

COCONUT PRODUCTION UNDER VARIOUS CROPPING PATTERNS AND ITS CORRELATION TO THE SOIL AND LEAF NUTRIENT ELEMENT

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ABSTRACT

Low productivity of coconut farm is the main problem of coconut industry. The fact that intercropped palms were more productive than when solely planted, the most suitable way to increase productivity is through multiple cropping. To cope with the existing variation of cropping pattern in relation to coconut production, soil and leaf nutrient element, various cropping patterns with four species of perennial crop as intercrops were conducted under study. The objectives of the study were (1) to study the effect of cropping patterns on the growth, nut production and farm productivity of coconut under farmer levels, soil chemical properties and leaf nutrient element and (2) to study the correlation between growth and production parameter with soil chemical properties and leaf nutrient elements. Various cropping patterns under study namely (1) coconut monoculture (control), (2) coconut + pineapple, (3) coconut + coffee, (4) coconut + papaya + pineapple, (5) coconut + banana + coffee, and (6) coconut + banana + papaya + coffee + pineapple. Total area for each cropping pattern was 0.5 ha with coconut planting distance 8 m x 10 m and the palms 35-40 years old. The site of the experiment conducted was at Silang, Cavite. Data on coconut growth and production, soil chemical properties and leaf nutrient parameters, were statistically analyzed in a randomized complete block design (RCDB) with three replications. Correlation analysis were performed on the following (1) Growth and production parameters with soil chemical properties, and leaf nutrient elements, (2) Relationship among nutrient element in the coconut leaves under various cropping patterns. Results of the study showed that the effect of cropping patterns on the number of full-grown nut increased significantly more nut and higher amounts of copra per tree were produced in intercropped farms than in the mono-cropped coconut plantation. These increase ranged from 64 to 98 percent in terms of nuts and 70 to 105 percent in terms of copra. Positive correlation was observed between nitrogen in the top soil with weight of copra and nut production. The exchangeable potassium in top soil was positively correlated with nut production. Meanwhile, the organic matter, content in the soil were positively correlated with weight of copra, nut production but negatively correlated with percentage of nut shedding. These results implies that increase organic matter content in the soil will increase coconut production including fruit set. Nitrogen concentration in the leaf was positively and highly significantly correlated with number of nut shedding. These finding suggested that the increased nitrogen concentration in the leaf greatly promotes nut production and fruit set of the palms under various cropping patterns in coconut. The potassium in the leaf was significantly correlated with nut production but negatively correlated with percentage of nut shedding.

Key words: Coconut production, cropping patterns, soil chemical, leaf nutrient elements, correlation

RINGKASAN

Produksi kelapa pada beberapa pola tanam dan hubungannya dengan kandungan unsur hara tanah dan daun kelapa

Rendahnya produktivitas tanaman merupakan masalah utama pada perkebunan kelapa. Salah satu cara untuk meningkatkan produktivitas yaitu melalui penerapan usahatani kelapa campuran. Suatu kenyataan bahwa penerapan intercropping menyebabkan tanaman kelapa lebih produktif dibandingkan dengan tanaman monokultur. Untuk mengetahui

sejauh mana pengaruh tersebut secara ilmiah, serta hubungannya terhadap unsur hara tanah dan unsur hara dalam daun kelapa maka dilakukan penelitian secara terencana pada pertanaman kelapa rakyat produktif. Tujuan penelitian ini (1) untuk mengetahui pengaruh pola tanam terhadap pertumbuhan dan produksi tanaman kelapa, terhadap unsur hara dalam tanah dan kadar hara daun kelapa dan (2) mempelajari korelasi antara parameter pertumbuhan dan produksi kelapa dengan hara tanah serta kadar unsur hara daun. Enam polatanam kelapa yang diuji dalam penelitian ini yaitu (1) kelapa monokultur, (2) pola tanam kelapa + nanas, (3) pola tanam kelapa + kopi, (4) pola tanam kelapa + papaya + nanas, (5) pola tanam kelapa + pisang + kopi dan (6) pola tanam kelapa + pisang + papaya + kopi + nanas dimana masing-masing pola tanam seluas 0.5 ha. Jarak tanam kelapa 8 m x 10 m, dengan umur 40-45 tahun. Penelitian dilakukan di Silang, Cavite. Penelitian menggunakan rancangan acak lengkap (randomized complete block design) dengan tiga ulangan. Parameter yang diamati meliputi jumlah daun, jumlah bunga betina (button) per tandan, kadar unsur hara tanah meliputi kandungan bahan organik, pH, CEC, Nitrogen, Phosphor, Calcium, dan Magnesium. Sedangkan unsur hara daun yaitu Nitrogen, Phosphor, Calcium, dan Magnesium. Analisis korelasi dilakukan terhadap (1) pertumbuhan dan produksi kelapa dengan unsur hara tanah, dan unsur hara daun dan (2) hubungan antar unsur hara daun kelapa pada beberapa polatanam kelapa yang diteliti. Hasil penelitian menunjukkan bahwa produksi buah dan kopra pada polatanam campuran lebih tinggi dibandingkan dengan hasil pola tanam kelapa monokultur. Peningkatan produksi buah 64-98 persen dan kopra 70-105 persen. Kadar nitrogen pada lapisan atas tanah mempunyai korelasi positif dengan berat kopra dan produksi buah. Sedangkan unsur kalium pada lapisan tanah yang sama mempunyai korelasi positif dengan produksi buah kelapa. Kandungan bahan organik tanah mempunyai korelasi positif dengan berat kopra, produksi buah namun berkorelasi negatif dengan presentase buah yang gugur (nut shedding). Hasil ini berimplikasi bahwa dengan meningkatnya kadar bahan organik tanah akan meningkatkan produktivitas tanaman kelapa. Lebih lanjut, hasil penelitian menunjukkan bahwa kadar nitrogen dan kalium pada daun mempunyai korelasi positif dengan peningkatan produksi kelapa dan persentase buah yang jadi.

