Annals of Tropical Research 20:58-74 (1998)
ViSCA, Leyte, Philippines

Important cultural and management practices for coconut

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ABSTRACT

Santiago, RM and JT Peña. 1998. Important cultural and management practices for coconut. Ann. Trop. Res. 20:58-74.

This paper discusses some important cultural and management practices for coconut specifically fertilizer application, covercropping, intercropping and pasture and cattle raising under coconut. Fertilizer application improves seedling growth, enhances maturation and increases nut production of coconut. Covercropping is a good cultural practice because it minimizes soil compaction, erosion and other degradation processes that lead to the early marginalization of coconut lands.

Intercropping is not injurious to the coconut provided that the nutritional and cultural requirements of both the main and subsidiary crops are properly observed. Under good management, intercropping in coconut is a profitable venture. Growing of pasture crops and cattle under coconut is another way of maximizing the use of coconut lands as well as of augmenting farmers' income, provided that improved management techniques are also employed.

Keywords: cattle raising. coconut. covercropping. fertilizer application. intercropping. pasture.

INTRODUCTION

Coconut (*Cocos nucifera* L.) is the most extensively grown tree crop in the tropics. Although geographically distributed worldwide, coconut is generally confined to the tropics particularly in areas of low elevation and high rainfall.

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This is because this plant requires warm temperature and sufficient water supply (Plucknett, 1979). Frequent, even short, periods of temperature below 15°C result in fruit abnormalities (Child, 1974) and nut shedding (Manciot *et al.*, 1980).

The coconut industry is a proverbial giant in Philippine agriculture. It continues to be the largest agricultural product export earner, turning in an average of US$800 million annually to the country coffers. In addition, coconut production value represents 1.4% of the national income. The country has approximately 1.4 million coconut farmers but another 21 million Filipinos indirectly benefit from the coconut industry (Eleazar, 1999).

Coconut remains predominantly a small-holder's crop and only few plantations stand as monoculture (Child, 1974). Small farmers grow subsidiary crops under coconut because monocropping does not meet their food or income needs (Plucknett, 1979).

In general, coconut production in the Philippines is far from being satisfactory. The nut yield per tree per year is very low. On the national level, the average annual nut production per tree is below 50, and there are regions where a tree produces only less than 30 nuts annually. Among the important factors causing low nut production are senility of the trees, non-application of fertilizers and climatic disturbances.

This paper discusses some important cultural and management practices that improve or have been found to improve coconut production and which increase the income of coconut farmers. Specifically, this focuses on fertilization, covercropping, intercropping, and pasture and cattle raising under coconut.

Fertilizer application

In the past, coconut had been dubbed as a "lazy man's crop". This notion developed from the observation that coconut, under suitable climate, grows and bears fruit even if not taken care of. This is quite true but the big question is: How vigorous and productive is the tree under such situation? Like other crops, coconut also needs adequate nutrition for normal growth and good yield. It is a heavy feeder of soil nutrients and takes up large quantities of nitrogen, potassium (CRI, 1970; Child, 1974) and chlorine (Magat and Prudente, 1976).

Seedlings at the nursery stage. The common practice is to grow the seedlings in the nursery before field planting. Opinions vary as to the length of time these seedlings should be grown or reared in the nursery. Some prefer to transplant 4 to 6 months old seedlings, while others transplant seedlings which are 7 months old or older. Both have advantages as well as disadvantages. For instance, transplanting the seedlings a few months after germination does not allow thorough and rigid selection but it reduces the bulk of seedlings during transport and transplanting. The reverse is true when older seedlings are field planted, i.e., seedlings are bulky to handle during transplanting but rigid selection of seedlings could be performed.

