NUTRIENT MANAGEMENT FOR INTERCROPPED *Colocasia esculenta* Var THAMARAKANNAN

BY

RAJASREE J.

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DECLARATION

I hereby declare that this thesis entitled "Nutrient management for intercropped *Colocasia esculenta* var. Thamarakannan" 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.

Rajasree

Vellayani,
8-07-1993.

RAJASREE J.

CERTIFICATE

Certified that this thesis entitled "Nutrient management for intercropped Colocasia esculenta var. Thamarakannan" is a record of research work done independently by Smt. Rajasree J., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. M. Oommen

Chairman,

Advisory Committee.

Vellayani,

8-7-1993

APPROVED BY:

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Dr. M. OOMMEN

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3. **Dr. (Mrs). P. SARASWATHY** 8/7/93

EXTERNAL EXAMINER: 19-10.93

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RAJASREE J.

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INTRODUCTION

INTRODUCTION

Colocasia esculenta L. Schott is one of the important, edible, tropical aroids cultivated as an intercrop in coconut gardens in Kerala. Colocasia is an adaptable crop and grows on a wide range of soils, but for maximum growth, fertile soils are required. As a pure crop, it is grown in small holdings, and as such, the exact area and production of colocasia in Kerala is not available.

Colocasia is adapted to a wide range of ecological conditions that exist in the tropics. The ability of colocasia to tolerate shady conditions makes them suitable for intercropping between taller plantation crops, so that light filtering through the plantation canopy is not wasted.

Colocasia has usually been studied as a monocrop in the open and at present, the recommendation is available only for the pure crop (Kerala Agricultural University, 1986).

Hence, a study of this type is undertaken to find out the nutrient levels for optimum tuber yields in intercropped colocasia compared with that grown in open. Also, the uptake of nutrients in colocasia under different cropping situations has not been studied so far.

Considering the above, the present investigation has been taken up with the following specific objectives:

1. To study the nitrogen and potassium requirements of colocasia as a pure crop in open and as an intercrop in coconut gardens.

2. To compare the nitrogen and potassium requirements of colocasia as a pure crop in the open and as an intercrop and

3. To work out the economics of Colocasia cultivation as a pure crop in the open and as an intercrop in coconut garden.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Colocasia is mostly grown as a subsistence crop throughout the tropics, sub-tropics and in many warmer regions of the temperate zone. Only in a few countries viz., Hawaii and certain islands in the Carribean has it attained the status of a commercial crop. Research work on Colocasia is meagre as compared to the other tropical root crops like cassava, sweet potato and yams. However, efforts have been made to collect the available research work on Colocasia, and wherever information is lacking, relevant work on other tuber crops have been reviewed.

This review is classified into two sections, viz., (i) the response of Colocasia and other tuber crops to varying intensities of shade, and (ii) response of Colocasia and other related crops to major plant nutrients under open and partially shaded conditions.

2.1. Response of Colocasia and other tuber crops to varying intensities of shade

2.1.1. Plant height

In the case of ginger, Aclan and Quisumbing (1976) reported that plants grown under full sunlight were shorter than those in shade.

Lalithabai (1981) reported maximum plant height at full illumination and this was on a par with 25 and 50 per cent shade and significantly superior to 75 per cent shade in Colocasia.

Bai and Nair (1982) reported that plant height is unaffected by shading in Colocasia.

Ramanujam et al. (1984) found that in different cultures of cassava, plant height continued to increase under shade.

Pushpakumari (1989) noticed the influence of shade on plant height in minor tuber crops. The height of Xanthosoma was significantly influenced by shading at different stages of growth and in elephant foot yam, the plants grown under 75 per cent shade were significantly taller than other shade levels.

Pramila (1990) reported that in Colocasia, plant height went on increasing with increasing levels of shade at 60 and 120 days after planting (DAP).

2.1.2. Number and size of leaves

Matusie Wiez (1967) in his pot culture study on sugar beet observed that the number of leaves died during the vegetative period and the total dry matter of leaves were increased by shading.

Aclan and Quisumbing (1976) also observed shorter and fewer number of leaves in ginger grown under full sun.

Gumbs and Ferguson (1976) reported that in yam, leaf development was not affected initially by light treatments, but 15 weeks after planting, the plants under shade had larger number of leaves and leaf area plant^{-1}.

Caesar (1980) tested Xanthosoma sagittifolium and Colocasia esculenta var. antiquorum for tolerance to shade and water stress and observed that Xanthosoma sagittifolium produced highest dry matter yield under shade and full water supply by developing long petioles and large leaf blades and the opposite was the case with Colocasia esculenta var. antiquorum.

Leaf area indices of crops, viz., ginger, tumeric and coleus were also observed to be not influenced by different shade intensities (Lalithabai, 1981).

Martin (1985) noticed increase in foliage growth of sweet potato under lower light intensities.

In an experiment with sweet potato, the plants were established in full sunlight for two weeks and thereafter shade treatments of full light, 25 per cent shade, 50 per cent shade and 75 per cent shade were given. Roberts - Nkrumah et al. (1986) observed no significant difference in mean total leaf area among treatments.

Pushpakumari (1989) stated that shade significantly influenced the LAI at all stages of growth in greater yam, lesser yam, tannia and elephant foot yam.

Pramila (1990) reported that no significant effect of shade on number of leaves was noticed either at 60th or 120th day after planting.

2.1.3. Dry matter production

Blackman and Wilson (1951 a & b) reported that the ability of plants to tolerate shade depends on the efficiency of total dry matter production.

Monteith (1969) demonstrated that the maximum amount of dry matter accumulated by a crop was strongly correlated with the amount of radiation intercepted by its foliage.

Caesar (1980) observed the highest dry matter yield of *Colocasia esculenta* under full sunlight, whereas *Xanthosoma sagittifolium* produced highest dry matter under shade.

Crops like ginger, turmeric, colocasia, coleus and sweet potato were reported to show a declining trend in the total dry weight of plant with increase in shade (Lalitha bai, 1981).

Increased dry matter production at reduced light is also reported in ginger (Ravishankar and Muthuswamy, 1987).

Pushpakumari (1989) reported that dry matter production was significantly influenced by shade. At harvest stage, highest dry weight accumulation was observed under open condition for greater yam and elephant foot yam while tannia and lesser yam recorded highest value at 25 per cent shade.

Pramila (1990) obtained the highest values of dry matter production in Colocasia at 25 per cent shade level.

2.1.4. Yield and yield attributes

The environmental condition under which a plant grows control the productivity of the plant to a great extent. Out of the various physical environmental factors, the light regime is one which has much influence on the growth and productivity of a plant (Bindra & Brar, 1977).

It has been reported that yield reduction in sweet potato when intercropped with corn (Escobar - Caranza, 1975, Lizarraya-Herrera, 1976 and Moreno, 1982) and coconuts (Zara *et al*, 1982) was attributed to shade imposed by taller crop.

Colocasia did not show any marked decrease in yield with increase in shade upto 50 per cent of full light (Lalithabai, 1981).

Caesar (1980) reported that in *Xanthosoma sagittifolium* and *Colocasia esculenta*, the corm grew only under shade condition and the growth of cormels was negligible. Cormel yield was only 50 per cent of that of corm under shade, as against twice the yield of cormel as that of corm in full sunlight and good water supply. He observed the enhanced ability of the plants grown under shade to survive stress conditions but only with a low yield of edible material.

Sweet potato recorded a drastic decrease and coleus recorded a linear decrease in yield with increase in shade intensity (Lalithabai, 1981). The effects of shading and mulching on the yield of potatoes was studied by Asandhi and Suryadi (1982) and reported that shading had no beneficial effect on potato growth and reduced dry matter production and tuber yield. Blanc (1983) reported that the rate of tuberisation increased with increase in the duration of exposure to light.

Ramanujam *et al*. (1984) and Okoli and Wilson (1986) found that cassava will respond to reduced light with a significant reduction in tuber yield.

Igbokwe *et al*. (1985) studied the intercropping effect of cocoyam with plantain and observed that intercropping reduced the yield of both Colocasia esculenta and Xanthosoma sagittifolium when compared to pure stands.

Pushpakumari (1989) noticed that with increase in shade intensity, the yield declined proportionately in greater yam and elephant foot yam recorded highest yield under open condition.

Pramila (1990) obtained highest tuber yield in Colocasia under light shade of 25 per cent.

2.1.5. Quality of produce

Light regimes of a plant determine the productivity and quality of its produce (Tikhomirov *et al*, 1976).

Aclan and Quisumbing (1976) recorded lowest starch contents in rhizomes under 75 per cent shade in ginger.

Hozyo and Kato (1976) observed that the roots of sweet potato when exposed to sunlight, resulted in the decrease in starch content of the exposed parts.

Ravishankar and Muthuswamy, (1987) noticed that ginger crop grown in shade provided quality rhizomes. When volatile oil, non volatile acetone extract, starch and protein showed a slow increase with increasing shade, the crude fibre content was unaffected by shading.

Pushpakumari (1989) reported that the percentage of starch in tuber was significantly influenced by shade showing a decreasing trend with increase in shade intensity in greater yam, lesser yam, tannia and elephant foot yam.

Pramila (1990) has reported that the starch content of the tuber showed a progressive decrease with shading from a mean of 28.6 to 21.6 per cent. The oxalic acid content was also high in the tuber grown in the open.

2.1.6. Nutrient content

According to Lalithabai (1981), contents of nitrogen, phosphorus and potassium in all the plant components of coleus, colocasia, sweet potato, turmeric and ginger increased with increasing intensities of shade.

Pushpakumari (1989) reported higher uptake of nitrogen, phosphorus and potassium for lesser yam and tannia at 25 per cent shade level.

Pramila (1990) observed that the quantities of nitrogen and potassium were more in the haulm compared to tubers, whereas phosphorus was more in tuber for Colocasia. In general, the nutrient contents in haulm and tuber were high under shaded condition compared to open.

Plant response to sunlight varies with species and most of the tuber crops prefer bright sunlight for its normal growth and expression of yield. However, some workers have noticed that crops like colocasia varied its response to light intensity. Up to 50 per cent shade did not show any marked depression in the growth and yield of the crop. It was also noticed that the size of the plant viz., height and leaf size was marginally increased due to shading upto 50 per cent light intensity. Under shaded conditions, the quality aspects viz., the starch content was reduced in most of the tropical tuber crops.

2.2. Response of Colocasia and other related crops to major nutrients under the open and in shade conditions

2.2.1. Effect of nitrogen on growth characters

Purewal and Dargan (1975 a) reported that though nitrogen had no effect on number of leaves, its application at 50-100 kg ha^{-1} significantly increased plant height and leaf area of *Colocasia*.

Haynes *et al*. (1967) found that in tannia, leaf area can be increased by the application of nitrogen fertilization.

According to de la Pena and Plucknett (1972), nitrogen fertilization increased corm weight of both upland

and lowland Colocasia and also leaf weight. Similar results were also obtained by Sivan et al. (1972) in Fiji, wherein the ill effects of closer spacing on reduced tuber size was nullified by the application of nitrogen in Colocasia.

Wilson (1973), in sweet potato observed that the onset of early tuber growth was inversely related to nitrogen supply. High levels of nitrate nitrogen retarded early tuber growth.

Enyi (1973) reported that in Colocasia, application of nitrogen increased the leaf area, duration, tuber number $plant^{-1}$ and mean bulking rate. He also observed that in tannia, application of fertilizer increased the LAI and also the dry weight of both primary and secondary corms.

Hussain and Rashid (1982) found that in Colocasia, plant height, leaf area etc., were modified by the higher levels of nitrogen only. Pardales et al. (1982) observed that the performance of Colocasia under low land condition was affected by genotype, nutritional status and population density.

Mohankumar (1986) reported that application of nitrogen at levels of 40 and 80 kg ha^{-1} had significant effect on plant height and LAI of Colocasia.

Pushpakumari (1989) observed that for greater yam grown in coconut based cropping system, the number of leaves per plant was not significantly influenced by fertilizer levels.

2.2.2. Effect of nitrogen on yield attributes

Plucknett *et al* (1970) reported that nitrogen application increased corm weight in both low and upland taro.

Enyi (1973) found that the application of nitrogen increased the tuber number per plant and mean bulking rate in taro.

Chandra (1979) from Fiji reported that in the absence of nitrogen, most of the corms were smaller in size and of low economic value. However, with nitrogen, most of the corms were in the preferred market range and only 10 per cent of the corms were less than the preferred market range in taro.

2.2.3. Effect of nitrogen on yield

Purewal and Dargan (1957) have reported that application of 100 kg of nitrogen per hectare was found to be more economic for increased yield of Colocasia.

Mathur *et al* (1966) found that with increased levels of nitrogen the tuber yield increased upto 224 kg ha^{-1} of nitrogen in Colocasia. But the economic optimum dose of nitrogen for Colocasia worked out to be 200 $kgha^{-1}$. It was observed by de la pena and Plucknett (1967) that in upland taro, the total yield increased significantly by increasing nitrogen fertilization.

Samuels and Veies (1968) reported that in tannia corm yields were increased by levels of N from 100 to 200 kg ha^{-1}.

Krochmal and Samuels (1970) found that in cassava, increased production of crop has to a large extent been associated with the increased use of fertilizers, particularly nitrogen.

Karikari (1974) in Ghana found that application of nitrogen upto 100 $kgha^{-1}$ increased yield in Xanthosoma.

Chandra (1979) reported that in Fiji, optimum economic response to taro was observed with 100 kg ha^{-1} of N. Application of nitrogen increased both the total plant yield and corm yield, but it slightly reduced dry matter of corms.

Sivan (1979) while studying the growth and development of taro under dryland condition in Fiji reported that nitrogen increased sucker production and yield. With adequate amounts of nitrogen, both sucker production and yield can be increased. Similar results were reported by Moles *et al*, (1984).

Hussain and Rashid (1982) in Bangladesh found that the yield of Colocasia for varying levels of nitrogen were 11.08, 13.63 and 16.72 t ha^{-1}, at 0, 40, 80 kg N ha^{-1} respectively.

Rahman and Rashid (1983) in Bangladesh observed that there was a linear response to the application of nitrogen to *Colocasia esculenta* from 0 to 50 $kgha^{-1}$.

Moles *et al* (1984) in Papua New Guinea found that there was a significant quadratic response to nitrogen for suckers, main corm and total yield in taro.

2.2.4. *Effect of nitrogen on quality of tubers*

Plucknett *et al* (1970) observed that nitrogen application increased the corm dry matter of taro in Hawaii. Similar results were reported by Mohandas and Sethumadhavan (1980) in Colocasia.

Chandra (1979) found that nitrogen increased both total yield and corm in taro.

Premraj *et al* (1980) reported that levels of nitrogen increased the oxalic acid content in tubers of Colocasia.

Mandal *et al* (1982) found that the oxalate content was not affected by nitrogen in Taro.

Mohankumar (1986) reported that the content of protein in cormel increased significantly with levels of N from 40 to 120 $kgha^{-1}$.

2.2.5. Effect of potassium on growth characters

Purewal and Dargan (1957) reported that plant height and leaf area increased significantly by the application of 50 kg of potash per hectare in Colocasia.

Fujise and Tsuno (1967) demonstrated that the leaf area was some what low in the high potassium plot as compared with the control.

Pillai (1967) did not observe any effect on height of the plant, number of suckers and leaf area upto 120 $kgha^{-1}$ whereas potash had significant effect on the number of leaves in colocasia.

2.2.6. Effect of potassium on yield and yield attributes

Pillai (1967) reported that the effect of potassium on the size and shape of Colocasia tubers was not significant.

Plucknett *et al* (1970) found that application of potassium seemed to increase the corm weight of lowland taro.

Asokan and Nair (1984) showed that the cormel size in Colocasia was conspicuously influenced by the application of potassium. The highest cormel size was recorded at 80 kg K_2O ha^{-1}. Increasing the potassium dose did not further improve the cormel size, but the yield and yield attributes increased with higher levels of potassium application.