Kata kunci: Produksi kelapa, polatanam, unsur hara tanah, kadar unsur daun, analisis korelasi

INTRODUCTION

Coconut is an industrial crop widely grown in Indonesia. The Indonesian coconut industry receives a considerable share of national attention because of its contribution to national economy. In 1999 Indonesian coconut production reached with total value amounting to US \$ 393 million (HAZ, 2001).

Coconut is one of the export product of Indonesia. Approximately 12.8 million coconut farmers and 20 million Indonesian depend upon this crop for their lively-hood (SULISTIYO, 1998 and KASRYNO *et al.*, 1998).

Based on production from the area devoted to coconut, the national average yield only 1.1 ton equivalent copra per hectare per year. (KASRYNO *et al.*, 1998).

Meanwhile, the socio-economic characteristic of coconut farming in Indonesia is such that the market price of copra, the principal product, is highly fluctuating and the farmers income from coconut is not stable. This is further complicated by relatively small coconut farm size and high population density which resulted in very small per capita income. Likewise, BAVAPPA and JACOB (1982) stated that land – to – man ratios in the developing countries of the tropics were fast narrowing and have already reduced the per head availability of arable land to less than 0.25 hectare in a number of countries like Bangladesh, Indonesia, Philippines and Srilanka.

CREENCIA (1978) suggested maximized utilization of coconut lands to provide a promising cushion from any future drops in the price of copra. He mentioned multiple cropping as a solution to increase productivity of coconut land. Similarly, NELLIAT *et al.* (1979) pointed out that the most suitable way to increase productivity is through multiple cropping which would keep the photosynthetic factory to be operative at higher efficiency and longer time.

Most intercrops grown, aside from being remunerative, had no adverse effect on the growth and yield of coconut (MARGATE, 1978). The fact that intercropped palms were more productive than when solely planted can be attributed to the constant cultivation and fertilization made on the intercrops (MARGATE, 1978). Intercropping improves the yield of coconut (MAGAT, 1999) and increase copra yield with one or more cropping combination ranged from 10-46 percent (MARGATE, 1978). Despite all these advantages, these has not been any serious study on farming pattern with perennial crops conducted with regard to growth of coconut, soil properties and leaf nutrient levels.

The objectives of the study were the following :

1. To study the effects of cropping patterns on the growth, nut production and farm productivity of coconut under farmer levels
2. To study the effects of cropping patterns on the soil chemical properties and leaf nutrient element under various cropping patterns and
3. To study the correlation between growth and production parameter with soil chemical properties and leaf nutrient elements

MATERIAL AND METHODS

Criteria in Selecting Coconut Cropping Patterns

The coconut trees as base of cropping pattern in this study, the age of the variety was indexed by the height of the trunk of tall varieties grow about high in a year. This information plus the help of the farmers whose coconut farms were established 40 to 45 years ago were included in the final listing of area samples. At this particular age

range, tall varieties of coconut trees are still in their peak of nut production. Only perennial intercrops and the most common practiced by the farmer in the area of study were used. Uniformity in ages from each intercrop within cropping pattern was considered.

The area of experiment was mostly plain and concentrated in one village. The elevation of the area was 47 m above sea level, the average rainfalls was 3 450 mm/year, the soil type was yellow red podzolic and the pH was 6.0.

Local tall variety was used in this study. Bole trunk is one of the criteria used in the selection of the coconut palms with plant distance 8 m x 10 m.

Meanwhile, the type of plants as intercrop (s) in this study were the perennial crops that commonly practiced by the local farmers. The sampled farms were limited to those with practiced under brushing and fertilization of inter crops (s) plant. There was no application of fertilization to coconut palms, as main crop in the cropping patterns.