Application of fertilizers may not be necessary when seedlings are grown in a fairly fertile soil and transplanted at the age of 6 months or younger (Fremond *et al.*, 1966). The study of Santiago (1978) showed an insignificant response of 7-month old coconut seedlings to increasing levels of NPK fertilization grown in three soil types. Aside from the inherent soil fertility which adequately supplied the needed nutrients, this result may be explained by the fact that seedlings at such age still have large amount of food reserves (Menon and Pandalai, 1958; Sawali, 1966). A number of studies, however, indicated the benefits of fertilizer application in terms of seedling vigor when they are reared in the nursery for more than 6 months (Fremond *et al.*, 1966; Almaden and Santiago, 1980). Fertilization improved seedling resistance to leafspot disease. Specifically, sulfur and chlorine applications were reported to reduce the incidence of the disease (Galasch, 1976; Abad *et al.*, 1978). Magat (1978) mentioned that the rate of fertilizer application recommended by the Philippine Coconut Authority (PCA) for coconut at the nursery stage is 20 g of ammonium sulfate [$(NH_4)_2SO_4$] and 25 g of potassium chloride (KCl) per seedling to be applied on the second month of growth. Another 40 g of $(NH_4)_2SO_4$ and 45 g of KCl should be applied three months after the first application.

Newly-established trees. Adequate fertilizer application was found to shorten the period required by coconuts to reach the reproductive stage (RCRC, 1996). In mid-1970's, PCA came up with an interim fertilizer recommendation (Table 1). The recommendation emphasized the application of fertilizers that contain nitrogen, chlorine and sulfur in coastal and inland (more than 2 km from the seashore) areas of the country (Magat, 1978). The rate of ammonium sulfate (fertilizer containing nitrogen and sulfur) application varied only with age of coconut (up to 5 years of age) regardless of whether or not it is grown in a coastal or in an inland area. In the case of potassium chloride (fertilizer containing potassium and chloride), the rate of application did not only vary with age of the plant but also with location. Greater quantity of fertilizer needs to be applied to trees growing in inland than in coastal areas. Salt spray from the sea which contains considerable chloride ions is common in coastal areas.

The Coconut Committee (1992) modified the above interim fertilizer recommendation. Slight changes were made on the rate of ammonium sulfate application in both coastal and inland areas (when the coconut is already ≥4 years) and on the rate of potassium chloride application for 1- and 3-year old trees planted more than 2 km away from the coastline. For 4-year old trees, the annual rate of ammonium sulfate application is 1250 g per tree, and for 5-year old trees, the annual rate is 1500 g per tree regardless of the distance of

Table 1. Recommended rates of fertilizer application for coconut in the Philippines

Age of coconut (year)	Coastal areas		Inland areas	
	Ammonium sulfate (g/plt/yr)	Potassium chloride (g/plt/yr)	Ammonium sulfate (g/plt/yr)	Potassium chloride (g/plt/yr)
	21-0-0	*0-0-60*	*21-0-0*	*0-0-60*
At planting	150	100	150	200
6 months	200	150	200	250
1	500	500	500	500 (600)*
2	750	750	750	900
3	1000	1000	1000	1600 (1500)*
4	1500 (1250)*	1250	1500(1250)*	1700
5-up	2000 (1500)*	1500	2000(1500)*	2000

Source: Magat (1978) except those marked by an asterisk which were taken from PCARRD (1994) the coconut farm from the coastline. For coconuts growing in inland areas, the annual rate of potassium chloride application for 1-year and 3-year old trees is 100 g higher and 100 g lower, respectively, than the recommendation of PCA (Table 1). Ideally, a good fertilizer recommendation must be location-specific or should at least specify the important soil properties where such fertilizer rates are likely to be effective. The work of Cordova (1965) as cited by Magat and Prudente (1976) clearly indicated that growth and yield performance of coconut trees are greatly influenced by soil chemical properties even if they are grown in the same locality and soil type.

Bearing trees. Coconut consumes large quantities of nitrogen, potassium and chlorine. Magat and Prudente (1976) estimated that chlorine is needed by coconut at quantities slightly greater than potassium and nitrogen. This is the reason why in the Philippines the recommended quantities of KCl fertilizer (for its chlorine content) are greater for inland than for coastal areas. Prudente and Mendoza (1979) reported that in all growth and yield parameters considered, coconut trees applied with KCl in combination with ammonium sulfate were always superior compared to the other treatments that did not include KCl application. They proposed that the important contributions of chlorine to coconut production are increased nut size and thickness of the meat resulting in more and heavier copra.