Investigations on the effect of potassiu fertilizers on the yield of Colocasia revealed th application of potassium fertilizers increased the y significantly over control (Purewal and Dargan, 1957).

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Investigations on the effect of potassium fertilizers on the yield of Colocasia revealed that application of potassium fertilizers increased the yield significantly over control (Purewal and Dargan, 1957).

Pillai (1967) reported that potassium fertilizers at the rate of 120 kg ha^{-1} increased the yield of Colocasia tuber significantly.

It was observed by de la Pena and Plucknett (1967) that there was a significant increase in yield of upland Colocasia due to increased fertilization with potassium.

Gollifer (1972) in Colocasia observed an yield increase of 50 per cent by increasing the potassium application from 0 to 160 kg ha^{-1}.

2.2.7. Effect of potassium on quality of tubers

Pillai (1967) reported that the application of potassium had significant influence on the starch content of tuber in *Colocasia*.

Mohandas and Sethumadhavan (1980) indicated that the higher levels of potassium application tended to increase the content of starch in *Colocasia*. Similar results were reported by Premraj *et al*. (1980). He also observed that both nitrogen and potassium increased the oxalic acid content of Colocasia tubers.

Asokan and Nair (1984) indicated that the content of oxalic acid tended to decrease with increasing levels of potassium.

Mohankumar (1986) reported that quality aspect like dry matter content and starch percentage in cormels were increased and oxalate content reduced significantly by potassium application ranging from 50 to 150 kg K_2O ha^{-1}.

2.2.8. Combined effect of Nitrogen and Potassium

Cresencio and Molinyawe (1967) stated that Colocasia required 500 to 600 kg per hectare of a mixture of 6 per cent N, 6 per cent P_2O_5 and 12 per cent K_2O for good yield of corms.

Pillai (1967) observed that Colocasia responded linearly to NPK application upto 80, 60, 120 kg ha^{-1} respectively.

Berwick *et al*. (1972) in Fiji found that *Colocasia* responded upto 100 kg ha^{-1} N. However there was no response to P & K.

Mandal *et al*. (1972) opined that Colocasia responded to NPK at the rate of 100:15:100 kg ha^{-1}.

Kagbo *et al*. (1973) found that application of P and K without N did not give any significant difference in yield.

Lyonga *et al*. (1973) in an NPK trial on *Diascorea rotundata* found that there was response to both N and K and a positive interaction between them, but not to P. Similar results were reported by Coursey (1968) and Lucas *et al*. (1973).

Villaneuva and Tupas (1979) in the Philippines reported that for lowland Colocasia, there was a linear respo upto 150:150:150 kg ha^{-1} whereas upland Colocasia responded up 90 : 90 : 90 kg NPK ha^{-1}.

Colocasia varies its response to N and K under open and shaded situations. The crop respond to N at the lower regimes viz., 40 to 80 kg ha^{-1} under the shaded environment. The higher application fails to exert any influence on the growth or yield of the crop. However, it marginally improved the protein content of the cormel. The response of K was almost linear upto 100 kg ha^{-1} in both open and shaded conditions. The K application not only increased the growth and yield attributes but improves the quality aspects also. A balanced dose of N and K to 1:2 or 1:4 depending on the soil conditions were necessary for better crop growth and yield.

The important tuber crops showed marked variation in its response to shade. It was noticed that colocasia prefers a shade environment upto 50 per cent. The requirement of nitrogen showed an appreciable variation in shade and open situations. The crop responds to comparatively lower levels of N in the shade environment than open. However, the K requirement showed a linear trend up to 100 kg ha^{-1} in both open and shade situations.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field experiment was conducted to study the effect of N and K on Colocasia esculenta variety Thamarakannan grown under open and as an intercrop in coconut garden.

3.1. Experimental site:

The experiment was carried out in the Instructional Farm attached to the College of Agriculture, Vellayani. The college is located at 8° N latitude $76^{\circ}57'$ E longitude and at an altitude of 29 metres above mean sea level.

3.1.2. Soil

The soil of the experimental area was red loam with the following physico-chemical properties.

Soil characteristics of experimental fields.

	Method	Open condition	Intercrop in coconut garden
A. Mechanical composition	(Piper, 1966)		
1. Coarse sand (%)		13.60	13.50
2. Fine sand (%)		33.40	33.00
3. Silt (%)		28.00	28.40
4. Clay (%)		24.90	25.00
B. Chemical composition			
1. pH	1:2.5 soil solution ratio using pH meter	5.30	5.30
2. Available N	Alkaline $KMnO_4$ method (Subbiah & Asija, 1956)	373.10 kg ha^{-1}	394.54 kg ha^{-1}
3. Available P	Bray colourimetric method (Jackson, 1967)	21.84 kg ha^{-1}	23.16 kg ha^{-1}
4. Available K	Ammonium acetate method (Jackson, 1967)	187.70 kg ha^{-1}	187.14 kg ha^{-1}

3.1.3. Cropping history of the field

The experimental fields were lying fallow for about a year prior to the start of the experiment.

3.2. Season

The experiments were conducted during the main Colocasia planting season of May - June to October - November, 1990. The experiments were conducted under rainfed condition.

3.3. Weather conditions

The meteorological parameters viz. maximum and minimum temperature, rainfall and relative humidity were recorded and collected from the meteorological observatory of the Department of Agronomy, College of Agriculture, Vellayani.

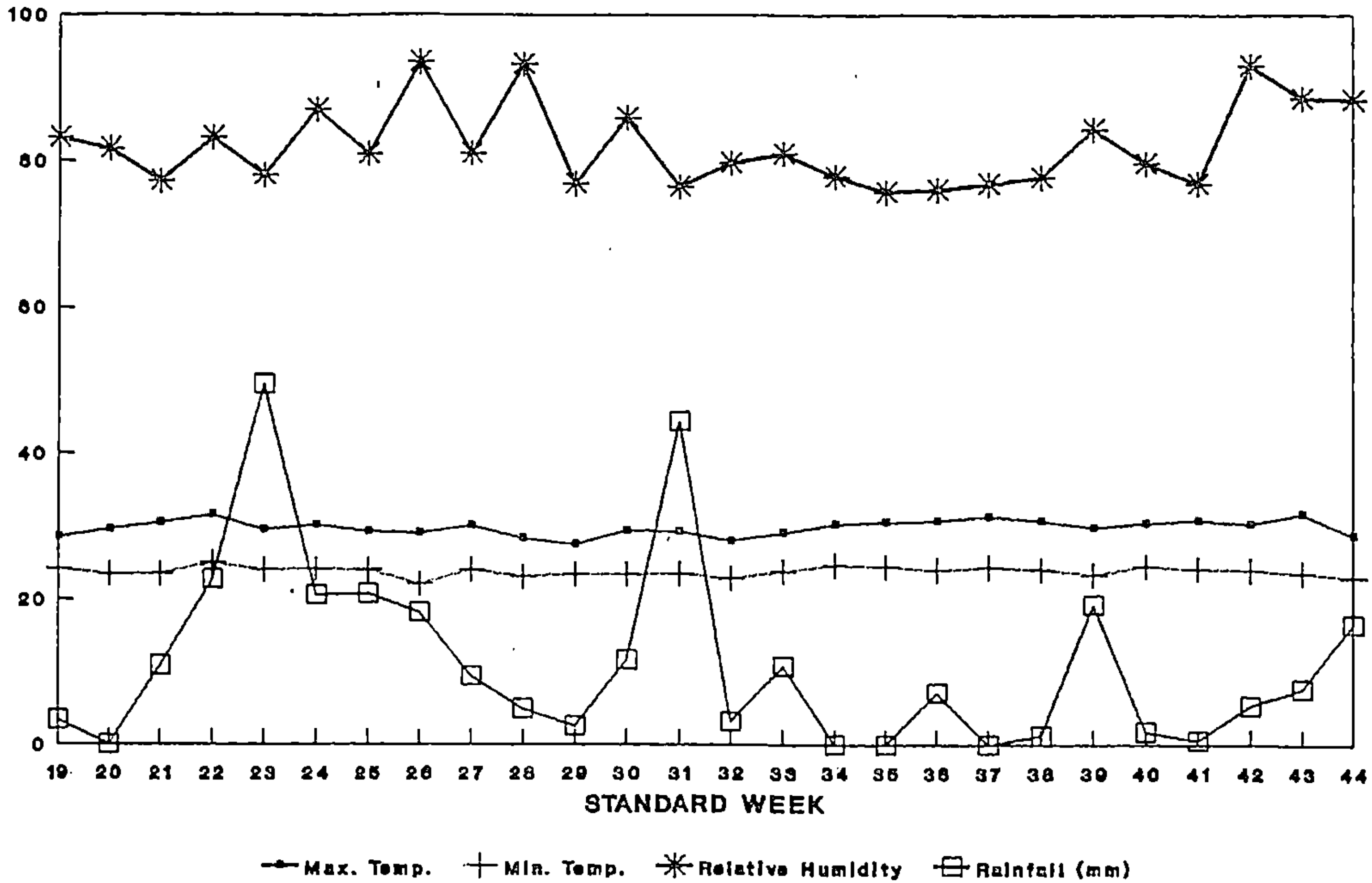
The weather condition which prevailed during the cropping period are shown in Appendix - I and illustrated in Fig.1.

3.4. Materials

3.4.1. Planting material and variety

The uniform sized planting material of variety Thamarakannan was obtained from the Central Tuber Crops Research Institute, Trivandrum. It is a popular

Fig. 1. Weather conditions during the cropping period (May to October, 1990)



variety cultivated throughout the state due to its superior cooking quality. It is not season bound and it can be raised during any part of the year provided there is irrigation facility.

3.4.2. Manures and Fertilizers

Farm yard manure containing 0.46 per cent N, 0.30 per cent P_2O_5 and 0.27 per cent K_2O was used for this trial. Fertilizers used for the study were urea with N content of 46 per cent, super phosphate with P_2O_5 content of 16 per cent and muriate of potash with K_2O content of 60 per cent.

3.5. Methods

3.5.1. Design and layout of the experiment

A. Effect of Nitrogen and Potassium on *Colocasia esculenta* var. Thamarakannan grown under open condition

The experiment was laid out in 3^2 factorial randomised block design. There were ten treatments with three replications each. The treatments consisted of combinations of three levels of Nitrogen and three levels of potash, and one control. The level of phosphorus was kept constant at the rate of 50 kg ha^{-1} in all the treatments. The different treatments were alloted randomly in each block.

The various treatment and their combination were as follows :

n_1 - 40 kg N ha^{-1}

n_2 - 60 kg N ha^{-1}

n_3 - 80 kg N ha^{-1}

k_1 - 80 kg K_2O ha^{-1}

k_2 - 120 kg K_2O ha^{-1}

k_3 - 160 kg K_2O ha^{-1}

Treatment combinations

T_1 $n_1p_ok_1$

T_2 $n_1p_ok_2$

T_3 $n_1p_ok_3$

T_4 $n_2p_ok_1$

T_5 $n_2p_ok_2$

T_6 $n_2p_ok_3$

T_7 $n_3p_ok_1$

T_8 $n_3p_ok_2$

T_9 $n_3p_ok_3$

T_{10} $N_oP_oK_o$ (control where nutrient application was as per the package of practices recommendations of KAU ie, 80 : 50 : 100 kg ha^{-1} NPK).

Number of replications - 3

Number of treatments per replication - 10

Gross plot size - 3.6 m x 2.7 m

Net plot size - 2.4 m x 1.8 m

Spacing - 60 cm x 45 cm

B. Effect of Nitrogen and Potassium on *Colocasia esculenta* var. Thamarakannan as an intercrop in coconut gardens.

Coconut garden of about thirty years age, at a spacing of 7.5 m x 7.5 m was selected as the experiment site. Fertilizer recommendations as per package of practices recommendations (for average management ie, 0.34, 0.17, 0.68 kg/palm of NPK) is being followed in the coconut garden. Plots for the experiment were laid out in between three rows of coconut trees. Two rows of plots, each containing fifteen plots were laid out. The various treatments and three combinations were the same as for experiment - I.

The lay-out plans for experiment A and B are presented in figure 2.

3.5.2. Land preparation and planting

The experimental area was ploughed to a depth of 20-25 cm and brought to a fine tilth. The plots were formed by forming small ridges of 30 cm width and 15 cm height all round the plots.

3.5.3. Manuring

Farm yard manure was applied uniformly as basal dressing in each plot at the rate of 12 tonnes ha^{-1} and well incorporated into the soil.

Fig. 2. LAY- OUT PLAN OF THE EXPERIMENTS

Design - 3^2 FACTORIAL EXPERIMENT IN RBD

Experiment A

(Open condition)

R_1	R_2	R_3
$n_1p_0k_1$	$n_1p_0k_2$	$n_1p_0k_2$
$n_2p_0k_3$	$n_2p_0k_1$	$n_3p_0k_3$
$n_1p_0k_3$	$n_3p_0k_3$	$n_2p_0k_2$
$n_3p_0k_1$	$n_2p_0k_3$	$n_0p_0k_0$
$n_2p_0k_1$	$n_1p_0k_1$	$n_3p_0k_2$
$n_3p_0k_2$	$n_0p_0k_0$	$n_2p_0k_1$
$n_0p_0k_0$	$n_1p_0k_3$	$n_3p_0k_1$
$n_2p_0k_2$	$n_3p_0k_1$	$n_1p_0k_3$
$n_3p_0k_3$	$n_3p_0k_2$	$n_2p_0k_3$
$n_1p_0k_2$	$n_2p_0k_2$	$n_1p_0k_1$

Experiment B

(Intercrop in coconut garden)

R_1	R_2	R_3
$n_3p_0k_1$	$n_1p_0k_2$	$n_1p_0k_2$
$n_0p_0k_0$	$n_2p_0k_1$	$n_3p_0k_3$
$n_1p_0k_3$	$n_3p_0k_3$	$n_2p_0k_2$
$n_2p_0k_2$	$n_2p_0k_3$	$n_0p_0k_0$
$n_1p_0k_2$	$n_1p_0k_1$	$n_3p_0k_2$
$n_3p_0k_3$	$n_0p_0k_0$	$n_2p_0k_1$
$n_2p_0k_1$	$n_1p_0k_3$	$n_3p_0k_1$
$n_3p_0k_2$	$n_3p_0k_1$	$n_1p_0k_3$
$n_1p_0k_1$	$n_3p_0k_2$	$n_2p_0k_3$
$n_2p_0k_3$	$n_2p_0k_2$	$n_1p_0k_1$

Levels of Nitrogen	Levels of Potassium
n_1 – 40 kg N ha^{-1}	k_1 – 80 kg K_2O ha^{-1}
n_2 – 60 kg N ha^{-1}	k_2 – 120 kg K_2O ha^{-1}
n_3 – 80 kg N ha^{-1}	k_3 – 160 kg K_2O ha^{-1}
	$n_0p_0k_0$ - 80 : 50 : 100 kg ha^{-1}

PLOT SIZE = 3.6 X 2.7 M

SPACING = 60 X 45 CM

3.5.4. Fertilizer application

Full dose of P and half the dose of N and K were applied one week after sprouting. The remaining half dose of nitrogen and potash were applied one month after the first application along with weeding and intercultivation.

3.5.5. Planting

Ridges were formed 60 cm apart and side corms of 25-35 g size were planted at a spacing of 45 cm on the ridges. Soon after planting, the ridges were covered with mulch material of dry leaves for the retention of moisture and control of weeds.

3.5.6. General condition of the crop

The stand of the crop was satisfactory and there was no insect or disease attack during the crop period.

3.5.7. Harvest

The crop was harvested on the 150^{th} day after planting by digging out the plants. The tubers were separated out from the plants into corms and cormels, ie., mother corms and side corms respectively.