Cropping Patterns Under Study

The selection of cropping patterns was based on the preliminary survey conducted in an area of coconut small holders in Silang Village, Cavite District. The results obtained were the basic material for this study. Various cropping patterns as used for the study such as (1) coconut monoculture as control (cc), (2) coconut + pineapple (cc/pi), (3) coconut + coffee (cc/cf), (4) coconut + papaya + pineapple (cc/pa/pi), (5) coconut + banana + coffee (cc/ba/cf) and (6) coconut + banana + papaya + coffee + pineapple (cc/ba/pa/cf/pi). Total area for each pattern is 0.50 ha, with plot size 60 palms /plot

Data Collected

The leaves of 10 tree chosen at random were counted per cropping patterns. The leaves totally damage by insects were not included. Also, fronds that were yellowing and drying at the basal portion of the peduncle were not considered.

The number of bunch produced from 10 palms per replication was gathered. Bunches with or without button and nuts were counted. The number of button per bunch was derived from three older bunches per palm sampled. Number of pedicles plus number of nut per bunch were counted as number of button per bunch.

Nut shedding data were gathered from bunches with full size nut stage. The data were counted by using the following formula.

$$\% \text{ nut shedding} = \frac{b}{a + b} \times 100\%$$

where :

a = number of full size nut/bunch

b = number of pedicel/bunch

The number of full-grown nut was gathered from bunches with full-sized nut to the oldest bunch. The number of nuts times two were counted as number of full-grown nut (nut production per tree per year).

Chemical soil properties analyzed were total nitrogen, available phosphorus, exchangeable magnesium, soil pH, organic matters and cation exchange capacity.

Meanwhile, nutrient concentration of the leaves was measured by tissue analysis. Nutrient concentration of the leaves analyzed were nitrogen, phosphorus, potassium, calcium and magnesium.

Sampling Procedure

Soil samples for chemical laboratory analysis were obtained from five pits that were dug randomly in every replication of cropping pattern. Two major horizons were sampled separately, namely topsoil with a depth of 0-40 cm and subsoil of 40-50 cm. Due to relatively great variation in each layer between replication, a composite sample was obtained.

The sampling and preparation of leaf samples were adopted from FREMOND *et al.* (1966). Leaf samples were gathered from the 14th leaf and derived from five trees per replication of cropping pattern. Every sample tree, six leaflets were taken from near the middle length of the blade, three from each side of the central rachis.

Procedure of Analysis

The nutritional status of soil under various cropping pattern were collected to determine the total N, P, K, Ca, Mg, organic matter (OM) and soil reaction (pH) of the sample. Procedure of analysis followed the standard method of analysis for soil, plant tissue, water and fertilizers (ANON., 1980).

Nitrogen, phosphorus, potassium, calcium and magnesium were analyzed from the leaf sample. The method used for soil analysis was the same procedural operation employed in leaf analysis, for the said nutrients elements.

Statistical Analysis

Data on growth parameters, production parameters, leaf or tissue analysis parameters were statistical analyzed in randomized complete block design (RCBD) with three replications. The HSD test was used in comparing the effects among the various cropping patterns.

Correlation analysis were performed on the following :

1. Growth and production parameters with soil chemical properties
2. Growth and production parameter with leaf nutrient elements and
3. Relationship among nutrient element in the coconut leaves

RESULT AND DISCUSSION

Number of Functional Leaves

The number of functional leaves in coconut palms was significantly affected by the type of cropping patterns (Table 1). Coconut palm with coffee (cc/cf) had substantially more functional leave than cc/pi and cc/ba/pa/cf/pi while the palm from other cropping patterns did not differ from either group. The trend did not seem to be related with cropping intensity.

MENON and PANDALAI (1958) attributed the variation in the number of leaves to a number of factors. Foremost were the age of the palm and the rate of leaf production. It was stressed further that the rate of leaf production was influenced by the vigor of the tree, culture and management practices, seasonal condition and fertility status of the soil and genetic make - up of the tree (FREMOND *et al.* 1966). The rate of production was much more in fertile than in an infertile soil. Proper soil nutrition does not only increase leaf production but also affect produce leaves (DAVIS, 1964).

Number of Bunch Produced

Cropping pattern in coconut had significantly affected the number of bunch produced per palm (Table 1). Cropping pattern cc/pa/pi produced significantly more coconut bunches than the coconut monoculture pattern. The palm in other patterns did not differ significantly from either of the above. The data also indicated that in the presence of intercroops in cropping pattern, more bunches were produced.

Table 1. Growth and production parameters of coconut under various cropping patterns
 Tabel 1. Pertumbuhan dan produksi kelapa pada beberapa pola tanam

Cropping patterns Pola tanam	Number of functional leaves Jumlah daun	Number of bunch Jumlah tandan	Number of button per bunch Jumlah bunga betina pertandan	Percentage of nut shedding Persentasi buah tidak jadi	Number of full grown nut Jumlah buah
Coconut Monoculture (cc)	23.69 ab	12.73 b	6.67 ab	58.83 a	28.84 b
Coconut + Pineapple (cc/pi)	22.60 b	14.51 ab	6.44 ab	42.41 b	47.87 a
Coconut + Coffee (cc/cf)	25.55 a	14.42 ab	8.76 ab	40.81 b	49.25 a
Coconut + Papaya + Pineapple (cc/pa/pi)	24.49 ab	14.82 a	6.00 b	40.03 b	47.38 a
Coconut + Banana + Coffee (cc/ba/cf)	23.55 ab	13.49 ab	9.47 a	43.44 b	49.33 a
Coconut + Banana + Papaya + Coffee + Pineapple (cc/ba/pa/cf/pi)	23.09 b	13.71 ab	8.02 ab	41.07 b	54.71 a

Note : Numbers followed by the same letter in each column are not significantly different at 5% level
 Keterangan : Angka yang diikuti huruf yang sama pada setiap kolom tidak berbeda nyata pada taraf 5%

This was attributed to increased organic matter content in the topsoil in the presence of intercrops. Fertility status of the soil affected the rate of leave production. The rate of production was much more in fertile soil than in infertile soil (FREMONT *et al.*, 1966).

