produced by PM treated plants but was on par with FYM. At the same time, no appreciable difference in tuber yield was observed between FYM and CPC treated plants. The tuber yield increased when N level was increased from 50 to 75 kg ha^{-1} but decreased when N level was further increased to 100 kg ha^{-1}.

Varieties or organic manures produced no significant variation in top yield. Top yield increased with increase in N level.

Utilization index was not influenced by varieties. Significantly higher UI was registered by PM followed by FYM and the lowest by coir pith compost. Application of 75 kg N ha^{-1} recorded the highest utilization index. Interaction effects also exhibited the same trend as that of main effects.

Neither varieties nor sources of organic manure recorded any significant variation in starch content of the tuber. Significantly higher starch content was registered by 75 kg N ha^{-1}. The interaction MxN had significant effect on starch content. The different sources of organic manure produced higher starch content with 75 kg N ha^{-1} than with 50 or 100 kg N ha^{-1}.

The local var. Kariyilapothiyan registered higher protein content than the improved var. Sree Vijaya. Regarding the source of organic manure, PM recorded the highest protein content. The organic sources, FYM and CPC recorded the same protein content. Nitrogen at 75 kg ha^{-1} was sufficient for obtaining higher protein content. The interactions VxM , VxN and MxN had significant effects on protein content of the tuber. Higher protein contents were produced by both varieties when FYM was used as the organic manure. The protein content was maximum when the local variety was fertilized with 50 kg N ha^{-1} while the improved variety recorded the highest protein content when fertilized with 100 kg N ha^{-1}. The organic manures FYM and CPC recorded higher protein content at 75 kg N ha^{-1} while PM recorded the highest protein content at 50 kg N ha^{-1}.

The HCN content of the tuber of the local variety was lower than the improved variety. With respect to source of organic manure, PM showed lower HCN content followed by farmyard manure. Coir pith compost registered the highest HCN content. Increase in the dose of N from 50 to 100 kg ha^{-1} increased the HCN content though it was within the permissible limits. The interaction effects reflected the trend of the main effects.

In general, the cooking quality of the tuber of both varieties was rated as good based on texture, appearance and overall acceptability. The improved var. Sree Vijaya was observed to cook well in lesser time and obtained higher scores for taste than the local variety. The taste of the tuber was not affected by the source of organic manure. Maximum score for taste was recorded by 75 kg N ha^{-1} compared to other N levels.

Uptake of N and K were not influenced by the varieties. But P uptake varied between varieties and var. Sree Vijaya registered higher uptake than the local variety. Nutrient uptake did not vary with the source of organic manure. The highest uptake of nutrients was registered by 75 kg N ha^{-1} compared to other N levels. The interaction effects were significant only in the case of P uptake. Higher values of P uptake were recorded by the improved variety when combined with different organic manures. The improved variety registered higher P uptake at 100 kg N ha^{-1} while the local variety registered higher P uptake at 50 kg N ha^{-1}. Application of 75 kg N ha^{-1} recorded higher P uptake when combined with different organic manures.

Varieties or N levels did not produce any significant effect on available N and K contents in the soil after the experiment. Among organic manures, FYM applied plots showed higher status of these nutrients compared to PM and CPC applied plots. Regarding post harvest available P status of the soil, the improved variety produced higher value than the local variety. Source of organic manure had no effect on available P status. Nitrogen at 75 kg ha^{-1} registered higher content of available P in the soil. Post harvest available N status was not influenced by the interaction effects. But available P and K contents in the soil was significantly influenced by VxM interaction. CPC applied plots recorded higher available P status but lower available K status in the case of both varieties. VxN interaction had significant effect only on available K content. The plots cultivated with either the improved variety or the local variety and fertilized with 75 kg N ha^{-1} showed higher available K content. The effect of MxN interaction had significant effect on available P status of the soil. All organic manures combined with 75 kg N ha^{-1} registered higher available P in the soil after the experiment.

When the economics of cultivation was worked out, the highest net income was obtained by the application of 5 t PM and 75 kg N along with 50 kg P_2O_5 and 100 kg K_2O ha^{-1} and the highest BCR was obtained by the application of 12.5 t FYM and 75:50:100 kg NPK ha^{-1} in the case of both varieties.

The results clearly revealed that, in lowlands, the response to N levels as well as to the sources of organic manure did not vary between the improved var. Sree Vijaya and the local var. Kariyilapothiyan, both having a duration of 6-7 months. The study also pointed out the need for application of FYM @ 12.5 t ha^{-1} or PM at 5 t ha^{-1} along with 75:50:100 kg NPK ha^{-1} for obtaining higher returns from cassava cultivation in lowlands. The study suggested the suitability of PM as an alternative to FYM for cassava cultivation in lowlands. Coir pith compost can also be used as an alternate source of organic manure provided it is made cost effective.

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Future line of research

In the present study, only two short duration varieties and varying levels of only N were tried. The trial may be repeated with other cassava varieties incorporating varying levels of P and K also to confirm the results. Studies may be conducted with other organic manures like vermicompost and neem cake. For economic viability, partial substitution of FYM with other organic manures rather than complete substitution also needs investigation.