3.6. Biometric observations

3.6.1. Pre harvest observations

3.6.1.1. Plant height

Height was measured from the ground to the tip of the longest leaf petiole at the blade joint (Purewal and Dargan, 1957). This observation was taken four times at regular intervals of 30 days, starting from the 60^{th} day of planting.

3.6.1.2. Number of leaves per plant

The total number of fully opened green leaves of the four observation plants was counted at monthly intervals starting from the 60^{th} day after planting.

3.6.1.3. Leaf area

The length (L) and breadth (B) of each leaf was measured. The length was taken from the apex of the leaf to the sinus region, while the breadth was measured across the point of petiole attachment. The leaf area was worked out by using the formula reported by Biradar et al (1978).

Y = 0.917 (P), where

Y = leaf area in cm^2

P = Product of length x breadth

The leaf area was worked out by adding the leaf area of all the fully opened leaves at the time of observation.

3.6.1.4. Leaf area index - LAI

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

3.6.2. Post harvest observations

3.6.2.1. Number of cormels per plant

The total number of cormels in the net plot was counted at harvest and the average number was found out by dividing with the number of plants.

3.6.2.2. Weight of cormel (size)

The mean weight of cormel was computed by dividing the total weight of cormels in the net plot by the number of cormels and it was then expressed in grams.

3.6.2.3. The cormel yield

The cormels from plants under each treatment was separated and the total weight per plant was calculated.

3.6.2.4. Corm yield

The corm under each treatment was separated and the total yield per unit area was calculated.

3.6.2.5. Cormel to corm ratio

This was calculated as the ratio of the weight of cormels under each treatment to the weight of corm.

3.6.2.6. Dry matter percentage in tuber (corm and cormel)

A known weight of cormel and corm under each treatment was sliced and dried to constant weights in a hot air oven at 54°C. Then the dry matter percentage was worked out.

3.6.2.7. Harvest Index

Harvest index (HI) was calculated by using the formula given below and expressed in percentage. Dry weight of the fallen and dead leaves was computed while calculating the total biological yield, which includes leaves, psuedostem and tuber.

$$HI = \frac{\text{Tuber yield (dry weight)}}{\text{Total biological yield (dry weight)}} \times 100 \quad \text{(Donald,1962)}$$

3.7. Chemical analysis

3.7.1. Plant analysis

Nitrogen, phosphorus and potassium contents of different plant parts were analysed at harvest.

3.7.1.1. Nitrogen

Total nitrogen content of plant samples were analysed by the modified microkjeldahl method (Jackson, 1967).

3.7.1.2. Phosphorus

Phosphorus was determined colorimetrically by the vanado molybdo phosphoric acid yellow colour method (Jackson, 1967).

3.7.1.3. Potassium

Potassium was determined flame photometrically using systronic flame photometer.

3.7.2. Uptake of nutrients

The total uptake of nitrogen, phosphorus and potassium was calculated from the nutrient contents and dry weight of the plant parts and expressed as kg ha^{-1}.

3.7.3. Tuber analysis

N, P & K content of tuber was found out by the methods described earlier.

3.7.3.1. Starch content

The percentage of starch in the tuber was estimated by potassium ferricyanide method as suggested by Aminoff *et al* (1970).

3.7.4. Soil Analysis.

Before commencement of the experiment, composite soil samples were taken and analysed for chemical properties. Plot wise analysis of soil samples were carried out for available nitrogen, available phosphorus and available potassium after crop harvest. The methods followed for the analysis are given below.

3.7.4.1. Available nitrogen

It was determined by the alkaline permanganate method of Subbiah and Asija (1956).

3.7.4.2. Available phosphorus

Available phosphorus was estimated by Bray's I method (Jackson, 1967).

3.7.4.3. Exchangeable potassium

Exchangeable potassium was extracted by neutral normal ammonium acetate solution and determined by a systronics flame photometer (Jackson 1967).

3.8. Statistical Analysis

The design of the experiment was 3^2 factorial randomised block. There were 10 treatments with three replications.

The statistical analysis of the data was done by the method suggested by Cochran and Cox (1965). Critical difference has been provided for all statistical analysis wherever F-test was significant. The critical difference values have not been given wherever F-test was not significant. In general, the results and discussion are based at probability levels of 0.05.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Field experiments were conducted at the Instructional farm attached to the College of Agriculture, Vellayani to study the performance of Colocasia at different N and K levels under open and intercropped situations in coconut garden. The experiments were conducted during May-June to October-November, 1990. The results are presented here under Experiment A (open condition) and Experiment B (intercropped situation in coconut garden).

4.1. Experiment A. Open condition

4.1.1. <u>Growth characters</u>

4.1.1.1. Plant height

The data on the pant height at different growth stages are presented in table 1.

A perusal of the data presented in the above table revealed that plant height increased progressively upto 120 days after planting (DAP) and then declined. This may probably be due to the fact that after 120 DAP, senescence started, as a result of which the plant height decreased upto harvest.

The difference in plant height for different levels of N was not significant in any of the growth stages, except

Experiment A

Table 1. Average effect of N and K on plant height at various stages of growth (cm)

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	29.37	43.10	52.42	43.20
n_2	30.27	44.60	53.29	44.44
n_3	30.40	45.74	52.16	45.97
C.D.	N.S.	N.S.	0.860	N.S.
k_1	28.27	44.07	52.84	43.27
k_2	30.06	44.24	52.01	45.01
k_3	31.71	45.13	53.01	45.03
C.D.	1.533	1.741	N.S.	N.S.

DAP - Days after planting

N.S. - Not significant

at 120 DAP. At that particular stage alone n_2 recorded an appreciable increase in plant height over n_1. The difference was also nullified at harvest. Hence, it may be inferred that for getting maximum plant height a dose of N at the rate of 80 kg ha^{-1} is sufficient.

The effect of K on plant height was well exhibited in the earlier stages of crop growth and continued upto 90 DAP. Thereafter the effect was nullified, though the same trend continued upto harvest. From the results it could be noticed that for quick growth, the crop requires a high dose of K. Similar increase in plant height due to higher dose of K application was reported by Purseglove (1968), Randhawa and Nandapuri (1969), Kay (1973) and Anonymous (1978).

The N and K interaction was not significant at any stage of the crop growth.

4.1.1.2. Number of leaves per plant

The number of leaves per plant at various stages of growth are presented in table 2.

In general, the leaf production increased upto 120 DAP in all the treatments and gradually diminished till harvest.

The effect of N was clearly exhibited at all the growth stages. The n_2 level showed a significant increase in

Experiment A

Table 2. Average effect of N and K on number of leaves plant^{-1} at various stages of growth

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	4.60	4.19	3.88	2.68
n_2	4.67	4.24	3.95	2.77
n_3	4.46	3.96	3.44	2.50
C.D.	0.071	0.136	0.096	0.058
k_1	4.37	4.09	3.69	2.59
k_2	4.63	4.11	3.71	2.63
k_3	4.74	4.30	3.88	2.73
C.D.	0.071	0.136	0.096	0.058

DAP - Days after planting

leaf production in all the growth stages over n_1 and n_3 levels. The higher dose of N reduced the leaf production over the lower doses throughout the crop period.

Like N, the response of K was also significant in leaf production throughout the crop growth. An increase in the dose of K increased the leaf production at all stages of crop growth.

As pointed out by Onwueme (1978), the crop might have entered the third phase of growth at 120 DAP and hence started senescence of leaves. So the photosynthates might have been translocated for tuber development. The reduction in leaf number at later stages might be due to abscission of existing leaves.

Interaction effect of N and K on leaf production was not noticed at any of the growth stages.

4.1.1.3. Leaf area index (LAI)

The data on the leaf area index at various growth stages are presented in table 3.

The LAI showed appreciable difference for different levels of N at 60, 90 and 120 DAP. Maximum LAI was recorded at n_2 level and was significantly superior over n_3 and n_1 at 60 and 90 DAP. At 120 DAP, n_2 and n_1 showed a higher LAI

Experiment A

Table 3. Average effect of N and K LAI at various stages of growth

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	0.55	0.65	0.83	0.28
n_2	0.57	0.68	0.84	0.28
n_3	0.56	0.63	0.81	0.28
C.D.	0.013	0.007	0.017	N.S.
k_1	0.55	0.63	0.81	0.27
k_2	0.56	0.64	0.83	0.28
k_3	0.57	0.66	0.84	0.29
C.D.	0.013	0.007	0.017	0.016

DAP - Days after planting

N.S. - Not significant

over n_3. At harvest no difference was observed between the treatments. The number of leaves was also maximum at n_2 level, which might have contributed to higher LAI at n_2 level.

LAI was increased markedly by increasing the levels of K. Maximum LAI was recorded at k_3 level and was significantly higher than k_2 and k_1. This increase in LAI might be due to the fact that higher number of leaves were produced at k_3 level. This is in confirmity with the findings of Purewal and Dargan (1957) and Abit and Alferez (1979).

The interaction effect of treatments on LAI was not significant at any stage of crop growth.

4.1.2. Yield components and yield

4.1.2.1. Number of cormels plant^{-1}

The data on the number of cormels plant^{-1} is given in table 4A.

The effect of N on the number of cormels plant^{-1} was not significant. N at higher level marginally reduced the number of cormels. Similar non significant effect of N levels was noticed on cormel number by Enyi (1973) in Colocasia, Tabata and Takase (1968) in potato and by Shanmughavelu *et al* (1973) in sweet potato.

Experiment A

Table 4A. Average effect of N and K on number of cormels plant^{-1}, mean weight/size of cormel, and cormel yield plant^{-1}

Treatments	No. of cormels plant^{-1}	Cormel mean weight (g)	Cormel yield plant^{-1} (g)
n_1	6.66	34.81	231.84
n_2	6.67	36.42	242.93
n_3	6.34	37.03	234.77
C.D.	N.S.	0.384	N.S.
k_1	5.91	35.40	217.56
k_2	6.79	34.89	235.99
k_3	7.16	34.24	254.37
C.D.	0.458	0.384	5.082

N.S. - Not significant

Experiment A

Table 4B. Average effect of treatments on number of cormels plant^{-1}, mean weight/size of cormel and cormel yield plant^{-1}.

Treatments	No. of cormels plant^{-1}	Cormel mean weight (g)	Cormel yield plant^{-1} (g)
n_1k_1	6.12	214.75	35.21
n_1k_2	6.73	232.72	32.12
n_1k_3	7.83	248.05	35.10
n_2k_1	5.99	221.80	35.12
n_2k_2	6.79	242.14	32.11
n_2k_3	6.92	264.85	34.50
n_3k_1	5.62	216.13	37.12
n_3k_2	6.58	237.13	35.16
n_3k_3	6.93	250.21	35.81
Control	6.67	231.80	34.83
C.D.	0.793	14.802	2.33

Potassium showed a remarkable increase in number of cormels plant^{-1} by increasing the levels from k_1 to k_3. The higher levels of K might have increased the sink capacity of the plant, thereby increasing the number of cormels, which is the most important yield contributing character. The K level at 160 kg ha^{-1} increased the number of tubers to a tune of 21.15 and 4.57 per cent over 80 and 120 kg ha^{-1} respectively. This finding corroborated with the observations of Mohan kumar (1986).

The interaction effect of N and K on number of cormels are presented in table 4 (B).

From the data it could be seen that an increase in potassium level invariably increased the number of cormels plant^{-1} in all the N levels. The maximum number of cormels were obtained in n_1k_3 treatment and it was on par with n_3k_3. It could also be inferred from the table that the number of cormels was significantly reduced by a reduction in K level. The control (as per package of practices recommendations) also gave appreciable increase in number of cormels over lower level of K even if there was an increase in N level. It was revealed from the interaction table that for getting a concommitant increase in number of cormels plant^{-1} an increase in K is essential. In most of the tuber crops a balanced dose of N : K ratio is to be maintained for higher tuber yield. This aspect was well established in this table also. Increasing the K level without an increase in N level resulted in lowering the number of cormels plant^{-1}. Comparing the absolute control and n_3 k_1 treatment it could be seen that the number of cormels is reduced almost to half by a reduction of 20 kg K alone.

4.1.2.2. Mean weight of cormels (size)

The data on the mean weight of cormels is summarised in table 4(A).

Like other yield attributing characters the N levels did not appreciably influence the mean weight of cormels. However, higher levels of N tend to increase the mean weight of cormels over the lower level.

Unlike other yield contributing characters, lower levels of K (k_1) exerted significant influence in mean weight of cormels over higher levels. This character seems to have a reverse trend compared to number of cormels plant^{-1}. The reduction of mean weight of cormels at higher levels of K might be due to the larger number of cormels present.

The interaction effect of N and K on mean weight of cormel is furnished in table 4(B).

The maximum mean weight of cormels was observed in n_3k_1 which was significantly superior to all other treatments. In all the three N levels, lowest level of K gave higher mean weight of cormel than higher levels of K. This is in confirmity with the earlier discussion. The reasons attributed there holds good here also.

4.1.2.3. Cormel yield per plant.

The data on the cormel yield plant^{-1} are presented in table 4(A).

The N at n_2 level explicitly increased cormel yield plant $^{-1}$ over n_3 and n_1 levels, which was reflected in the final yield of marketable tubers.

Like other yield contributing characters, the cormel yield plant^{-1} was also positively influenced by higher levels of K over lower levels. The k_3 and k_2 levels increased the cormel yield to a tune of 16.92 and 8.47 per cent over k_1. This result clearly revealed that application of higher levels of potash is essential for getting higher cormel yield plant^{-1} in Colocasia.

The interaction effect of N and K on the cormel yield plant^{-1} is presented in table 4 (B).

The interaction of N and K was significant and the highest cormel yield was produced in n_2k_3 treatment which was comparable to n_3k_3 level but significantly higher than n_1k_3. In all the N levels, an increase in K level appreciably increased the cormel yield plant^{-1}. However, an increase in N without a corresponding increase in K failed to exhibit an increase in cormel yield. This might be due to the disturbance in N-K ratio which is a prerequisite for tuber production in crops like Xanthosoma, Colocasia and yams.

4.1.2.4. Corm yield

The table containing corm yield is furnished in table 5 (A) and the interaction in table 5 (B).

The effect of N,K and their interaction on corm yield was significant.

N at n_2 level gave the highest corm yield than the higher and lower levels. The n_3 level showed a decline in corm yield as compared to n_1. Mohankumar (1986) reported that an increase in N level alone has reduced the corm yield in Colocasia. The present result is in conformity with the above findings.

An increase in potash level linearly increased the corm yield from k_1 to k_3. Higher level of K might be necessary for the early establishment of crop and development

Experiment A

Table 5A. Average effect of N and K on corm yield $plant^{-1}$, cormel to corm ratio, yield of marketable tubers and harvest index.

Treatments	Corm yield $plant^{-1}$ (g)	Cormel to corm ratio	Yield of marketable tubers (tha^{-1})	Harvest index
n_1	170.83	1.36	9.91	83.81
n_2	186.38	1.30	10.43	84.81
n_3	164.34	1.43	9.22	84.45
C.D.	4.391	N.S.	0.205	0.468
k_1	157.90	1.38	9.31	84.22
k_2	177.35	1.33	9.69	84.34
k_3	190.80	1.33	10.57	84.91
C.D.	4.391	N.S.	0.205	0.468

N.S. - Not significant

Experiment A

Table 5B. Average effect of treatments on corm yield plant^{-1}, cormel to corm ratio, yield of marketable tubers and harvest index.

Treatments	Corm yield plant^{-1} (g)	Cormel to corm ratio	Yield of marketable tubers (tha^{-1})	Harvest index
n_1k_1	153.93	1.40	8.27	84.10
n_1k_2	173.87	1.34	10.63	84.14
n_1k_3	184.69	1.34	10.77	83.20
n_2k_1	165.50	1.34	10.20	85.97
n_2k_2	186.57	1.30	10.33	84.68
n_2k_3	207.07	1.28	10.83	83.78
n_3k_1	154.27	1.40	9.47	84.39
n_3k_2	168.62	1.41	8.10	84.21
n_3k_3	170.13	1.47	10.10	84.76
Control	175.13	1.32	10.40	84.57
C.D.	7.606	N.S.	0.356	0.810

N.S. - Not significant

of corm. Similar results in tannia were obtained by Pushpakumari (1989).