Although P application has been reported by numerous workers to have significantly hastened flowering in young non-bearing palms, it appears to have only a slight effect on bearing coconuts. Manciot *et al.* (1980) mentioned that deficiency symptom of this element is rare. A study in Malaysia by Kanapathy (1972) as cited by Wahid *et al.* (1977) indicated an insignificant relationship between leaf level of P and nut yield (Table 2). The same observation was reported by Fremond (1966) as cited by Wahid *et al.*, (1977). Child (1974) stated that it is likely that in a crop such as coconut which has a low demand for P, the phosphate potential of the soil settles down to a fairly constant value sufficient to maintain the modest removal of 12 to 15 kg/ha. In Sri Lanka, however, some experiments had consistently shown positive response of coconut to P fertilization (Wahid *et al.*, 1977). Few similar cases were also observed in India and Madagascar (Manciot *et al.*, 1980). This discrepancy

Table 2. Phosphorus in leaf of palms at Talok Bahru Agricultural Station, Malaysia

Type of palms	Nut yield/palm/year	Leaf P (%)
Tall palms	above 150	0.123
	101 - 150	0.126
	51 - 100	0.124
	10 - 50	0.125
Semi-tall palms	above 150	0.145
	101 - 150	0.140
	51 - 100	0.143
	10 - 50	0.144
Dwarf palms	above 150	0.138
	101 - 150	0.135
	51 - 100	0.138
	10 - 50	0.138

Source: Kanapathy (1972) as cited by Wahid *et al.* (1977)

regarding the response of coconut to P fertilization deserves further investigation. With regard to the effect of N fertilization on coconut, several reports strongly indicated a positive response to this element which is commonly found limiting in the soil.

Method of fertilizer application

The method of fertilizer application which is probably applicable to all coconut-growing countries is to place the fertilizer in full circle on the surface of the entire weeded area around the palm and then forked into the soil (Child, 1974). This method is advisable only in flatlands where surface flow of water during heavy rains is not severe unlike in sloping or hilly areas. Placing the fertilizers in trenches or holes around the weeded area is preferable when land is susceptible to severe soil erosion. The radius of the weeded area where to broadcast the fertilizers varies with age of the coconut tree. As reported by Manciot *et al.* (1980), the recommended scale for hand application is as follows:

Age of palm (year)	Radius (meter)
1	0.4
2	0.5
3	0.8
4	1.2
5	1.6
6 & over	2.0

Covercropping

Like in the production of other crops, the maintenance of soil fertility is a major concern in coconut farming. One of the important causes of soil fertility depletion is erosion due to runoff or surface flow of water. The greater are the volume and velocity of water flow, the greater is the volume of soil that will be eroded. However, the volume and velocity of water flow could be reduced by increasing the infiltration capacity of the soil or by controlling the movement of water in the soil surface. One of the cultural practices that could be employed in order to achieve these management techniques for runoff water is covercropping. This cultural practice is highly desirable for coconut farms in sloping and rolling areas especially when the soil surface is bereft of vegetative cover.

A covercrop is a plant purposely planted or seeded to provide soil cover. When properly carried out, covercropping is not only effective in minimizing soil erosion but also in controlling weed growth and in increasing the organic matter content of the soil. The extent to which these three beneficial effects could be achieved depends largely on the kind of covercrops. The desirable characteristics of a covercrop are: (a) easy to establish and fast growing; (b) has abundant growth of succulent tops and roots; (c) has a growth habit which encourages ground cover soon after establishment; and (d) has the ability to grow in poor soils. Many of the widely adopted covercrops are legumes such as Kudzu (*Pueraria phaseoloides*), Centrosema (*Centrosema pubescens*) and Stylo (*Stylosanthes guianensis*).

One drawback of planting covercrop is that it produces a thick mass of vegetative growth which hinders some farm operations. This problem, however, could be overcome by periodic pressing close to the ground using a roller.

Intercropping

Intercropping in coconut is not a new practice among coconut farmers. There are more small coconut farm owners who practice it than big coconut farm owners. The desirability of intercropping in coconut appears to be a controversial issue.