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INTEGRATED NUTRIENT MANAGEMENT FOR SHORT DURATION CASSAVA IN LOWLANDS

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ABSTRACT

An investigation entitled "Integrated nutrient management for short duration cassava in lowlands" was undertaken in the Instructional Farm, College of Agriculture, Vellayani from September 2002 to April 2003 to develop an integrated nutrient schedule for short duration cassava in lowlands and to work out the economics of cultivation. The treatments consisted of factorial combinations of two varieties of cassava (Sree Vijaya and Kariyilapothiyan), three sources of organic manure (farmyard manure, poultry manure and coir pith compost) and three levels of nitrogen (50, 75 and 100 kg N ha^{-1}). The trial was laid out in 3^2 x 2 asymmetrical confounded factorial design with two replications confounding VMN in replication I and MN in replication II. A uniform dose of 50 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} was applied to all the plots.

In general, the local var. Kariyilapothiyan recorded superior values of growth characters like plant height, leaf number and leaf area index. Among organic manures, farmyard manure produced higher values of growth characters. But total dry matter production was not influenced either by varieties or by sources of organic manure. Levels of N had profound influence on growth characters and 75 kg N ha^{-1} was found superior in the case of both varieties.

Varieties exhibited no variation in yield components except length of tuber. The improved var. Sree Vijaya produced longer tubers than the local variety. The yield components except tuber weight per plant did not vary with the source of organic manure. Poultry manure recorded the highest value of tuber weight per plant. Nitrogen @ 75 kg N ha^{-1} recorded higher values of yield components.

The performance of both varieties in terms of tuber yield, top yield and utilization index was found similar. Among organic manures, the highest tuber yield was recorded by poultry manure which was on par with farmyard manure but superior to coir pith compost. At the same time the effect of farmyard manure was on par with coir pith compost. The top yield was not influenced by the source of organic manure but utilization index exhibited the same trend as that of tuber yield. The tuber yield increased when N level was increased from 50 to 75 kg N ha^{-1} but decreased with further increase in the level of nitrogen. Top yield increased with increase in the level of nitrogen. Application of 75 kg N ha^{-1} registered the highest utilization index.

Neither varieties nor sources of organic manure recorded any significant variation in starch content of the tuber. But the local variety recorded higher protein content and lower HCN content than the improved variety. Poultry manure treated plants registered the highest protein content and the lowest HCN content. Application of 75 kg N ha^{-1} was sufficient for obtaining higher starch and protein contents. The HCN content increased with increase in the level of nitrogen though it was within permissible limits.

The improved var. Sree Vijaya obtained higher scores for taste than the local variety. The taste of the tuber was not affected by the source of organic manure. Maximum score for taste was recorded by 75 kg N ha^{-1}. The cooking quality of the tuber of both varieties was judged as good.

Uptake of N and K was not influenced by varieties. But in the case of P uptake, the var. Sree Vijaya recorded higher P uptake than the local variety. Nutrient uptake did not vary with the source of organic manure. Maximum uptake of nutrients was observed when 75 kg N ha^{-1} was applied.

Significant variation in available N and K status of the soil after the experiment was observed only due to source of organic manure. Farmyard manure applied plots showed higher status of these nutrients compared to poultry manure and coir pith compost applied plots. Higher status of available P was observed in the soil when the improved variety was raised irrespective of the source of organic manure. Nitrogen @ 75 kg N ha^{-1} registered higher available P content in the soil after the experiment.

The study revealed that application of farmyard manure @ 12.5 t ha^{-1} or poultry manure @ 5 t ha^{-1} along with 75:50:100 kg NPK ha^{-1} resulted in higher returns from Sree Vijaya and Kariyilapothiyan, two short duration varieties of cassava, in lowlands. No variation between varieties was observed in their response to N levels as well as to the sources of organic manure. The results suggested the suitability of poultry manure as an alternative to farmyard manure for cassava cultivation in lowlands. Coir pith compost can also be used as an alternate source of organic manure provided it is made cost effective.

APPENDIX I

Weather data during the cropping period – weekly averages

Standard week	Maximum temperature °C	Minimum temperature °C	Rainfall (mm)	Relative humidity (%)	Evaporation (mm)
39	29.1	23.7	25.7	74.6	5.0
40	30.6	23.5	8.7	83.1	3.2
41	30.3	22.9	5.2	86.9	2.6
42	30.0	23.1	3.3	90.4	1.7
43	30.2	23.7	4.8	85.4	3.4
44	30.3	23.2	3.0	86.0	2.1
45	30.2	23.5	nil	87.1	1.9
46	31.2	23.7	0.5	84.1	2.6
47	31.3	22.9	nil	83.1	0.5
48	31.1	22.2	nil	83.0	3.1
49	30.6	23.4	nil	83.0	2.6
50	31.1	22.9	nil	78.2	3.2
51	32.0	21.6	nil	76.9	2.4
52	31.6	20.8	nil	78.1	2.9
1	31.2	21.3	0.3	78.4	3.4
2	31.6	22.5	nil	75.6	3.3
3	31.9	21.1	7.4	72.2	3.9
4	32.1	21.6	2.2	77.8	3.5
5	31.2	20.9	nil	74.0	4.0
6	31.9	23.1	0.2	76.8	4.1
7	32.5	23.3	nil	79.0	4.4
8	32.8	21.9	1.24	77.6	4.3
9	32.0	22.8	14.2	77.1	3.8
10	32.6	22.8	0.6	76.5	4.4
11	32.5	23.7	4.3	75.2	4.2
12	33.2	23.6	0.1	79.3	4.1
13	32.9	23.6	2.0	79.3	3.8
14	33.0	24.4	2.9	77.8	3.9
15	32.3	24.6	6.7	77.9	3.0
16	32.7	25.0	16.3	79.7	3.4
17	32.5	25.3	0.6	77.0	3.3
18	32.5	24.6	nil	83.2	4.5