The highest corm yield was obtained at n_2k_3 and n_2k_2 combination which was comparable with n_1k_3 and was significantly superior over other treatment combinations. Like the individual effects higher levels of N tend to decrease the corm yield at the lower two levels of K. The higher level of corm yield at n_2k_3 might be due to the balanced N-K ratio.

4.1.2.5. Cormel to corm ratio

The cormel to corm ratio is presented in table 5 (A) and 5 (B).

The effect of N,K and their interaction did not influence this character, though there were numerical differences.

4.1.2.6. Yield of marketable tubers

The response of N, K and their interaction on yield of marketable tubers is presented in table 5 (A) and5 (B).

The N levels appreciably increased the yield of marketable tubers and n_2 level gave the maximum yield which was significantly higher than n_1 and n_3. The increase in yield at n_2 level was 5.25 and 13.12 per cent respectively over n_1 and n_3 levels. The results indicated that in open conditions the crop responded upto 60 kg N ha^{-1}. Further increase in nitrogen showed a declining trend. This difference in yield increase was exhibited in all yield contributing characters. Mohankumar (1986) and also reported that at higher levels of N, the colocasia yield was reduced.

The K levels had a profound influence on marketable tuber yield and as increase in tuber yield was noticed from lower level to higher level. K at 160 kg ha^{-1} gave an appreciable increase in tuber yield over 120 and 80 kg ha^{-1}. The increase was in the order of 13.53 and 13 per cent respectively. The k_2 level also exerted remarkable influence in tuber yield over k_1 level. The study clearly revealed that higher levels of K is essential for getting higher tuber yield in Colocasia. This fact is well established in all the tropical tuber crops. In Colocasia, similar increase in yield due to the application of K was reported by Mohankumar (1986).

The interaction effect of N and K clearly revealed that in all the three N levels an increase in K markedly increased the tuber yield. At lower N level, differences between k_2 and k_3 was not observed. However, at higher level of N, this difference was well exhibited. This might be due to the change in N-K ratio. At $n_2$level, k_3 gave the maximum tuber yield and was significantly higher than that with lower levels of K. Hence it might be inferred that for getting maximum tuber yield the crop required a combination of N and K at 60 and 160 kg ha^{-1}. Similar N and K ratio was reported by Mohankumar (1986). The yield at n_3k_3 level was higher than that of the control treatment (the present package of practice recommendations ie., 80 and 100 kg N and K ha^{-1} respectively).

4.1.2.7. Harvest Index

The data on the effect of treatment and their interaction on harvest index is presented in table 5 (A) and (B).

It could be seen that application of N had significant effect on harvest index. Harvest index increased from n_1 to n_2 and at n_3 there was a reduction though it was on par with n_2.

K also had a positive effect on harvest index. Harvest index increased with an increase in K level from k_1 to k_3. The same trend was reflected in the marketable tuber yield also. It could be inferred that at higher level of N the tuber yield was reduced at the expense of vegetative growth of the crop.

The interaction effect of N and K was not significant.

4.1.3. Quality aspects

The data on quality aspects viz., drymatter percentage in cormel, corm and the starch percentage in tuber are presented in table 6.

4.1.3.1. Dry matter percentage in cormel

It was evident from the data that the N and K levels had significant effect on the percentage of drymatter in cormel. Maximum drymatter percentage was observed at n_1 level which was significantly superior to n_2 and n_3. The probable explanation for low percentage of drymatter under higher levels of N application might be due to the fact that in plants where the N supply and other growth factors are favourable, the tendency is for the utilization of carbohydrates to form more protoplasm and more cells, rather than for deposition of carbohydrate to thicken the cell wall. Cell produced under such conditions tend to be large and have thin walls. Because protoplasm is mostly water, high nitrogen promotes growth resulting in a relatively high proportion of water and low proportion of drymatter (Black, 1973). Similar results were also obtained by Enyi (1973) in lesser yams, wherein N application encouraged greater total

Experiment A

Table 6. Average effect of N and K on dry matter percentage in cormel, dry matter percentage in corm and starch content of tubers.

Treatments	Dry matter percentage in cormel	Dry matter percentage in corm	Starch percentage
n_1	25.33	19.86	56.73
n_2	25.01	19.61	56.74
n_3	24.84	19.45	57.04
C.D.	0.159	0.079	N.S.
k_1	24.16	19.16	48.58
k_2	24.85	19.62	59.29
k_3	25.48	20.12	62.63
C.D.	0.159	0.079	0.359

N.S. - Not significant

drymatter production but reduced the content of tuber.. Mandal et al (1982) observed highest drymatter production in taro at the lowest level of nitrogen ie., 40 kg N ha^{-1}.

Increasing the level of potassium recorded a remarkable increase in the percentage of drymatter. This might probably be due to the fact that potassium is essential for the action of enzymes that catalyse certain reactions both in carbohydrate and nitrogen metabolism. Yield and drymatter content of tubers continue to increase with K assimilates (Black, 1973). Similar results were reported by Fujise and Tsuno (1967) in sweet potato, Enyi (1973) in yams and Premraj et al (1980) in taro.

The N and K interaction was not significant.

4.1.3.2. Dry matter Percentage in corm

An examination of the data on corm drymatter percentage revealed that by increasing the level of N from n_1 to n_3 drymatter percentage was reduced significantly.

Positive increase in drymatter percentage was observed by increasing the level of K from k_1 to k_3. The reasons attributed in 4.1.3.1. holds good here also.

There was no interaction between N and K for any of the treatments.

4.1.3.3. Starch percentage in tuber

The data revealed that the percentage of starch due to varying levels of nitrogen were on par with each other. Similar results were reported by Anderson (1936) and Morgan (1939) who observed that starch content did not show any significant difference due to nitrogen application in sweet potato.

The starch content of tuber increased appreciably due to an increase in the level of K and the maximum values were obtained at 160 kg k_2O ha^{-1}. The beneficial effect of K on this quality trait can be attributed to the well known role of K in carbohydrate synthesis and translocation. CIAT (1979) reported linear increase in starch yield with increasing amounts of applied K upto 200 kg K_2O ha^{-1}. The observation in the present investigation is in confirmity with the findings of Pillai (1967), Mohandas and Sethumadhavan (1980) and Premraj _et al_ (1980).

N and K interactions were not significant for any of the treatments.

4.1.4. _Nutrient uptake by vegetative non economic plant parts_

The uptake of N, P and K as influenced by N and K and their interaction are summarised in table 7 (A) and 7 (B).

4.1.4.1. Uptake of Nitrogen

The N levels did not exert any significant influence on the uptake of nitrogen, while K levels profoundly influenced the uptake of N. The interaction of N and K clearly revealed that the uptake of N was influenced only by K levels. At higher levels of K, the uptake of N was invariably high (n_1k_3, n_2k_3, n_3k_3), while at lower levels of K even with an increased level of N, the uptake of nitrogen was not improved. Similar results were obtained by Mohankumar (1986).

4.1.4.2. Uptake of Phosphorus

The effect of treatments on the uptake of P showed that only K level had significantly influenced the uptake of P. The highest level of P uptake was noticed at k_3 level, which was significantly superior than the other two levels. Like N uptake, the interaction of N and K on the uptake of P was significant, and the maximum uptake was noticed at n_2k_3 and n_1k_3.

4.1.4.3. Uptake of Potassium

A perusal of the data revealed that levels of N had not influenced the uptake of K by the plant. Application of K had a significant effect on the uptake of K. There was a linear increase in the uptake of K from k_1 to k_3 level. The

Experiment A

Table 7A. Average effect of N and K on the uptake of NPK by non economic plant parts (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	10.56	1.57	25.11
n_2	10.60	1.63	25.28
n_3	10.54	1.58	25.32
C.D.	N.S.	N.S.	N.S.
k_1	7.71	1.70	21.02
k_2	10.18	1.09	26.21
k_3	13.81	2.00	28.47
C.D.	0.369	0.056	0.324

N.S. - Not significant

Experiment A

Table 7B. Average effect of treatments on the uptake of NPK by non economic plant parts (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	7.50	1.65	20.89
n_1k_2	10.29	1.08	26.40
n_1k_3	13.88	2.00	28.05
n_2k_1	7.65	1.76	21.15
n_2k_2	10.32	1.09	26.17
n_2k_3	13.84	2.02	28.04
n_3k_1	7.98	1.68	21.04
n_3k_2	9.93	1.09	26.05
n_3k_3	13.72	1.98	28.86
Control	9.49	1.94	25.62
C.D.	0.640	0.096	0.562

N.S. - Not significant

increased uptake of K in the present study for the higher levels of K might probably be due to the higher leaf concentration of this element. This is in agreement with the findings of Obigbesan and Agboola (1978) that the uptake of mineral from farm land through crop harvest depends on yield of drymatter and the concentration of element in that drymatter.

The interaction effect of N and K on the uptake of K revealed that higher levels of K invariably increased the K uptake irrespective of N levels.

4.1.5. <u>Nutrient uptake by tuber</u>

The data on the uptake of N, P and K as influenced by levels of N and K and their interaction are presented in table 8 (A) and (B).

4.1.5.1. Uptake of Nitrogen

From the data, it is evident that the levels of N had no significant effect on the uptake of N by tuber. Application of K had a remarkable effect on the uptake of nitrogen by tuber. Maximum uptake of N was recorded at k_3 level.

N and K interactions at higher levels of K, irrespective of N levels, recorded higher uptake of N by tuber.

Experiment A

Table 8A. Average effect of N and K on the uptake of NPK by tubers (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	25.68	4.16	34.43
n_2	25.69	4.18	33.86
n_3	25.69	4.19	34.67
C.D.	N.S.	N.S.	0.269
k_1	21.89	4.06	28.23
k_2	25.97	4.18	34.75
k_3	29.20	4.29	39.97
C.D.	0.194	0.035	0.269

N.S. - Not significant

Experiment A

Table 8B. Average effect of treatments on the uptake of NPK by tubers (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	21.75	4.07	28.19
n_1k_2	25.91	4.17	35.24
n_1k_3	29.36	4.25	39.86
n_2k_1	21.92	4.05	28.01
n_2k_2	25.96	4.19	34.46
n_2k_3	29.19	4.29	39.10
n_3k_1	22.01	4.05	28.49
n_3k_2	26.03	4.20	34.50
n_3k_3	29.04	4.32	40.96
Control	29.24	4.20	32.34
C.D.	0.337	0.061	0.466

of K had a profound effect on the uptake of P by tuber.

In the case of P uptake by tuber also, the interaction effect of N and K was similar to the N uptake, and the maximum uptake was noticed at n_3k_3 treatment, which was significantly superior to all other treatment combinations.

4.1.5.3. Uptake of potassium

It is evident from the data that by increasing the level of N from n_1 to n_2, there was a significant decrease in uptake of K by tuber. Increasing the level of N from n_2 to n_3, the uptake was increased, but remained on par with n_1. The application of K had a significant effect of the uptake of K by tuber. The uptake was linearly increased from k_1 to k_3.

The interaction effect of N and K showed that the highest uptake of K was obtained at n_3k_3 treatment, which was on par with n_1k_3. The increase in K levels, irrespective of N levels showed an increase in the uptake of K by tuber. This is probably due to the relationship between high starch synthesis and K nutrition.

4.1.6. Available nutrient status of soil at the time of harvest

The data on available N P K at the time of harvest due to N and K levels and its interaction are presented in table 9 (A) and (B).

4.1.6.1. Available Nitrogen

The levels of N, K and its interaction did not influence the available N status in soil. This might probably be due to the mineralisation of liberally applied organic manure at the time of planting of the crop.

4.1.6.2. Available Phosphorus

Similar to N, the P status of soil was not influenced due to various levels of N and K application. A common dose of P_2O_5 @ 50 kg ha^{-1} was applied to all the plots and hence, a static P equilibrium was maintained in all the treatments.

4.1.6.3. Available Potassium

Though the N levels had not influenced the uptake of K, the levels of K had a profound influence on it. At higher levels of K, a higher amount of available K was noticed in the soil. Since the crop required a larger

Experiment A

Table 9A. Average effect of N and K on the changes in available soil NPK at harvest (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	324.26	32.61	168.46
n_2	327.56	32.70	169.20
n_3	333.90	29.37	168.95
C.D.	N.S.	N.S.	N.S.
k_1	312.18	32.23	154.89
k_2	324.56	33.29	171.58
k_3	348.98	29.16	180.14
C.D.	N.S.	N.S.	1.124

N.S. - Not significant

Experiment A

Table 9B. Average effect of treatments on the changes in available soil NPK at harvest (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	309.28	32.60	154.57
n_1k_2	320.14	30.55	171.47
n_1k_3	340.26	34.67	179.35
n_2k_1	312.92	31.30	155.36
n_2k_2	323.25	34.80	171.60
n_2k_3	346.96	31.93	180.65
n_3k_1	314.29	32.79	154.74
n_3k_2	330.29	34.46	171.69
n_3k_3	356.72	30.88	180.43
Control	356.37	30.32	166.43
C.D.	N.S	N.S.	N.S.

N.S. - Not significant

Experiment A

Table 10. Economics of Colocasia cultivation under open condition*

Treatments	Fixed cost (Rs)	Variable cost (Rs) N	Variable cost (Rs) K	Total cost (Rs)	Yield (t ha^{-1})	Gross returns (Rs)	Net returns (Rs)	Benefit : cost ratio
n_1k_1	9,000	220	180	9,400	8.27	16,540	7,140	1.76
n_1k_2	9,000	220	270	9,490	10.67	21260	11,770	2.24
n_1k_3	9,000	220	360	9,580	10.77	21,540	11,960	2.23
n_2k_1	9,000	330	180	9,510	10.20	20,400	10,890	2.15
n_2k_2	9,000	330	270	9,600	10.33	20,660	11,060	2.15
n_2k_3	9,000	330	360	9,690	10.83	21,660	11,970	2.24
n_3k_1	9,000	440	180	9,620	9.47	18,940	9,320	1.97
n_3k_2	9,000	440	270	9,710	8.10	16,200	6,490	1.67
n_3k_3	9,000	440	360	9,800	10.10	20,200	10,400	2.06
Control	9,000	440	225	9,665	10.40	20,800	11,135	2.15

Cost of 1 kg N – Rs 5.50

Cost of 1 kg K_2O – Rs 2.25

Price of colocasia tuber – Rs 2.00 / kg

* Not statistically analysed.

quantity of K for its metabolism, at lower levels of K, there might have been a severe depletion of K from the soil pool. This might have resulted in the lower K status in k_1 and k_2 level than k_3 level.

The interaction effect of N and K were not significant.

4.1.7. Economics of Colocasia cultivation

The data in table 10 showed that application of N @ 60 kg ha^{-1} and K @ kg ha^{-1} resulted in highest net return (Rs 11,970 ha^{-1}) and highest benefit cost ratio of 1 : 2.24.

4.2. Experiment B. As an intercrop in coconut gardens

The results of the experiment conducted under intercrop conditions with coconut garden of about 30 years age are presented here. The treatment levels are of the same as experiment A.

4.2.1. Growth Characters

4.2.1.1. Plant height

The data on plant height as influenced by N, K and their interaction are presented in Table 11A and Table 11B.

Experiment B

Table 11A. Average effect of N and K on plant height at various stages of growth (cm)

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	54.91	75.78	104.60	96.68
n_2	54.66	77.66	105.29	95.26
n_3	55.90	75.83	105.46	94.36
C.D.	N.S.	N.S.	N.S.	N.S.
k_1	44.23	67.27	90.29	83.04
k_2	57.99	77.22	106.80	93.01
k_3	63.24	84.78	118.26	110.23
C.D.	2.056	1.782	2.018	2.541

DAP - Days after planting

N.S. - Not significant

Experiment B

Table 11B. Average effect of treatments on plant height at various stages of growth (cm).