Among the advantages of intercropping with coconuts are: (a) it maximizes land utilization; (b) it provides additional income and increases food production; and (c) it provides better labor utilization. Its disadvantages, on the other hand, include: (a) competition of intercrops with coconut for water, plant nutrients and other growth factors; (b) intercrops may harbor or attract pests or diseases harmful to coconuts; and (c) the growth habit of some intercrops may obstruct some management operations such as fertilizer application and harvesting.

There is a wide array of annual and perennial crops that could be grown singly or in combination under coconut. But because of variations in agroclimatic conditions as well as of other variables such as level of management employed, their yield performance also varies with location (PCARRD, 1994).

A good intercropping system is one where neither the maincrop nor the subsidiary crop(s) exerts serious adverse effects on the other. Nelliat *et al.* (1974) stated that the crops that could be meshed into mutually compatible combinations should have varying nutritional and environmental requirements and morphological and physiological features, and the subsidiary crop should be relatively shade-tolerant. Banzon and Velasco (1982) advocated that in choosing an intercrop for coconut, some of the points to be considered include: (a) the product must have a reasonably attractive and viable market; (b) it must benefit or be benefited by the relationship without causing negative effects; (c) it must be shade-tolerant and deep-rooted to avoid competition for moisture and nutrients with the coconut which is shallow-rooted; (d) it must not be a heavy consumer of potassium which the coconut uses in big amounts; and (e) it must not harbor pests which attack coconut.

When supply of fertilizer is limited, it is practical to grow intercrops which are not heavy feeder of nutrients or whose nutritional requirement is relatively low. In places where rainfall is not adequate, growing of crops that are less sensitive to water stress is advisable and appropriate.

In general, intercropping in coconut is suitable to plantations where spacing of trees is about 8m x 8m or wider. When coconuts are still young and short, annual crops are usually used as intercrops. Intercropping with fast-growing perennials may prove deleterious to the maincrop, unless periodic pruning is performed. The subsidiary crop may excessively shade the coconuts which are sun-loving. On the other hand, in old coconut groves, intercrops may not perform well especially if the spacing of the trees is quite close. Under this condition, light becomes a major limiting factor of crop growth.

The yield of a number of annual crops grown under coconut is lower than when planted in the open. However, there are crops that perform better under coconut such as ramie and taro (Plucknett, 1979). The yield of coconut, on the other hand, is not adversely affected if suitable subsidiary crops are grown. Under specific agroclimatic condition, intercropping coconut with coffee and black pepper greatly improved nut yield (Table 3). Creencia (1979) reported that yield of coconut in Malaysia increased up to 30% when intercropped with cacao. A similar increase in the yield of coconut was also observed two years after they were intercropped with cacao in the Philippines

Table 3. Yield of coconut (nut/tree) intercropped with black pepper and coffee

Variables	Location					
	Mariano Marcos, Sultan Kudarat			Kabacan, North Cotabato		
	Months after establishment					
	24	27	30	24	27	30
Coffee alone	27	29	30	19	19	-
Black pepper alone	29	28	29	17.5	18	-
Coffee + black pepper	27	29	28	16.5	16.7	-
Coconut alone	15	13*	14	8.5	8.5	-

Source: PCARRD (1994)

and in Papua New Guinea. Creencia (1979) emphasized, however, that not all coconut farms are suitable for cacao planting. He suggested the following soil and climatic factors as basic requirements in growing cacao under coconuts: the soil must be clay loam, good-structured and well-shaded to minimize organic matter decomposition; it must be slightly acidic; air temperature must not be lower than 15°C nor higher than 38°C; and the locality must have no dry season.

In any intercropping schemes, it is highly desirable to provide fertilizers

Table 4. Yields of coconut and coffee as affected by the different treatments (1989 harvest)

Treatment	No. of Nuts/ tree	Copra/tree (kg)	Fresh weight of berry/hill (kg)
coconut unfertilized + coffee unfertilized	120.9	24.7	0.44
coconut unfertilized + coffee fertilized	113.3	24.9	1.32
coconut fertilized + coffee unfertilized	127.6	31.3	0.41
coconut fertilized + coffee fertilized	128.0	31.2	2.04

Source: PCARRD (1994)

to both the maincrop and the subsidiary crop(s). The advantage of this practice is reflected by the data presented in Table 4. Coconut and coffee yields improved when both crops were applied with fertilizers. In addition, in a cropping system where the crop components develop their canopies at different strata in the field (multi-storey), it is necessary that the canopies of the crops in the upper strata should allow certain amount of sunlight to penetrate and reach the crop in the lowest stratum. The rooting habit of both the main and subsidiary crops must also be considered to minimize competition for soil nutrients.