In normal conditions, every axil of each leaf contains of flower bud which develops to the flowering and fruit bunch. Other things being equal, the more leave there are, the more bunches of nut will there be per tree. However, flower abortion is not uncommon in coconut palms.

Number of Button per Bunch

Cropping pattern in coconut significantly affected the number of button per bunch (Table 1.) with cc/ba/cf pattern having the highest and statistically higher than cropping pattern cc/pa/pi which had the lowest. Cropping pattern cc/cf, cc/ba/pa/cf/pi, coconut monoculture, and cc/pi did not differ significantly.

It was interesting to note that the presence of coffee plant as an intercrop in the cropping patterns increased the number of button per bunch. For one thing, it has the deepest root system and that it sheds the most leaves among intercrops.

Percentage of Nut Shedding

The average percentage of nut shedding under various cropping patterns is presented in Table 1. The coconut monoculture pattern had the highest percentage of nut shedding with an average 53.83 percent. This was significantly higher than the nut shedding of palms in the other cropping patterns which had 40.8 to 43.3 percent. In other words, fruit set in intercropped coconut farms was higher than in coconut monoculture.

Higher percentage of nut shedding (low fruit set) on the coconut monoculture might be due to agronomic problem, like weeding and lack of organic matter and inorganic fertilizer to the farms. The visual observation indicated that nitrogen concentration of coconut leaf from coconut monoculture pattern showed a deficiency symptom, thus the negative effect on fruit set and cause low productivity in coconut palms (FREMONT *et al.*, 1966).

Number of Full – Grown Nut

The number of full-grown nuts in coconut monoculture pattern was significantly lower than fruit set in any intercropped patterns (Table 1). This finding suggested that cropping patterns in coconut improved number of full-grown nuts per tree per year markedly. It was interesting to note that the presence of coffee plant as an intercrop in the cropping patterns increased the number of full-ground nut.

The increment in the number of full-grown nuts over the control (cc) ranged from 64.29 to 89.7 percent. Furthermore, the data indicated that the presence of intercrop (s) in the cropping patterns increased number of bunch per tree, decreased percentage of nut shedding (Table 2) and generally increased number of button per bunch. NAIR and SUBADRAO (1977) suggested that the additional increase in yield of coconut under mixed cropping with cacao could be due to the synergistic effect of crop combination. CREENCIA (1978), however, believed that the beneficial effects of intercropping on coconut was due mainly to the weeding and cultivation of the intercrops. DOLLAR (1961) and MAGAT (1976) on the other hand, attributed the increase in coconut yield to the fertilizer and regular cultivation given the intercrops. The application of crop residues increased soil organic matter (FOTH and TURK, 1974; MILLER and AMSTAD, 1971) and nitrogen derived from the breakdown of plant formed humus (CHILD, 1964). The increment the organic matter to the soil in intercropped areas seemed to explain the higher yields in intercropped palm (THAMPAN, 2002).

Nut Production

The average nut production per hectare per year as affected by cropping patterns in coconut is presented in Table 2. Nut production in the monoculture (cc) pattern was the lowest compared to any of the intercropping patterns. This implied that the cropping pattern in coconut improved nut production per hectare per year. These production followed the trend of nut production per tree per year. Also, in the presence of coffee plant as an intercrop in a cropping pattern, there was higher increment on nut production.

The increment of nut production per hectare due to the presence of intercrop over the control (cc) ranged from 64.29 to 98.27 percent as found in nut production per tree or number of full-grown nut. This may due to increments in organic matter (THAMPAN, 2002) and decreased percentage of nut shedding (Table 1).

Copra Production

The average copra production per hectare per year as affected by cropping pattern in coconut is also presented

in Table 2. Cropping patterns cc/ba/pa/cf/pi had the highest copra production per hectare per year with an average of 1398.25 kg/ha/yr followed closely by cropping patterns cc/ba/cf, cc/cf, cc/pi and cc/pa/pi with production of about 1.2 tons. The copra produced from monoculture plantation was about half that much. (682.5 kg).

The increment due to intercropping in the copra production over the control (cc) ranged from 69.7 to 104.9 percent. This may be due to increased fruit set and increased organic matter in intercropped farm. These results were in consonance with those of FREMOND *et al.* (1966) who reported that increased nitrogen as the increment of organic matter in the soil affects the number of nut and weight of copra per nut.