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1k_1	44.40	65.77	90.80	87.03
n_1k_2	57.97	78.63	105.03	93.90
n_1k_3	62.37	82.93	117.97	109.10
n_2k_1	44.57	71.40	91.07	82.37
n_2k_2	56.70	75.87	106.23	91.00
n_2k_3	62.70	85.70	118.57	112.40
n_3k_1	43.73	64.63	89.00	79.73
n_3k_2	59.30	77.17	109.13	94.13
n_3k_3	64.67	85.70	118.23	109.20
Control	56.57	72.23	102.60	95.90
C.D.	3.561	3.086	3.495	4.400

DAP - Days after planting

N.S. - Not significant

In general the plant height increased upto 120 DAP and then declined gradually. Comparing with the open condition there was an appreciable increase in plant height throughout the plant growth under intercrop situations in coconut garden.

The N levels failed to exert any significant effect on plant height. However, the K levels and its interaction with N recorded a remarkable increase on plant height. An increase in K level from k_1 to k_3 linearly increased the plant height at all stages of growth. Similar increase in plant height due to K application was reported by Ngongi (1976) and Nair (1986) in cassava, Dubey and Bharadwaj (1971) and Krishnappa and Sivasankara (1981) in potato and Hussain and Rashid (1982) in Colocasia.

The interactions of N and K on plant height at various growth stages of the crop showed that higher levels of K in combination with all levels of N increased the plant height favourably. At lower levels of K an increase in N failed to exert any appreciable difference in plant height. This further illustrates the requirements of K for quick growth of Colocasia under shaded situations. This result is in conformity with the observations of Hussain and Rashid (1982).

4.2.1.2. Number of leaves per plant

The data on the number of leaves per plant at various growth stages as affected by N, K and their interaction are furnished in Table 12A and 12B.

In general, like open situation, the leaf number progressively increased from 60 to 120 DAP and declined thereafter. However, under intercrop situation with coconut, there was always a profound increase in leaf number which was almost three times higher from 90 DAP onwards.

The data revealed that N had significant effect on the number of leaves only at 120 and 150 DAP. K had a significant effect on number of leaves at 60, 90 and 120 DAP. The number of leaves was maximum at k_3 level which was on par with k_2 but significantly superior to k_1.

The interaction effect on N and K showed significant difference only at 90 and 120 DAP. During both the stages, higher levels of K with different levels of N gave maximum number of leaves and were on par with each other. At 90 DAP a marked difference was noticed between n_3k_2 and recommended practices given as control. Both the treatments were same except for an increase of 20 kg K in n_3k_2 treatment, clearly indicating the higher requirement of K for higher yield production.

Experiment B

Table 12A. Average effect of N and K on number of leaves $plant^{-1}$ at various stages of growth.

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	5.91	10.01	13.37	11.52
n_2	5.80	9.82	12.62	10.87
n_3	6.08	9.66	12.53	10.47
C.D.	N.S.	N.S.	0.588	0.861
k_1	5.82	8.44	12.23	10.72
k_2	5.94	10.49	12.56	10.93
k_3	6.48	10.56	13.73	10.90
C.D.	0.493	0.830	0.588	N.S.

DAP - Days after planting

N.S. - Not significant

Experiment B

Table 12B. Average effect of treatments on number of leaves plant^{-1} at various stages of growth.

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1k_1	6.07	9.07	12.60	11.47
n_1k_2	5.33	10.63	13.03	11.67
n_1k_3	6.33	10.33	14.47	11.43
n_2k_1	5.47	8.10	11.83	10.33
n_2k_2	5.37	10.50	12.33	10.20
n_2k_3	6.57	10.87	13.70	11.17
n_3k_1	5.93	8.17	12.20	10.37
n_3k_2	5.77	10.33	12.30	10.93
n_3k_3	6.53	10.47	13.03	10.10
Control	5.50	8.53	13.37	11.40
C.D.	N.S.	1.437	1.018	N.S.

DAP - Days after planting

N.S. - Not significant

4.2.1.3. Leaf Area Index

The data on LAI at various growth stages as influenced by N, K and their interaction are furnished in table 13(A) and 13(B).

The LAI showed appreciable differences for different levels of N only at 60 DAP. Maximum LAI was recorded at n_1 level and was significantly superior over n_2 and n_3. LAI was increased markedly by increasing the levels of K. Maximum LAI was recorded at k_3 level and was significantly higher than k_2 and k_1. The reasons attributed in 4.1.1.3. holds good here also.

The interaction effects of N and K on LAI was significant at 60, 90 and 120 DAP. Maximum LAI was recorded at k_3 level with all levels of N.

4.2.2. Yield components and yield

The effect of N, K and their interaction of yield and yield attributing characters viz., number of cormels plant^{-1}, mean weight of cormels, cormel yield, corm yield and cormel to corm ratio are presented in table 14A, 14B, 15A and 15B.

4.2.2.1. Number of cormels plant^{-1}

In general, there was a remarkable increase in number of cormels plant^{-1} under intercrop situations in

Experiment B

Table 13A. Average effect of N and K on LAI at various stages of growth.

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1	0.86	1.54	2.43	1.20
n_2	0.83	1.51	2.43	1.23
n_3	0.80	1.50	2.43	1.61
C.D.	0.049	N.S.	N.S.	N.S.
k_1	0.79	1.51	2.38	1.14
k_2	0.86	1.54	2.40	1.21
k_3	0.90	1.55	2.53	1.32
C.D.	0.049	0.034	0.041	0.093

DAP - Days after planting

N.S. - Not significant

Experiment B

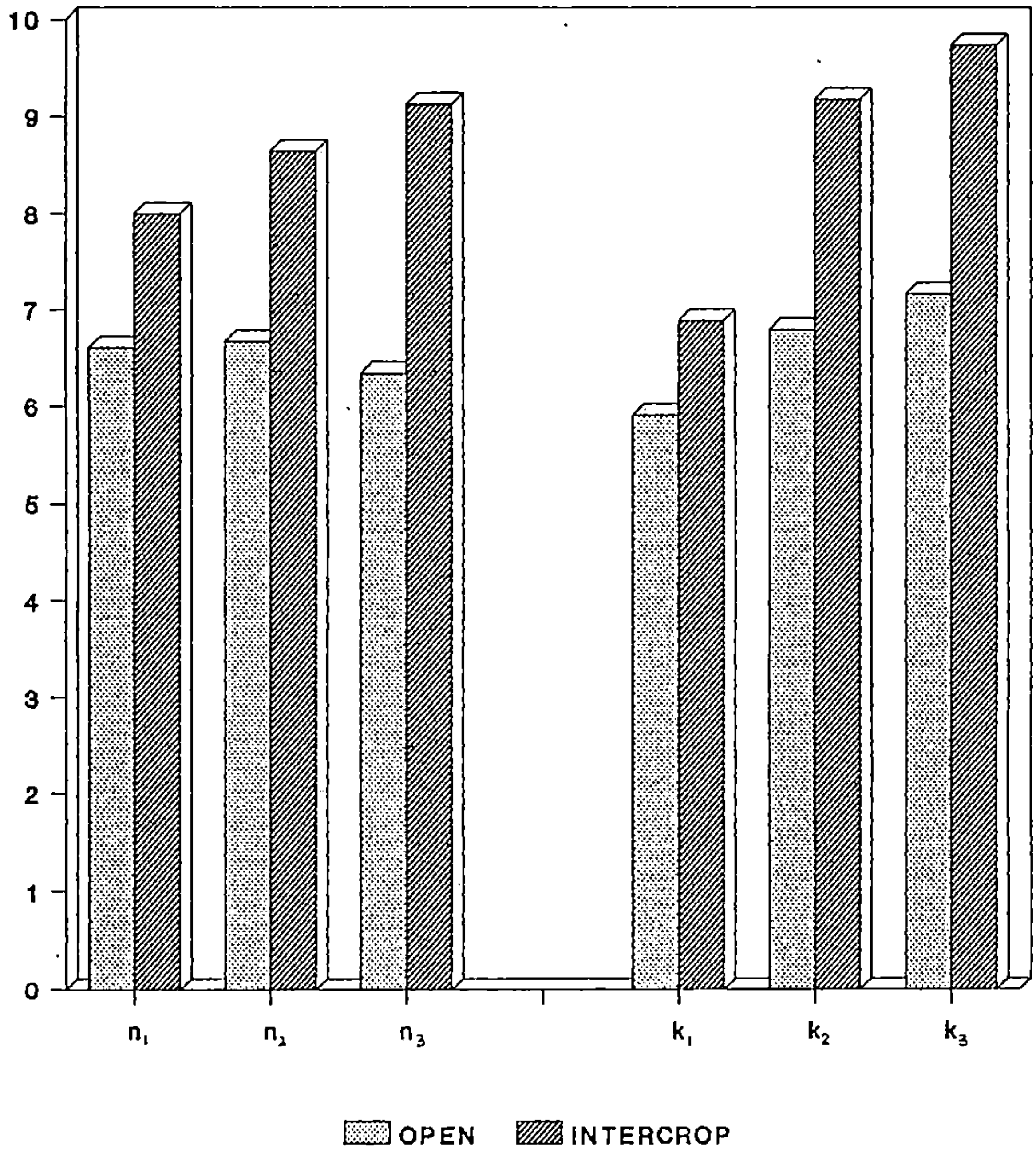
Table 13B. Average effect of treatments on LAI at various stages of growth.

Treatments	60 DAP	90 DAP	120 DAP	150 DAP
n_1k_1	0.82	1.49	2.35	1.10
n_1k_2	0.87	1.52	2.40	1.24
n_1k_3	0.89	1.61	2.48	1.26
n_2k_1	0.78	1.52	2.35	1.16
n_2k_2	0.89	1.56	2.37	1.22
n_2k_3	0.89	1.59	2.50	1.36
n_3k_1	0.79	1.48	2.35	1.16
n_3k_2	0.80	1.56	2.37	1.22
n_3k_3	0.81	1.59	2.50	1.30
Control	0.78	1.49	2.35	1.18
C.D.	0.023	0.060	0.070	N.S.

DAP - Days after planting

N.S. - Not significant

Fig. 3. Effect of N and K on number of cormels plant^{-1} in the open and as an intercrop in coconut garden



Experiment B

Table 14A. Average effect of N and K on number of cormels plant^{-1}, mean weight (size) and cormel yield plant^{-1}.

Treatments	No. of cormels plant^{-1}	Cormel mean weight (g)	Cormel yield plant^{-1} (g)
n_1	8.00	52.83	422.67
n_2	8.65	48.20	416.90
n_3	9.13	45.56	415.99
C.D.	0.356	1.885	N.S.
k_1	6.89	50.89	350.62
k_2	9.18	50.96	467.85
k_3	9.74	51.20	498.72
C.D.	0.356	1.885	58.43

N.S. - Not significant

Experiment B

Table 14B. Average effect of treatments on number of cormels, $plant^{-1}$, cormel mean weight (size) and cormel yield $plant^{-1}$.

Treatments	No. of cormels $plant^{-1}$	Cormel mean weight (g)	Cormel yield $plant^{-1}$ (g)
n_1k_1	7.84	54.29	417.39
n_1k_2	8.06	53.37	419.26
n_1k_3	8.10	50.83	431.36
n_2k_1	8.04	49.36	413.26
n_2k_2	8.86	48.29	415.23
n_2k_3	9.05	46.98	422.21
n_3k_1	8.97	46.58	413.68
n_3k_2	9.15	45.98	416.35
n_3k_3	9.27	44.12	417.94
Control	9.08	44.78	415.41
C.D.	0.645	3.437	N.S.

N.S. - Not significant

coconut garden compared to open conditions. A marginal increase in number of cormels plant^{-1} was observed due to increase in N levels. Asokan and Nair (1984) also obtained similar increase in number of cormels plant^{-1} due to increase in N levels.

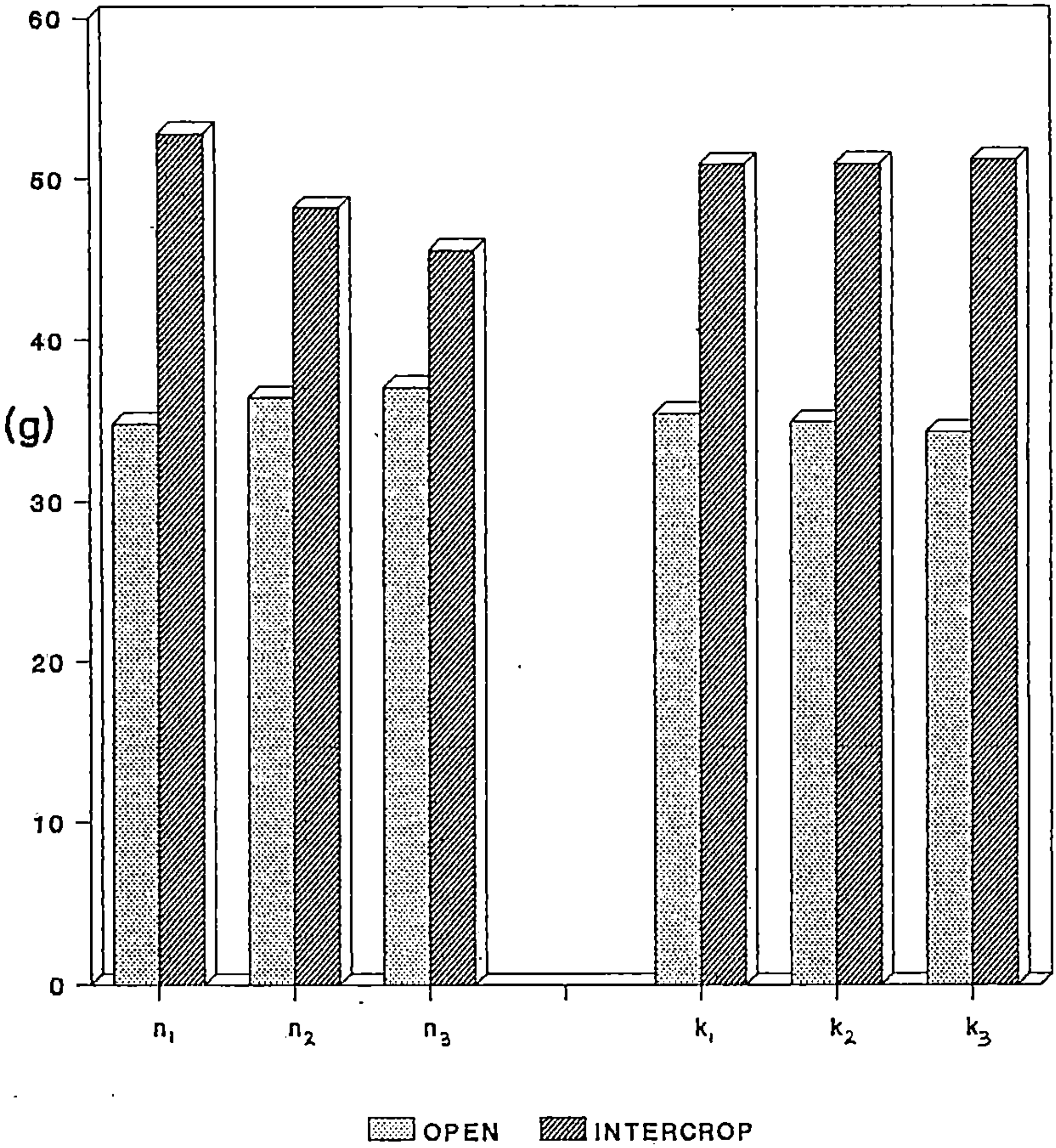
An increase in K levels progressively increased the number of cormels plant^{-1}. K level at 160 kg ha^{-1} showed an increase in number of cormels plant^{-1} to a tune of 3 and 1 per cent over k_1 and k_2 levels respectively. Similar results were reported by Pushpakumari (1989) in tannia.