Knowing the rooting habit of each crop component will enable one to increase the efficiency of fertilizers applied by placing them at a distance from the base of the crop where root activity is highest.

Pasture and cattle raising under coconut

Throughout the coconut-growing countries of the world, raising of cattle either on natural or improved pasture under coconut is common. Plucknett (1979) and Reynolds (1988) indicated that this system of utilizing land spaces between coconut trees could be profitable if appropriate management practices are observed.

Selection of pasture species. A number of grass and legume pasture species have been reported to perform satisfactorily under coconut. Yield, palatability and nutritive value, and tolerance to shade and drought are among the major

Table 5. Criteria for selecting pasture species (Reynolds, 1978)

1. forage production class	9. probable competition with coconut
2. ability to compete with weeds	10. ability to stand heavy grazing
3. shade tolerance	11. ability to establish from cuttings
4. height of sward	12. ability to tolerate low management levels
5. establishment ability	13. ability to respond to fertilizer use
6. ability to spread quickly	14. ease of locating harvested nuts
7. drought tolerance	15. cost of planting materials
8. animal preference	16. animal performance

considerations in choosing what species to grow. Using a 16-point criteria (Table 5), Reynolds (1978) rated *B. miliformis, B. humidicola, I. aristatum, B. brizantha and P. maximum* cv. Embu as the top 5 most acceptable grass pasture species for coconut areas.

In the Philippines especially in Mindanao, Para grass *(Brachiaria mutica)*, Alabang grass *(Dicanthium aristatum)* and Guinea grass *(Panicum maximum)* are the most common grass pasture species while Centrosema

(*Centrosema pubescens*) and Kudzu (*Pueraria phaseoloides*) are the most widely adopted legume species in improved pasture (De Guzman and Allo, 1975).

An improved pasture could be a pure stand of a grass species only. But most improved pasture systems rely on a grass-legume mixture rather than single stand of grass or legume species. Sanchez (1976) claimed that the role of legumes in such mixture is to contribute nitrogen to the grass to improve the overall nutritional content of the pasture particularly in terms of protein, phosphorous and calcium contents. The grass, on the other hand, provides the bulk of the energy to the animals because of their large dry matter production. He further claimed that since the compatibility of grass and legume species is related to their growth habits and similar adaptation to a specific climate, soil moisture, and soil fertility regime, the proper grass-legume combination is, therefore, site-specific.

Reynolds (1988) mentioned that in grass-legume pasture, the legume component must at least be 30%. Liveweight gains of beef cattle were observed to be linearly related to pasture legume where this ranged from 10 to 40%.

Fertilizer application. An important factor to consider in coconut-pasture association is the nutritional requirement of both crop components. Plucknett (1979) stated that production of pasture crops probably will not have depressive effect on nut and copra yields provided that adequate fertilizers are applied to both pastures and palms.

Fertilizer application must be done in a manner that would minimize serious competition between the pasture plants and coconut trees in the uptake of nutrients. Santhirasegaram (1959) observed that in a grass pasture-coconut combination, broadcast application of fertilizer in circle at the base of the tree resulted in highest nut yield per plot regardless of the kind of pasture grass involved. However, caution should be observed if the material to be used is urea. When applied to a bare soil surface or to soil in a sod cover, significant quantities of ammonia is lost by volatilization because of its rapid hydrolysis to ammonium carbonate (Tisdale and Nelson, 1975). When nitrogen-containing fertilizer such as urea or ammonium sulfate is being applied, it must be incorporated with the soil or covered with a thin layer of soil.