Number of Nut on Productive Bunch

The average number of nut on productive bunch at full-sized nut stage is presented in Table 3.

Cropping pattern cc/ba/cf and cc/cf had the highest number of nuts on productive bunch followed by cc/ba/pa/cf/pi pattern with average of 6.37, 6.37, and 6.06

Table 2. Production of coconut tree and farm productivity under various cropping patterns
Tabel 2. Produksi per pohon dan produktivitas pertanian kelapa pada beberapa pola tanam

Cropping patterns Pola tanam	Production/tree/year Produksi /ph/th		Production/ha/year** Produksi/ha/th	
	Nut Buah	Copra (kg) Kopra(kg)	Nut Buah	Copra (kg) Kopra (kg)
Coconut Monoculture (cc)	28.8 b	5.55 b	3 605.00	682.50
Coconut + Pineapple (cc/pi)	47.9 a	9.64 a	5 983.75	1 205.25
Coconut + Coffee (cc/cf)	49.3 a	9.97 a	6 156.25	1 245.75
Coconut + Papaya + Pineapple (cc/pa/pi)	47.4 a	9.27 a	5 922.50	1 158.13
Coconut + Banana + Coffee (cc/ba/cf)	49.3 a	10.34 a	6 166.25	1 292.13
Coconut + Banana + Papaya + Coffee + Pineapple (cc/ba/pa/cf/pi)	54.7 a	11.19 a	6 838.75	1 398.25

Note : Numbers followed by the same letter in each column are not significantly different at 5% level

Keterangan : Angka yang diikuti huruf sama pada setiap kolom tidak berbeda nyata pada taraf 5%

** Production based on plant density 125 palms /ha (8m x 10m)

Table 3. Fruit set of coconut palms under various cropping patterns
Tabel 3. Buah kelapa yang jadi pada beberapa pola tanam

Cropping patterns Pola tanam	Number of nut per productive bunch Jumlah buah/tandan	Number of productive bunch at full-size Jumlah tandan produktif	Number of barren bunch Jumlah tandan hampa	Percent productive bunch ** Persentasi tandan produktif
Coconut Monoculture (cc)	3.46 c	4.13 ab	0.53 ab	90.25
Coconut + Pineapple (cc/pi)	4.63 bc	5.13 a	0.31 ab	94.51
Coconut + Coffee (cc/cf)	6.37 a	4.02 ab	0.53 ab	88.94
Coconut + Papaya + Pineapple (cc/pa/pi)	4.60 bc	5.22 a	0.14 b	97.63
Coconut + Banana + Coffee (cc/ba/cf)	6.37 a	3.91 b	0.42 ab	90.78
Coconut + Banana + Papaya + Coffee + Pineapple (cc/ba/pa/cf/pi)	6.06 ab	4.58 ab	0.64 a	88.72

Note : Numbers followed by the same letter in each column are not significantly different at 5% level

Keterangan : Angka yang diikuti huruf sama pada setiap kolom tidak berbeda nyata pada taraf 5%

** Ratio of productive bunch to the number of bunch at full size nut stage

nuts, respectively. These were significantly higher than that of coconut monoculture but the last of the cropping patterns was significantly different from those of cropping patterns cc/pi and cc/pa/pi. The palm in the cropping patterns cc/ba/pa/cf/pi had significantly more nuts on productive bunches than those of cropping patterns cc/pi and cc/pa/pi but did not differ significantly from the palm in the other cropping patterns.

It was interesting to note that the presence of coffee as an intercrop plant in the cropping patterns increased the number of nuts on productive bunches. This finding may be due to the effect of coffee intercrop on the increased number of button per bunch as shown earlier (Table 1).

Number of Productive Bunch at Full-Sized Nut Stage

Cropping pattern cc/pa/pi had the highest number of productive bunch at full sized nut stage followed by cc/pi with average 5.22 and 5.13 respectively (Table 3). These were significantly higher than the cropping of cc/ba/cf.

The data also indicated the presence of pineapple as an intercrop plant, increased the number of productive bunch at full sized nut stage. This may be due to increment in the number of bunch produced in the presence of pineapple as an intercrop in the cropping pattern under the study (Table 1).

Number of Barren Bunch at Full-Sized Nut Stage

The average number of barren bunch at full-sized nut stage under various cropping pattern is presented in Table 3. Cropping pattern in coconut insignificantly affected the number of barren bunches at full-sized nut stage at five percent level. However, cropping pattern significantly affected number of barren bunches at the 10 percent level, with cc/ba/pa/cf/pi pattern having the highest and of cc/pa/pi pattern the lowest. The rest were intermediate and did not differ from either.

Percent Productive Bunch

Cropping pattern did not significantly affect the percentage of productive bunches although cc/pa/pi had the highest ratio with an average of 97.63 percent and the most intensively cropped farms, the lowest (88.72 percent). The differences were still insignificant when the means were compared at 10 percent level. This result suggested that the ratio of productive bunch to number of bunch at full-sized nut stage was not affected by cropping patterns in coconut.