The interaction effect of N and K indicated that maximum number of cormels plant^{-1} were obtained in n_3k_3 and was on par with n_2k_3 and n_1k_3. This might be due to the balanced N : K ratio which is a pre-requisite for tuber production in tropical tuber crops.

4.2.2.2. Mean weight of cormels

The N levels remarkably influenced the mean weight of cormels and the highest mean weight was noticed in n_1 and was significantly superior to n_2 and n_3 levels. Hence, it may be inferred that at higher levels of N, though the number of cormels increased it was not reflected in the mean weight which ultimately gave a higher percentage of non marketable tubers. Hence, for shaded situations, for getting higher

Fig. 4. Effect of N and K on mean weight of cormels in the open and as an intercrop in coconut garden



mean weight of cormels, the crop required a N requirement of 40 kg ha^{-1}. In the Philippines, Villanueva and Abenoja (1984) reported that application of 30 kg N ha^{-1} was required for getting higher mean weight and yield and the present result is in conformity with the above result.

Unlike open condition, under intercropped situation, an increase in K level increased the mean weight of cormels.

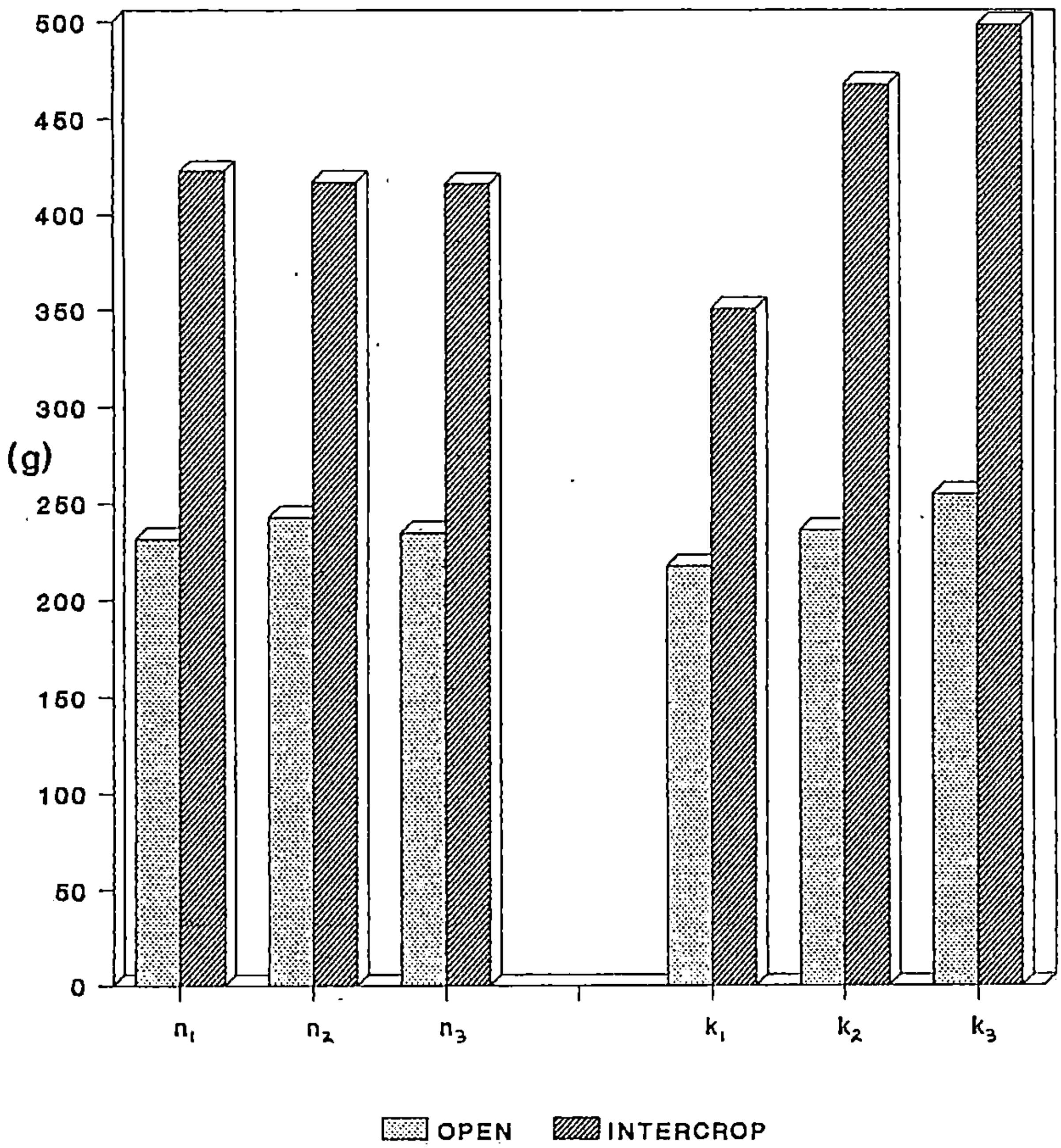
The interaction effect of N and K on mean weight of cormel indicated that the maximum mean weight was obtained in n_1k_1 treatment and was on par with n_1k_2.

4.2.2.3. Cormel yield $plant^{-1}$

The N levels did not exert any influence on the cormel yield indicating that the lowest level is optimum for getting comparable yield. Ramasamy et al (1982) reported that for getting higher yield a maximum dose of 40 kg ha^{-1} was sufficient in Colocasia. The present result corroborated with the above finding.

Similar to other yield attributing characters, an increase in K level progressively increased the cormel yield $plant^{-1}$. The increase in cormel yield at k_3 level was to the tune of 42 and 6 per cent over k_1 and k_2 level respectively.

Fig. 5. Effect of N and K on cormel yield plant^{-1} in the open and as an intercrop in coconut garden



The interaction between N and K did not have any effect on cormel yield plant^{-1}.

4.2.2.4. Corm yield plant^{-1}

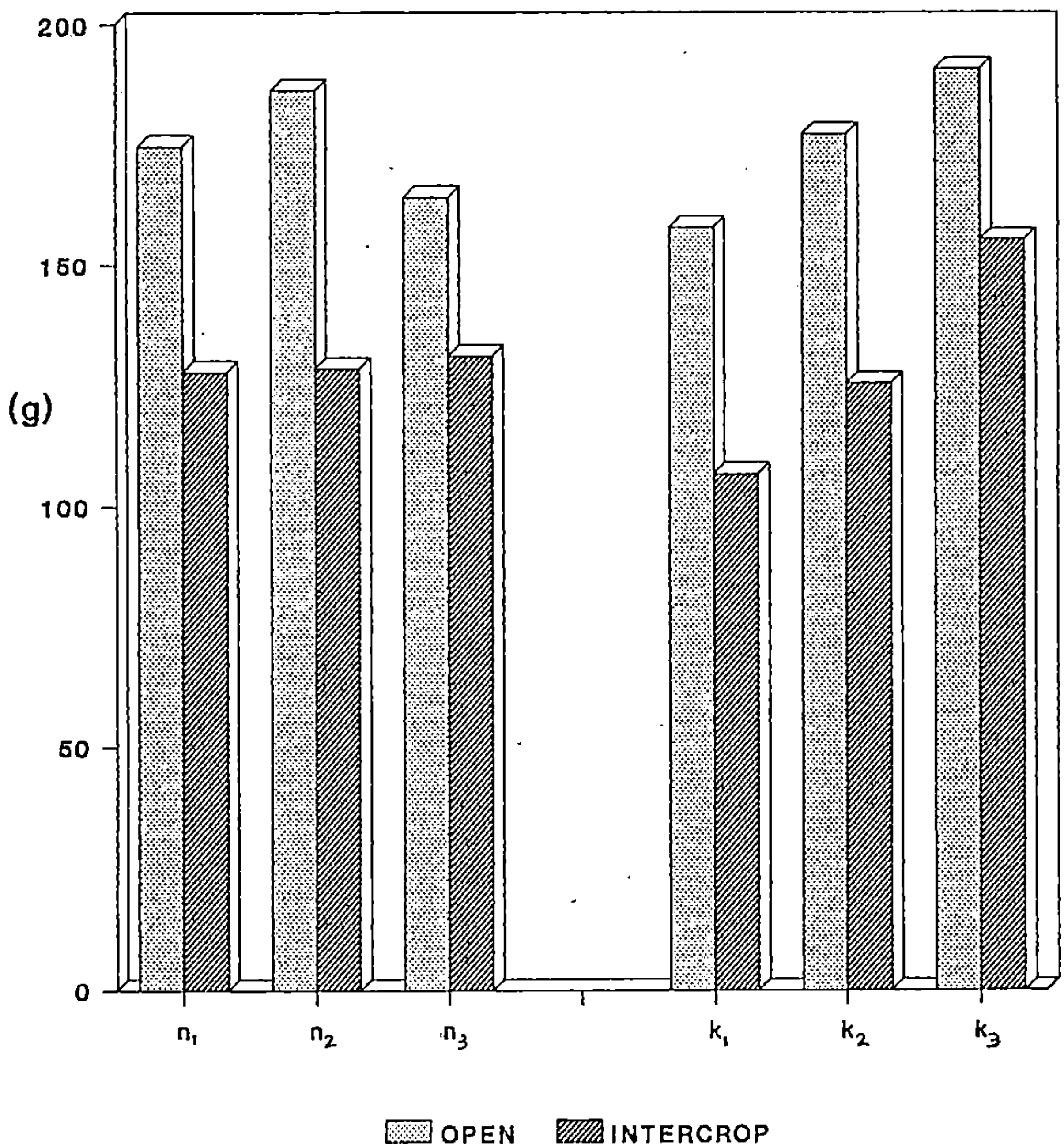
The corm yield was influenced by K and its interaction with N. The K levels showed a remarkable difference in corm yield and the highest yield was obtained at k_3 level. At k_3 level an increase of 45.26 and 29.26 per cent over k_1 and k_2 level respectively was noticed in corm yield. Similar increase in corm yield due to application of K was reported by Mohankumar (1986) in Colocasia.

The interaction effect of N and K on corm yield revealed that the highest yield was obtained in n_3k_3 which was on par with n_2k_3 and n_1k_3. Irrespective on N levels, K level invariably increased corm yield. The control treatment as envisaged in the Package of Practices recorded a significant reduction in corm yield compared to n_3k_2 treatment, which clearly revealed the requirement of higher level of K for increased corm yield.

4.2.2.5. Cormel to corm ratio

The effect of N, K and their interaction did not influence this character though there were numerical differences.

Fig. 6. Effect of N and K on corm yield $plant^{-1}$ in the open and as an intercrop in coconut garden



Experiment B

Table 15A. Average effect of N and K on corm yield plant^{-1}, cormel to corm ratio, yield of marketable tubers and harvest index.

Treatments	Corm yield plant^{-1} (g)	Cormel to corm ratio	Yield of marketable tubers t ha^{-1}	Harvest index
n_1	127.93	3.30	20.60	85.88
n_2	128.59	3.24	20.57	85.90
n_3	131.07	3.17	20.74	85.46
C.D.	N.S.	N.S.	N.S.	N.S.
k_1	106.87	3.28	17.23	82.04
k_2	125.48	3.73	21.03	86.87
k_3	155.24	3.21	23.64	88.34
C.D.	5.238	N.S.	0.506	0.520

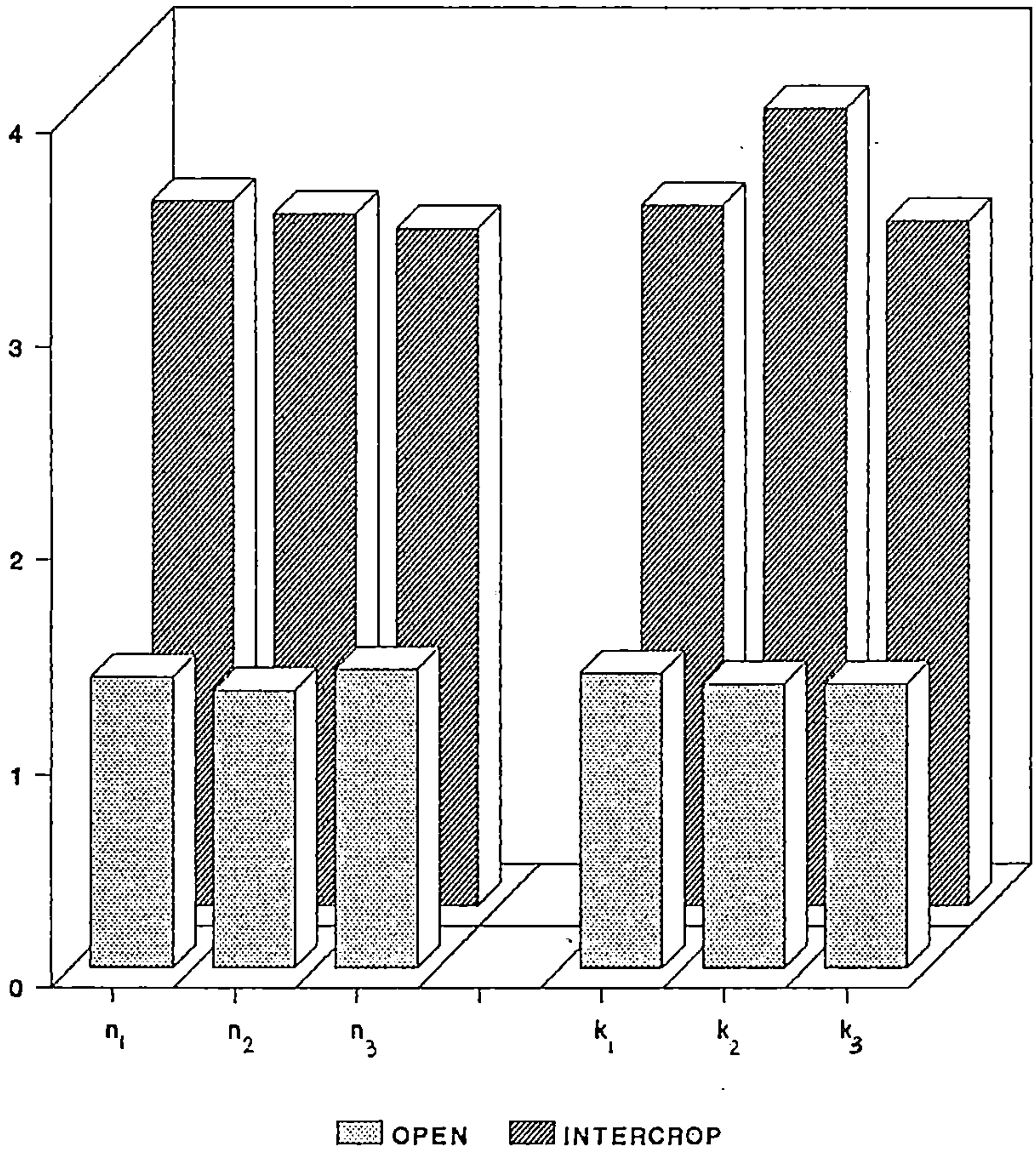
N.S. - Not significant

Experiment B

Table 15B. Average effect of treatments on cormel yield plant^{-1} (g), cormel to corm ratio, yield of marketable tubers (t ha^{-1}) and harvest index.