Actual rates of fertilizer application are location-specific. However, fertilizer application schedules found effective in other places may be site-tested. For instance, the report that legume establishment will benefit from an application at planting of 100 kg per hectare of superphosphate or potassium superphosphate on low potash areas (Reynolds, 1988) may be applicable under our local conditions. Likewise, application of 56 kg N, 18 kg P and 125 kg K/ha to *B. brizantha* which resulted in good forage and nut yields in other areas (Reynolds, 1988) may be also effective locally.

Stocking rate. The number of animals allowed to graze per unit pasture area may influence not only the pasture but also the yield of coconut. Table 6 shows the yield of coconut as affected by two pasture grasses and four grazing intensities. Highest nut yield was obtained from the lowest stocking rate (0.8 ha/animal) in both *Paspalum* and *Bracharia* pasture grasses. Lowest nut yield was obtained from ungrazed *B. brizantha* which indicated that with this pasture species, grazing has a positive effect on coconut yield.

Table 6. Effect of two pasture grasses and four grazing intensities on coconut yield[1]

Pasture cover	Nut yield (kg/ha)
No grass (weeds)	12,804
Paspalum commersonii (not grazed)	12,219
Paspalum, 0.4 ha/animal	12,330
Paspalum, 0.6 ha/animal	10,962
Paspalum, 0.8 ha/animal	12,557
Brachiaria brizantha (not grazed)	10,344
Brachiaria , 0.4 ha/animal	11,476
Brachiaria , 0.6 ha/animal	10,549
Brachiaria , 0.8 ha/animal	12,562

Source: Santhirasegaram (1959)

[1] At planting, pasture received 28 kg P/ha and 250 K/ha. After planting, N was applied at 25 kg/ha every three months. Four months after planting, 560 kg of lime/ha was applied. Fertilizers for coconut were not specified.

The carrying capacity of natural pastures under coconut ranges from 0.75 to 2.5 heads of cattle per hectare (Plucknett, 1979). While the carrying capacity of improved pastures ranged from 0.75 to 4 heads of cattle per hectare. The stocking rate or carrying capacity of pastures under coconut may vary according to differences in planting density and age of palms; botanical composition of the pasture; climatic factors; soil fertility and amount of fertilizer used; type and age of animals; grazing system and pasture condition; and availability of supplementary feeds (Reynolds, 1988).

Potential problems. Among the more important issues raised against pasture and cattle production under coconut are: (1) cattle can cause soil compaction; and (2) cattle manure is a good breeding place for rhinoceros beetle, a major insect pest of coconut. The first problem may be minimized by periodic tillage (in flatland) or by maintaining low stocking rate if the soil is heavy-textured. The second one may be prevented by gathering the manures and placing these in an appropriate area to be used as fertilizer for pasture and coconut.

CONCLUSION

Coconut is a very important agricultural commodity in the Philippines but its production in terms of annual nut yield per tree is low. It is predominantly a small holder's crop. Coconut is a heavy consumer of soil nutrients particularly nitrogen, potassium and chlorine. Fertilization for coconut may start in its nursery stage especially if the seedlings are allowed to grow for more than six months. Adequate application of fertilizers containing nitrogen, potassium and chlorine shortens the time required by coconut to reach the reproductive stage. It also increases nut production. The kinds of fertilizer to be used and the rates of application vary with age up to the fourth or fifth year after planting. They also vary with location because of differences in soil properties. The method of application to employ is the one that would ensure high fertilizer efficiency. Covercropping is a good cultural practice because it minimizes soil compaction, erosion and other degradation processes that lead to the early marginalization of coconut lands.

Because the income derived from coconut monoculture is not sufficient to meet their needs, small farmers resort to planting subsidiary crops in spaces between coconut trees. This practice could be injurious to the coconuts unless the nutritional and cultural requirements of both the main and subsidiary crops are properly observed. Environmental requirements, morphological and physiological features of the crops should be considered. Under good management, intercropping in coconut is profitable.

Growing of pasture crops and cattle under coconut is another way of maximizing the utilization of coconut lands as well as of augmenting farmers' income, provided that improved management techniques are employed.

REFERENCES

ABAD, R. C., R. L. PRUDENTE and S. S. MAGAT. 1978. Incidence of leaf spot in coconut fertilized with various combinations of nitrogen, phosphorus and potassium chloride. *Philippine Journal of Coconut Studies*. **3**(1):37-44.