Correlation Analysis

Growth and Production Parameter With Soil Chemical Properties

Result of linier correlation analysis between growth and production parameters and soil chemical properties under various cropping patterns in coconut is presented in Table 4. Correlation values both in the top and subsoil were indicated.

Organic matter

The organic matter content in the top and subsoil were positively though weakly correlated with number of functional leaves, weight of copra, nut production, number of button per bunch and ratio of productive bunch to number of bunch at full size nut stage; but negatively correlated with percentage of nut shedding. These results implied that increase organic matter content in the soil will increase growth and production parameters, including fruit set (reverse of percentage of nut shedding).

Soil reaction (pH)

Weak correlation existed between pH and most growth and production parameters, except for a significantly positive correlation with percent nut shedding. The number of leaves, number of bunch and nut production were negatively correlated with pH but a direct relationship existed with weight of copra. This means that within pH ranges 4.83-5.33, increase in pH may improve the weight of copra per nut but may also increase nut shedding. However, the same change in soil reaction may reduce the other growth parameters.

Cation exchange capacity

Cation exchange capacity was directly though weakly correlated with all growth and production parameters studied except for copra weight and nut shedding. These results implied that increase cation exchange capacity in the soil will reduce weight of copra per nut and percentage nut shedding (increase fruit set).

Nitrogen

A significant positive correlation at five percent level was observed between nitrogen in the top soil with

Table 4. Linear correlation (r) between growth, and production parameters and soil chemical properties under various cropping patterns
 Tabel 4. Korelasi linier antara parameter pertumbuhan dan produksi dengan unsur hara tanah pada beberapa pola tanam kelapa

Soil chemical properties Sifat kimia tanah	Number of functional leaf Jumlah daun	Number of bunch Jumlah tandan	Number of button per bunch Jumlah bunga betina per tandan	Percentage of nut shedding Persentasi buah tidak jadi	Nut production Produksi buah	Weight of copra Berat kopra	Bunch ratio***
Organic Matter	TS 0.40952	0.18636	0.26880	-0.18989	0.39371	0.39634	0.05899
Bahan organik	SS 0.36430	0.36684	0.23455	-0.21014	0.03596	0.34453	0.09431
Soil Reaction (pH)	TS -0.32131	-0.37020	0.00137	0.59557**	-0.38708	0.03721	-0.11213
Reaksi tanah pH	SS -0.15778	-0.23059	-0.07526	0.33164	-0.20016	0.08963	0.15577
Cation/Exchange	TS 0.39020	0.16020	0.20995	-0.20584	0.29103	-0.23389	0.45234
Capacity Kapasitas tukar kation	SS 0.30928	0.43482	-0.18778	-0.30268	0.39184	-0.08672	0.04778
N	TS 0.40405	-0.16062	0.44025	-0.26319	0.52119*	0.52378*	-0.07853
	SS 0.45892	0.02787	0.16565	0.05119	0.02361	0.24161	0.26988
P	TS 0.08064	-0.15901	0.45039	0.10612	0.12167	0.12167	-0.28528
	SS 0.18621	-0.19302	-0.03136	-0.28604	-0.33314	-0.17998	0.39039
K	TS 0.18178	0.49330*	0.05517	-0.42921	0.48810*	0.28208	0.19153
	SS 0.31455	0.69863**	0.18292	0.73331**	0.71971**	0.40435	0.03060
Ca	TS -0.05214	-0.21364	0.18538	0.19262	0.00445	0.08734	-0.14350
	SS -0.01380	0.48694*	-0.10060	-0.50627*	0.47255*	0.17698	0.22240
Mg	TS -0.22104	0.10612	-0.19496	0.33536	0.21056	0.03070	0.03348
	SS -0.23129	-0.11100	-0.28604	0.01580	0.01397	-0.03850	0.27738

Note : TS - Topsoil

SS = Subsoil

Keterangan : * Significantly different at 5% level Berbeda nyata pada taraf 5%

** Significantly different at 1% level Berbeda nyata pada taraf 1%

*** Ratio of productive bunch to number of bunch at fullsize nut stage

weight of copra and nut production. The results implied that the weight of copra and nut production increase with higher levels of topsoil nitrogen. This findings jibed with that FREMOND *et al.*, (1966) who reported on nitrogen nutrient effect on the number of nut and weight of copra per nut.

The data indicated positive relationship of topsoil nitrogen to number of functional leaf and number of button per bunch, though not significantly. Also, negative but insignificant correlation with number of bunch, percentage of nut shedding and the ratio of the productive bunch to number of bunch with full size nut stage also existed.

Nitrogen in the subsoil was not significantly correlated with the same growth and production parameter.

Phosphorus

The available phosphorus in either top or subsoil was weakly correlated to growth and production parameters. The relationship was positive for most parameters except for the number of bunch, percentage nut shedding and ratio of productive bunch to number of bunch with full size nut stage as was the case with nitrogen in the topsoil. In the subsoil, positive correlations were observed in number of functional leaf, percentage of nut shedding and the ratio of productive bunch to number of bunch with full size nut stage.