Treatments	Corm yield plant^{-1} (g)	Cormel to corm ratio	Yield of marketable tubers t ha^{-1}	Harvest index
n_1k_1	105.17	3.97	17.33	82.04
n_1k_2	127.47	3.29	21.20	86.83
n_1k_3	151.57	2.85	23.57	88.75
n_2k_1	105.23	3.93	17.13	81.98
n_2k_2	125.23	3.32	21.00	87.36
n_2k_3	155.30	2.72	23.27	88.35
n_3k_1	110.20	3.75	17.23	82.04
n_3k_2	123.73	3.36	20.90	86.41
n_3k_3	159.27	2.62	24.10	87.92
Control	113.50	3.66	19.30	83.96
C.D.	9.073	N.S.	0.877	0.900

Fig. 7. Effect of N and K on cormel to corm ratio in the open and as an intercrop in coconut garden



4.2.2.6. Yield of marketable tubers

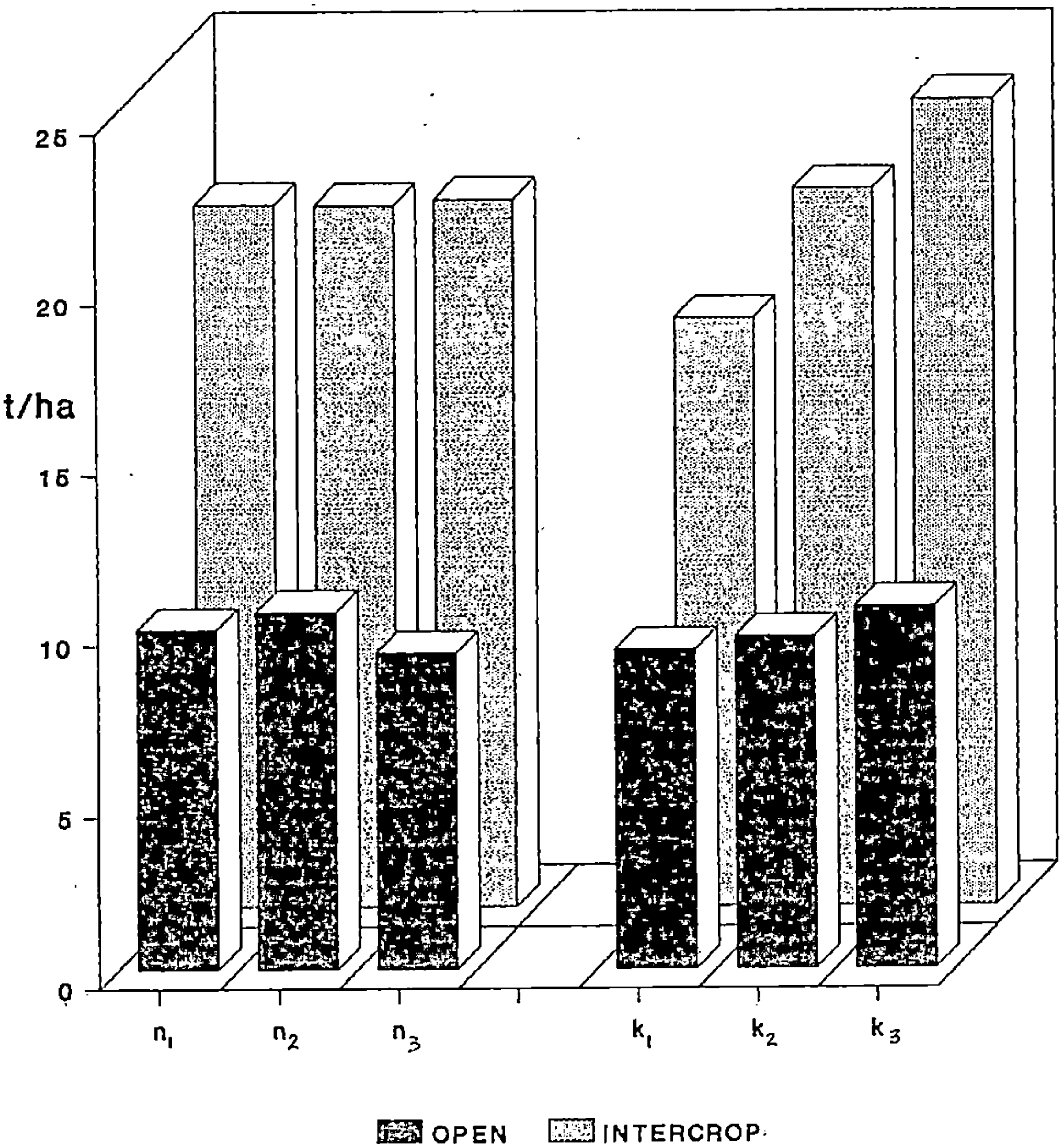
The data on yield of marketable tubers as influenced by N and K and their interaction are presented in Table 15A and 15B.

A comparison of yield under open and intercropped situation in coconut gardens clearly revealed that Colocasia is a shade loving crop, which is evident by an increase of 109 per cent in yield of marketable tubers.

Nitrogen levels did not have any significant influence on marketable tuber indicating that the lowest level is enough for Colocasia under intercropped situations in coconut gardens. In the Philippines, Villanueva and Abenoja (1984) reported that 30 kg N ha^{-1} was required to obtain optimum yield of taro. Ramasamy et al (1982) reported that the crop required 40 kg ha^{-1} of N while Abit and Alferez (1979) reported a requirement of 50 kg N ha^{-1}. The present study also indicated that 40 kg N ha^{-1} is enough for getting comparable yields.

Similar to open condition, K levels linearly increased the yield with increasing levels. At k_3 level increase of 37.2 and 12.41 per cent was recorded over k_1 and k_2 levels. This increase was due to an increase in number of cormels $plant^{-1}$, mean cormel weight, cormel yield and corm yield $plant^{-1}$. All the yield contributing characters were

Fig. 8. Effect of N and K on the yield of marketable tubers in the open and as an intercrop in coconut garden



significantly influenced by K application and was reflected in the final yield. This result is in conformity with the findings of Ramasamy et al (1982).

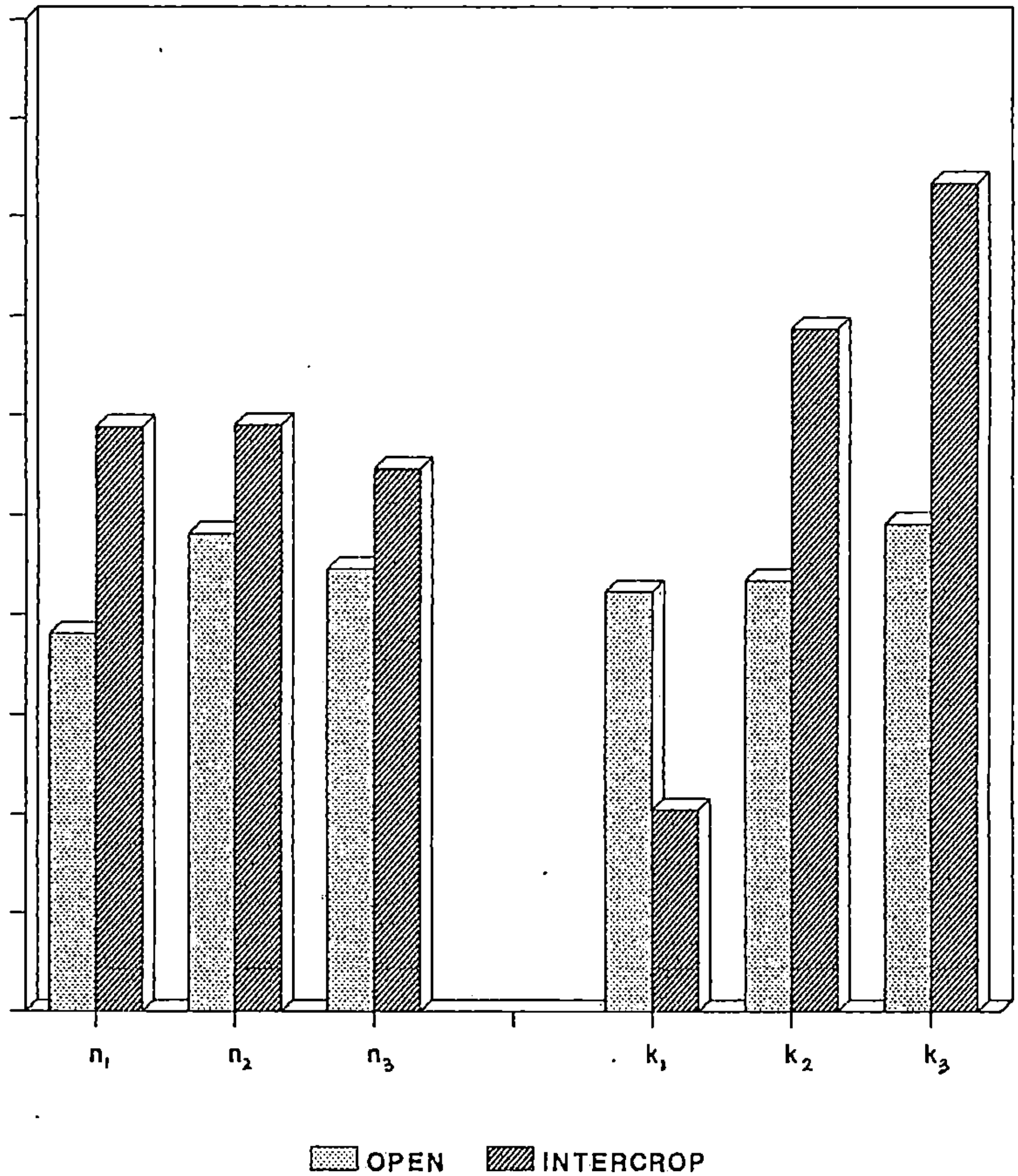
Interaction effect of N and K was significant. At k_3 level, all the N levels gave comparable results. Hence it could be inferred that n_1k_3 is the most important economic level for Colocasia under intercropped situation in coconut gardens. The present recommendation as given in the control showed a remarkable difference with n_3k_2 and n_3k_1 treatments. This is an indication of the essentiality of K for higher tuber yields. Hence, it could be inferred that for getting higher yields, the present fertilizer recommendation may be modified. The present study reveals that there is a possibility for reducing N by 50 per cent and increasing the quantity of K by 60 per cent for exploiting maximum production in Colocasia.

4.2.2.7. Harvest Index

The effect of N and K and their interaction on harvest index is provided in table 15A and 15B.

The K level and its interaction with N showed appreciable differences in harvest index. The nitrogen levels were on par with each other. Hence, it could be presumed that N level above 40 kg ha^{-1} is not required for

Fig. 9. Effect of N and K on harvest index of Colocasia in the open and as an intercrop in coconut garden



higher harvest index. The k_3 level of K showed remarkable increase in harvest index over other two levels indicating the enhanced K requirement for Colocasia for getting higher harvest index. Similar to other yield attributes and yield, harvest index was also maximum at higher level of K in all the three N levels. Therefore, n_1k_3 may be selected as the best economic combination for achieving maximum harvest index.

4.2.3. Quality aspects

The quality aspects viz., the dry matter percentage in cormel, dry matter percentage in corm and starch percentage in tuber as affected by N, K and their interaction are summarised in table 16A and 16B.

4.2.3.1. Dry matter percentage in cormel

A perusal of the data revealed that neither N, K or their interaction had any significant effect on the dry matter percentage in cormel.

4.2.3.2. Dry matter percentage in corm

Similar to cormel, in corm also the dry matter production did not give any appreciable differences due to the levels of N, K or their interaction.

Experiment B

Table 16A. Average effect of N and K on dry matter percentage in cormel, dry matter percentage in corm and starch percentage in tubers.

Treatments	Dry matter percentage in cormel	Dry matter percentage in corm	Starch percentage in tuber
n_1	26.09	20.71	53.89
n_2	25.13	20.04	53.90
n_3	24.19	19.48	54.19
C.D.	N.S.	N.S.	0.568
k_1	25.14	19.41	46.15
k_2	24.93	20.59	56.33
k_3	24.01	20.90	59.50
C.D.	N.S.	N.S.	0.568

N.S. - Not significant

Experiment B

Table 15B. Average effect of N and K on dry matter percentage in cormel, dry matter percentage in corm and starch percentage in cormel.

Treatments	Dry matter percentage in cormel	Dry matter percentage in corm	Starch percentage in tuber
n_1k_1	27.18	20.06	46.02
n_1k_2	26.06	20.92	55.69
n_1k_3	25.03	21.15	59.96
n_2k_1	25.39	19.89	46.12
n_2k_2	25.11	20.02	55.36
n_2k_3	24.89	20.22	60.22
n_3k_1	24.29	19.07	46.39
n_3k_2	24.16	19.27	56.40
n_3k_3	24.12	20.13	59.78
Control	24.07	19.05	45.98
C.D.	N.S.	N.S.	0.906

N.S. - Not significant

4.2.3.3. Starch percentage in tuber

Unlike other quality aspects, the starch percentage was favourably influenced by the treatment. The n_3 level of N recorded remarkable differences in starch percentage over n_1 and n_2 levels. The influence of N on starch was not obtained under open condition. This difference might be due to the difference in environmental conditions. Ghosh et al (1988) reported that large variations in chemical consistuents were observed in taro under different environmental conditions. The present study is in agreement with the above observation.

The K levels also influenced the starch percentage of cormels registering the maximum value at k_3. The requirement of K for starch synthesis explained in 4.1.3.3. holds good here also.

The K levels with n_2 and n_3 levels of N marginally increased the starch percentage. However, at higher levels of K, the N levels did not influence the starch percentage.

4.2.4. Nutrient uptake by vegetative non economic plant parts

The data on uptake of N P K by vegetative non economic plant parts (Leaves, psuedostem and roots) are presented in table 17A and 17B.

Experiment B

Table 17A. Average effect of N and K on the uptake of NPK by vegetative non economic plant parts (kg ha $^{-1}$).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	27.76	3.16	54.34
n_2	28.99	3.48	53.70
n_3	29.18	3.55	53.73
C.D.	0.549	0.222	N.S.
k_1	24.78	2.78	45.15
k_2	27.26	3.32	54.94
k_3	33.88	4.09	61.67
C.D.	0.549	0.222	0.735

Experiment B

Table 17B. Average effect of treatments on the uptake of NPK, by vegetative non economic plant parts (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	24.03	2.58	45.82
n_1k_2	26.40	3.15	54.93
n_1k_3	32.83	3.73	44.97
n_2k_1	25.01	2.83	44.97
n_2k_2	27.63	3.34	55.05
n_2k_3	34.32	4.27	61.10
n_3k_1	25.30	2.94	44.67
n_3k_2	27.76	3.45	54.85
n_3k_3	34.49	4.26	61.67
Control	27.01	3.39	52.36
C.D.	0.951	0.385	1.273

4.2.4.1. Uptake of Nitrogen

The uptake of nitrogen was profoundly influenced by N, K and its interaction. An increase in N level progressively increased the uptake of N and the maximum uptake was observed at n_3 level. This trend revealed that at higher levels of N, the crop had a tendency to consume more nitrogen. However, the enhanced uptake was not reflected in the final yield as evident in table 15A.

The uptake was also linearly increased with the increase in K levels. At k_3 and k_2 levels, 36.72 and 24.28 per cent increase in the K uptake was noticed over k_1 level. The enhanced uptake of K was exhibited in the plant growth, yield attributes and final yield.

The interaction of N and K showed that N uptake was greater at higher levels of N and K than at lower levels. At n_3k_3 and n_2k_3 the uptake was significantly higher than n_1k_3 level.

4.2.4.2. Uptake of Phosphorus

Similar to N uptake, the uptake of P was also influenced by N, K and their interaction.

The data presented in the table revealed that maximum uptake of phosphorus was recorded at n_3 level which was on par with n_2 and significantly superior to n_1. k_3 level recorded the maximum uptake of phosphorus which was significantly superior to k_2 and k_1. The interaction of N and K showed that a higher uptake of P was recorded at n_3k_3 and n_2k_3 than other treatment combinations.

4.2.4.3. Uptake of Potassium

The uptake of K by vegetative plant parts were influenced only by K and its interaction with N. The N levels did not influence the uptake of K in vegetative plant parts while the higher levels of K favourably influenced it. The increased uptake of K in plant parts was reflected in the growth and yield attributing characters also.