Potassium

The exchangeable potassium in the topsoil was positively and significantly correlated with nut production and number of bunch but insignificantly correlated with the number of functional leaf, weight of copra, number of button per bunch and the ratio of productive bunch to number of bunch with full size nut stage. However, it was negatively though insignificantly correlated with percentage nut shedding. These results implied that with higher exchangeable potassium in the topsoil, increase in nut production, number of bunch produced and fruit set may be expected. This finding conformed with FREMOND *et al.*, (1966) who reported that potassium increased the number of inflorescence, the number of female flowers, the proportional of fruit set, the number of nuts and their weight. Also, MENON and PANDALAI (1958) reported that potash increased the yield and improved the quality of plant products.

The exchangeable potassium in the subsoil was positive and highly significantly correlated with nut production and number of bunch but was weakly correlated with the number of functional leaf, weight of copra, number of button per bunch and the ratio of productive bunch to number of bunch with full size nut stage. Further, the data indicated that significantly negative correlation existed with percentage of nut shedding, suggesting that increase

potassium in the subsoil reduced percentage of nut shedding or increase fruit set of the nuts.

Calcium

The exchangeable calcium in the topsoil was positively correlated with weight of copra, nut production, number of button per bunch and percentage of nut shedding but negatively correlated with number of functional leaf, number of bunch and the ratio of productive bunch to number of bunch with full size nut stage. The relationships were weak, however, suggesting that these growth and production parameters were practically insensitive to exchangeable calcium at 8.90 to 10.92 percent in the topsoil.

Subsoil exchangeable calcium was positively and significantly correlated with nut production and the number of bunch but insignificantly correlated with weight of copra and the ratio of productive bunch to number of bunch with full size nut stage, respectively. Also, it was found that exchangeable calcium was negatively and insignificantly correlated with percentage of nut shedding. These results implied that the higher exchangeable calcium is in the subsoil the lower percentage of nut shedding. In other words, the higher exchangeable calcium is in the subsoil, the higher the fruit set of the palm.

Magnesium

The exchangeable magnesium in the top and subsoil were not significantly correlated with number of functional leaf, weight of copra, nut production, number of bunch, number of button per bunch, percentage of nut shedding, and the ratio productive bunch to number of bunch with full size nut stage. These results suggested that growth and production parameters are practically insensitive to exchangeable magnesium under various cropping patterns in coconut.

Growth and Production Parameter with Leaf Chemical Components

Correlation analyses were undertaken to determine the relationship between growth and production parameters with leaf chemical components under various cropping patterns in coconut. The results are presented in Table 5.

Nitrogen (N)

Nitrogen concentration in the leaf was positively and highly significantly correlated with nut production and number of bunch but negatively and highly significantly correlated with number of nut shedding. It was also positively but weakly with weight of copra, number of button per bunch and ratio of productive bunch to number of bunch at full-size nut stage. These finding suggested that the increase in concentration of nitrogen in the leaf greatly promotes nut production, number of bunch and fruit set of the palms under various cropping patterns in coconut.

Phosphorus (P)

Leaf phosphorus (P) was weakly and negatively correlated with number of functional leaf, number of button per bunch, and percentage of nut shedding; but positively correlated with weight of copra, nut production, number of bunch and ratio of productive bunch number of bunch with full-size nut stage (Table 5). The r-values, however, were not significant at five percent level. The results implied that growth and production parameters were not very sensitive to the phosphorus concentration of the coconut leaf.

Potassium (K)

The K in the leaf was positively and significantly correlated with nut production, but negatively and highly significantly with percentage of nut shedding. These

Table 5. Linear correlation (r) between growth and production parameters and leaf chemical components under various cropping patterns
Tabel 5. Korelasi linier antara parameter pertumbuhan dan produksi dengan unsur hara daun kelapa pada beberapa pola tanam

Leaf nutrient components Unsur hara daun	Number of functional leaf Jumlah daun	Weight of copra Berat kopra	Nut production Produksi buah	Number of bunch Jumlah tandan	Number of button per bunch Jumlah bunga betina per tandan	Percentage of nut shedding Persentasi buah tidak jadi	Bunch ratio***
N	0.16783	0.17318	0.73863**	0.73159**	0.07690	-0.59672**	0.05959
P	-0.41920	0.29632	0.03115	0.30798	-0.37714	-0.45584	0.42088
K	0.03185	-0.43967	0.69741*	-0.36752	-0.35739	-0.75280**	-0.05014
Ca	-0.02506	0.27499	0.28228	-0.4402	0.40360	-0.40749	0.05576
Mg	-0.14726	0.08932	0.40490	-0.25856	0.00516	0.08133	0.17520

*** Ratio of productive bunch to number of bunch at full size nut stage

** Significantly different at 5% level *Berbeda nyata pada taraf 5%*

* Significantly different at 1% level *Berbeda nyata pada taraf 1%*

observations suggested that the increase in concentration of potassium in the leaf promotes nut production and reduces nut shedding (increase fruit set) on the coconut under various cropping patterns. However, K is positively and significantly correlated with number of functional leaf, but negatively correlated with weight of copra, number of bunch, number of button per bunch and ratio of productive bunch to number of bunch with full-size nut stage.

Calcium (Ca)

Leaf calcium (Ca) was positively correlated with weight of copra, nut production, number of button per bunch and ratio of productive bunch to number of bunch with full size nut stage (Table 5). While Ca was below the critical level, the *r*-value with number of leaves, number of bunch and percentage nut shedding was negative. These results suggested that the increase in concentration of Ca in the leaf reduces number of leaves, number of bunch but increase fruit set of the palms.

Magnesium (Mg)

The magnesium in the leaf was negatively and significantly correlated with number of functional leaf, nut production and number of bunch; but positively correlated with weight of copra, number of button, percentage nut shedding and ratio of productive bunch to number of bunch with full size nut stage (Table 5). The *r*-values, however, were not significantly high.

Relationship Among Nutrient in the Coconut Leaf

Correlation analysis were undertaken to determine the relationships between nutrient elements in the coconut leaf. Result is shown in Table 6.

Nitrogen was highly significantly but negatively correlated with potassium which was also negatively correlated with calcium. The relationship of nitrogen (N)

and potassium (K) with phosphorus (P) was weakly positive and negative, respectively; but phosphorus was strongly and positively correlated with leaf magnesium (Mg). Other correlation between any two nutrient element were weak.

Based on the months of this study, in term of growth and productivity of coconut showed that cropping patterns in coconut affected the number of button per bunch. The average percentage of nut shedding in the coconut monoculture pattern had the highest percentage of nut shedding with an average 53.83 percent. This was significantly higher than the nut shedding of palms in the other cropping patterns which had 40.8 to 43.83 percent. In other words, fruit set in intercropped coconut farms was higher than in coconut monoculture. The number of full-grown nuts in coconut monoculture pattern was significantly lower than fruit set in any intercropped pattern. Furthermore, the results showed that the increment in the number of full grown nuts over monoculture range from 64 to 98 percent and 70 to 105 percent in term of copra. This finding implied that cropping patterns in coconut increase number of nut per tree and higher amount of copra produced in coconut plantation.

Result of linier correlation analysis showed that positive correlation was observed between nitrogen in the top soil with weight of copra and nut production. The organic matter content in the soil were positively correlated with weight of copra, nut production but not correlated with percentage of nut shedding. This results implied that increase organic matter content in the soil will increase coconut production including fruit set. Meanwhile, nitrogen concentration in the leaf was positively and highly significantly correlated with nut production and number of bunch but negatively and highly significantly correlated with number of nut shedding these finding suggested that the increase in concentration of nitrogen in the leaf greatly promotes nut production, number of bunch and fruits set of the palm under various cropping patterns of the coconut. The potassium in the leaf was positively and significantly correlated with nut production but negatively and highly significant with percentage of nut shedding. These results suggested that the increase in concentration of potassium in the leaf promote nut production and reduces nut shedding

Table 6. Matrix correlation (*r*) between nutrient element in the coconut leaf under various cropping patterns.
Tabel 6. Matrik korelasi antar unsur hara daun pada beberapa pola tanam kelapa

Nutrient in the leaf Unsur hara daun	N	P	K	Ca	Mg
N	-	0.19717	-0.63674**	0.28514	-0.23290
P		-	-0.24286	0.07997	0.54023*
K			-	-0.53548*	0.03437
Ca				-	0.28585
Mg					-

* - Significantly different at 5% Berbeda nyata pada taraf 5%

** - Significantly different at 1% Berbeda nyata pada taraf 1%

(increase fruit set) of the coconut under various cropping patterns.

CONCLUSIONS

The effect of cropping patterns on the number of full-grown nut increased 19-26 percent with intensity of cropping pattern. However, number of functional leaves and number of button per bunch responded erratically. In the presence of coffee as an intercrop, there seemed to be more functional leaves, number of bunch and number of full-grown nuts. More number of nuts and higher amounts of copra per tree were produce in intercropped farms than in mono-cropped coconut plantations. These increase ranged from 64 to 98 percent in terms of nuts and 70 to 105 percent in term of copra.

Positive correlation was observed between nitrogen in the top soil with weight of copra and nut production. However, the available phosphorus in either top or subsoil was weakly correlated to growth and production parameter. The exchangeable potassium in the top soil was positively correlated with nut production and number of bunch but not correlated with the number of functional leaf, weight of copra, and number of button per bunch. The organic matter content in the soil were positively correlated with, weight of copra, nut production but not correlated with percentage of nut shedding. These results implied that increase organic matter content in the soil will increase coconut production, including fruit set.

Nitrogen concentration in the leaf was positively correlated with nut production but negatively correlated with number of nut shedding. The potassium concentration in the leaf also was positively correlated with nut production but negatively correlated with percentage of nut shedding. These finding implied that the increase nitrogen and potassium concentration in the coconut leaf, greatly promotes nut production and fruit sets of the palms under various cropping patterns in coconut.

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