The interaction of N and K revealed that irrespective of N levels the highest level of K favourably increased the uptake of K in vegetative plant parts. The control plot of present recommendations showed a decline of K in vegetative plant parts as compared to n_3k_2, indicating the enhanced K requirement of the crop to maintain higher K status of vegetative plant parts.

4.2.5. Nutrient uptake by tuber

The effect of N and K and their interaction on the uptake of N P K by tubers are furnished in table 18A and 18B.

Experiment B

Table 18A. Average effect of N and K on the uptake of NPK by tuber (kg ha $^{-1}$).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	55.05	12.79	74.34
n_2	57.47	13.27	73.64
n_3	57.64	13.40	73.90
C.D.	1.010	N.S.	N.S.
k_1	49.19	11.97	65.30
k_2	53.59	12.30	75.15
k_3	67.39	15.22	81.47
C.D.	1.010	N.S.	0.810

N.S. - Not significant

Experiment B

Table 18B. Average effect of treatments on the uptake of NPK by tuber (kg ha $^{-1}$).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	48.03	10.49	65.82
n_1k_2	52.07	12.18	75.05
n_1k_3	65.05	12.70	82.29
n_2k_1	49.83	12.49	65.06
n_2k_2	54.04	16.36	75.17
n_2k_3	68.52	16.36	80.71
n_3k_1	48.69	10.46	65.01
n_3k_2	54.64	12.24	75.24
n_3k_3	68.58	16.59	81.43
Control	60.35	16.35	72.36
C.D.	1.749	N.S.	1.403

N.S. - Not significant

4.2.5.1. Uptake of Nitrogen

It could be seen from the data that N had a marked effect and maximum uptake was recorded at n_3 level which was significantly superior to n_1 and n_2.

Similarly, K exerted a significant influence on the uptake of N by tuber and maximum uptake was recorded at k_3 level which was significantly superior to k_1 and k_2.

The interaction of N and K on the uptake of N by tubers revealed that the maximum uptake was at n_3k_3 and n_2k_3 level. At lower level of K, N uptake was not influenced by N levels, confirming the balanced N : K ratio for the absorption of N.

4.2.5.2. Uptake of Phosphorus

Unlike the variation in the uptake of P by vegetative plant parts, the uptake of P in the tuber did not vary due to the influence of N, K or its interaction.

4.2.5.3. Uptake of Potassium

An observation of the data revealed that N had no effect on the uptake of K by tubers, while K had a significant effect on the same. Maximum uptake was recorded at k_3 level which was significantly superior to k_2 and k_1.

The interaction of N and K on K uptake by cormel showed the maximum uptake of K at higher levels of K in combination with all levels of N. The control treatment showed a diminishing trend of K uptake by tuber as compared to n_3k_2 treatment. This difference was noticed in the marketable tuber yield also, clearly establishing the enhanced K requirement not only for improving the yield but also for improving the quality.

4.2.6. Available nutrient status of soil at the time of harvest

The data on available N P K in soil at the time of harvest due to N and K levels and its interaction are presented in table 19A and 19B.

4.2.6.1. Available Nitrogen

The effect of N, K and its interaction had a positive influence on available N status in soil at harvest. At higher levels of N, the available N in the soil was maximum and was significantly higher than the lower level of N. At lower levels of N, there might be an enhanced uptake of N from the soil which resulted in a reduced content of available N.

Experiment B

Table 19A. Average effect of N and K on the changes in available soil NPK, at harvest (kg ha $^{-1}$).

Treatments	Nitrogen	Phosphorus	Potassium
n_1	309.96	24.27	147.83
n_2	311.62	24.98	148.75
n_3	312.31	25.48	151.40
C.D.	1.361	N.S.	1.345
k_1	282.64	25.74	133.89
k_2	307.35	21.39	153.96
k_3	343.90	27.30	160.13
C.D.	1.361	N.S	1.345

N.S. - Not significant

Experiment B

Table 19B. Average effect of treatments on the changes in available soil NPK, at harvest (kg ha^{-1}).

Treatments	Nitrogen	Phosphorus	Potassium
n_1k_1	282.10	25.14	132.11
n_1k_2	305.93	20.59	151.48
n_1k_3	341.84	26.59	159.89
n_2k_1	284.89	25.87	133.51
n_2k_2	307.01	21.83	153.03
n_2k_3	342.47	27.24	159.70
n_3k_1	280.93	25.72	136.65
n_3k_2	309.12	21.76	157.35
n_3k_3	346.89	28.06	160.79
Control	329.50	21.48	145.51
C.D.	2.358	1.040	2.329

Levels of K had a significant effect on the available soil N. At higher level of K the available N in the soil was maximum and was significantly higher than lower levels of K.

The maximum available soil N was recorded in the n_3k_3 treatment which was comparable with n_2k_3 treatment.

4.2.6.2. Available Phosphorus

Unlike N, the P status of the soil was not influenced due to various levels of N and K application or their interactions.

4.2.6.3. Available Potassium

The available K level in soil was profoundly influenced by N, K and their interaction. At n_3 level of N the available K in the soil was maximum and was significantly higher than the lower levels of N.

At higher levels of K, a higher level of available K was noticed in the soil. The reasons attributed under 4.1.6.3. holds good here also.

The N and K interaction effect was significant and maximum available soil K was recorded in n_3k_3 which was on par with n_2k_3 and n_1k_3.

4.2.7. Economics of Colocasia cultivation

The data in table 20 revealed that application of N @ 40 kg ha^{-1} and K @ 160 kg ha^{-1} resulted in highest net returns (Rs 37,560 ha^{-1}) and higher benefit cost ratio of 1 : 4.92.

Experiment B

Table 20. Economics of Colocasia cultivation under intercropped situations in coconut gardens.*

Treatments	Fixed cost (Rs)	Variable cost (Rs) N	Variable cost (Rs) K	Total cost (Rs)	Yield (t ha^{-1})	Gross returns (Rs)	Net returns (Rs)	Benefit : cost ratio
n_1k_1	9,000	220	180	9,400	17.33	34,660	25,260	3.69
n_1k_2	9,000	220	270	9,490	21.20	42,400	32,910	4.47
n_1k_3	9,000	220	360	9,580	23.57	47,140	37,560	4.92
n_2k_1	9,000	330	180	9,510	17.13	34,260	24,750	3.60
n_2k_2	9,000	330	270	9,600	21.00	42,000	32,400	4.38
n_2k_3	9,000	330	360	9,690	23.27	46,540	36,850	4.80
n_3k_1	9,000	440	180	9,620	17.23	34,460	24,840	3.58
n_3k_2	9,000	440	270	9,710	20.90	32,090	40,829	4.30
n_3k_3	9,000	440	360	9,800	24.10	48,200	38,400	4.92
Control	9,000	440	225	9,665	19.30	38,600	28,935	3.99

Cost of 1 kg N - Rs 5.50

Cost of 1 kg K_2O - Rs 2.25

Price of colocasia tuber - Rs 2.00 / kg.

* Not statistically analysed.

SUMMARY

An investigation was undertaken at the College of Agriculture, Vellayani during the period from April-May to October-November, 1990 to study the performance of Colocasia at different N and K levels under open and intercropped situations. The experiment was laid out in 3^2 factorial in RBD with 40, 60 and 80 kg ha^{-1} N and 80, 120 and 160 kg K_2O ha^{-1}. Observations on growth characters, yield attributes and yield, quality aspects, uptake of NPK by vegetative, non economic plant parts and tubers and changes in available soil NPK at harvest were recorded. The results of the study are summarised below.

The application of 60 kg N ha^{-1} resulted in maximum height of the plant while K @ 160 kg ha^{-1} recorded the maximum plant height under open condition. As an intercrop in coconut garden, N levels failed to exert any significant effect on plant height while K @ 160 kg ha^{-1} gave the maximum height.

The number of leaves were maximum when N and K were applied @ 60 and 160 kg ha^{-1} in the open. As an intercrop, higher number of leaves were obtained at 40 kg N and 160 kg K ha^{-1}.

Maximum LAI was recorded when N @ 60 kg ha^{-1} and K @ 160 kg ha^{-1} were applied in the open condition while N and K @ 40 and 160 kg ha^{-1} respectively gave maximum LAI under intercropped situations.

Nitrogen had no effect on the number of cormels $plant^{-1}$ under open condition while K @ 160 kg ha^{-1} recorded higher number of cormels $plant^{-1}$ in open situation. As an intercrop maximum number of cormels was recorded at 80 kg N and 160 kg K ha^{-1}.

The mean weight of cormels was not influenced by N under open condition while K @ 80 kg ha $^{-1}$ gave the highest mean weight of cormels. As an intercrop highest mean weight was noticed when N @ 40 kg ha^{-1} and K @ 160 kg ha^{-1} were applied.

Higher cormel yield and corm yield $plant^{-1}$ were obtained when N @ 60 kg ha^{-1} and K @ 160 kg ha^{-1} were applied under open condition. N had no significant effect on cormel yield and corm yield $plant^{-1}$ under intercropped situation while K @ 160 kg ha^{-1} gave the highest cormel and corm yield $plant^{-1}$.

The cormel to corm ratio was not influenced by the effect of N and K both under open and intercropped situations.

Nitrogen @ 60 kg ha^{-1} and K @ 160 kg ha^{-1} gave the highest yield of marketable tubers and harvest index under open condition while K @ 160 kg ha^{-1} gave the maximum yield and harvest index under intercropped situation. N had no influence on yield of marketable tubers and harvest index under intercropped situations.

The dry matter percentage in corm and cormels were maximum when N @ 40 kg ha^{-1} and K @ 160 kg ha^{-1} were applied under open condition. N and K had not effect on the drymatter percentage in corm and cormels under intercropped situations.

Potassium application increased the starch percentage of tuber and 160 kg ha^{-1} resulted in the maximum value under open condition. N @ 80 kg ha^{-1} and K @ 160 kg ha^{-1} recorded the maximum starch percentage of tuber under intercropped situation.

Plant uptake of N was influenced by levels of K and was the highest at highest levels of K under open condition. Levels of N and K influenced the plant uptake of N under intercropped situation and the highest uptake was at the highest levels of N and K.

Plant uptake of P was influenced only by K at highest level under open conditon. N and K at 80 and 160 kg

ha^{-1} recorded maximum plant uptake of P under intercropped situations.

There was a progressive increase in the plant uptake of K with increase in levels of K under open and intercropped conditions.

Nitrogen uptake by tuber was maximum at k_3 level under open condition. Maximum N uptake by tuber under intercropped condition was noticed when N and K were applied @ 80 and 160 kg ha^{-1} respectively.

Phosphorus uptake by tuber was highest at the highest level of K under open condition while N and K did not affect this character under intercropped situations.

Under open conditions N and K @ 60 and 160 kg ha^{-1} recorded the maximum uptake of K by tuber. N had no effect on the uptake of K by tuber while K @ 160 kg ha^{-1} recorded the maximum uptake under intercropped situations.

Available N and P content of the soil was not influenced by N and K levels under open conditon, while the available K was maximum when 160 kg ha^{-1} was applied. Under intercropped situation available N was maximum when N and K @ 80 and 160 kg ha^{-1} were applied. Available P was not influenced by levels of N and K. Higher level of available K was noticed when N and K were applied @ 80 and 160 kg ha^{-1}.

The economics worked out showed that an application of 60 kg N and 160 kg K ha^{-1} gave the maximum net returns and benefit cost ratio under open conditon. N @ 40 kg ha^{-1} and K @ 120 kg ha^{-1} gave the maximum net returns and benefit cost ratio under intercropped situations.

Future line of work

The present package of practice recommendation for Colocasia is 80 : 50 : 100 kg NPK ha^{-1}. This study implies that the dose of N can be reduced by 50 per cent and that of K increased by 60 per cent. Since this is an experiment conducted during one season only, it has to be repeated for getting more conformatory results.

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* Original not seen

APPENDICES

APPENDIX - I

Weather data during the Cropping Season (weekly averages)
[from May to October, 1990]

Standard week	Period From	To	Maximum temperature °C	Minimum temperature °C	Relative humidity %	Rainf (mm
19	6-5-90	12-5-90	28.50	24.21	83.21	3.4
20	13-5-90	19-5-90	29.60	23.44	81.72	--
21	20-5-90	26-5-90	30.50	23.56	77.41	10.
22	27-5-90	2-6-90	31.60	25.10	83.28	22.
23	3-6-90	9-6-90	29.46	24.11	78.20	49.
24	10-6-90	16-6-90	30.20	24.12	87.13	20.
25	17-6-90	23-6-90	29.53	24.07	81.07	20.
26	24-6-90	30-6-90	29.14	22.20	93.64	18.
27	1-7-90	8-7-90	30.13	24.07	81.14	9.4
28	9-7-90	15-7-90	28.30	23.16	93.28	5.0
29	16-7-90	22-7-90	27.50	23.42	77.00	2.6
30	23-7-90	29-7-90	29.37	23.50	86.00	11.
31	30-7-90	5-8-90	29.34	23.57	76.60	44.
32	6-8-90	12-8-90	28.00	22.90	79.90	3.1
33	13-8-90	19-8-90	29.08	23.90	81.10	10.
34	20-8-90	26-8-90	30.30	24.80	78.00	--
35	27-8-90	2-9-90	30.60	24.60	75.90	--
36	3-9-90	9-9-90	30.80	24.10	76.20	7.1
37	10-9-90	16-9-90	31.40	24.50	77.00	--
38	17-9-90	23-9-90	30.80	24.20	77.90	1.3
39	24-9-90	30-9-90	29.90	23.50	84.50	19.
40	1-10-90	7-10-90	30.50	24.70	79.90	1.8
41	8-10-90	14-10-90	30.90	24.30	77.07	0.6
42	15-10-90	21-10-90	30.40	24.02	93.20	5.3
43	22-10-90	28-10-90	31.80	23.70	88.69	7.7
44	29-10-90	4-11-90	28.80	23.10	88.50	16.

NUTRIENT MANAGEMENT FOR INTERCROPPED *Colocasia esculenta* Var THAMARAKANNAN

BY

RAJASREE J.

ABSTRACT OF THE THESIS
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VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

Field experiments were conducted at the Instructional Farm, College of Agriculture, Vellayani to study the effect of nitrogen and potassium on growth and yield of Colocasia and uptake pattern of major nutrients under open and intercropped situations in coconut gardens. The treatments in the experiment consisted of a combination of three levels of N (40, 60 and 80 kg/ha) and three levels of K (80, 120 and 160 kg/ha). The experiment was laid out in 3^2 factorial RBD.

Different growth attributes like plant height, number of leaves plant^{-1} and LAI were maximum when N @ 60 kg/ha and K @ 160 kg/ha were applied under open condition. Under intercropped situations N @ 40 kg/ha and K @ 160 kg/ha recorded the maximum values for these characters.

The yield attributes viz., number of cormels plant, mean weight of cormels, cormel and corm yield plant, and harvest index gave maximum values when N @ 60 kg/ha and K @ 160 kg/ha were applied under open condition. In the intercropped situation, the highest values were obtained when N and K were applied @ 40 and 160 kg/ha. Nitrogen @ 60 kg/ha and K @ 160 kg/ha gave the highest yield of marketable tubers under open condition while K @ 160 kg/ha gave the maximum yield under intercropped situation.

Nitrogen had no influence on yield of marketable tubers under intercropped situations. Potassium application increased the starch percentage of tubers and 160 kg K/ha^{-1} resulted in the maximum value under open and intercropped situations. Plant uptake of N, P and K were influenced by increasing levels of K and was highest at the highest level of K in both open and intercropped situations. Available N and P content of the soil was not influenced by N and K levels under open condition, while the available K was maximum when 160 kg/ha^{-1} was applied in both open and intercropped situations. Maximum benefit cost ratio and net returns were obtained by the application of N and K @ 60 kg/ha^{-1} and 160 kg/ha^{-1} respectively under open conditions and 40 kg ha^{-1} and 160 kg/ha^{-1} respectively under intercropped situation with coconut.