ALMADEN, E. and R. M. SANTIAGO. 1980. Response of coconut seedlings to spacing and application of nitrogen and potassium. *Annals of Tropical Research* 3(3):177-186.

BANZON, J. A. and J. R. VELASCO. 1982. *Coconut Production and Utilization.* PCRDF, Manila, Philippines.

CHILD, R. 1974. *Coconuts* (2nd ed.) Longman Ltd. London.

COCONUT RESEARCH INSTITUTE. 1970. The manuring of adult coconut palms. Leaflet No. 26. CRI. Ceylon.

CREENCIA, R. P. 1979. Intercropping coconut with cacao. *Philippine Journal of Coconut Studies* **4**(4):29-35.

DE GUZMAN, M. R. JR. and A. V. ALLO. 1975. *Pasture Production Under Coconut Palms*. Food and Fertilizer Technology Center. Taiwan, Republic of China.

ELEAZAR, J. R. 1999. Fallacies, facts and the vertical interpretation of the coconut industry. *Proc. Coconut Farmers' Cooperative Workshop*, March 17-19, 1999, COCOFED 2F Wardley, Bldg., Pasay City.

FREMOND, Y., R. ZILLER and M. DE NUCE DE LAMOTHE. 1966. *The Coconut Palm.* International Potash Institute, Berne, Switzerland.

GALASCH, H. E. 1976. Coconut nutrition in the Markham Valley of New Guinea. *The Papua New Guinea Agricriculture Journal* **27**(4):75-89.

MAGAT, S. S. 1978. A review of fertilizer studies on coconut. *Philippine Journal of Coconut Studies* **3**(2):51-72.

MAGAT, S. S. and R. L. PRUDENTE. 1976. Soil and leaf analysis in relation to coconut yield. *Philippine Journal of Coconut Studies* **2**(1):1-12.

MANCIOT, R., M. OLLAGNIER and R. OCHS. 1980. Mineral nutrition and fertilization of the coconut around the world. *Oleagineux*. **35**:41-54.

MENON, K. P. W. and K. M. PANDALAI. 1958. *The Coconut Palm*: A Monograph, Indian Central Coconut Committee.

NELLIAT, E. V., K. V. BAVAPPA and P. K. R. NAIR. 1974. Multi-storeyed cropping: A new dimension in multiple cropping for coconut plantations. *World Crops*. **26**(6):263-266.

PCARRD. 1994. *Coconut-based Farming Systems*. PCARRD Book Series 146. Los Baños, Laguna.

PLUCKNETT, D. L. 1979. *Managing Pastures and Cattle Under Coconut*. Westview Press. Boulder, Colorado.

PRUDENTE, R. L. and A. M. R. MENDOZA. 1979. The effects of NPK fertilizers on coconut from transplanting to full bearing. *Potash Review*. No. 1. International Potash Institute. Berne, Switzerland.

REGIONAL COCONUT RESEARCH CENTER. 1996. *Annual Report*. ViSCA, Baybay, Leyte.

REYNOLDS, S. G. 1988. *Pastures and Cattle Under Coconuts*. Plant Production and Protection Paper 91. FAO, Rome.

SANCHEZ, P. A. 1976. *Properties and Management of Soils in the Tropics*. John Wiley and Sons, Inc. New York.

SANTHIRASEGARAM. 1959. Report of the agrostologist - 1958. Annual Report. Ceylon Coconut Research Institute. Government Publishing Bureau, Colombo.

SANTIAGO, R. M. 1978. Growth of coconut seedlings as influenced by different fertility levels and three soil types. *Philippine Journal of Coconut Studies*. 3(4):15-27.

SAWALI, F. O. 1966. *The effects of age of coconut seedlings and removal of seedling nut at transplanting on the growth of the plants*. B.S. Thesis, UPCA, College, Laguna.

THE COCONUT COMMITTEE. 1992. *The Philippines Recommends for Coconut.* Philippines Recommends Series No. 2-5/1993. PCARRD-PARR I-PCRDF. Los Baños, Laguna.

TISDALE, S. L. and W. L. Nelson. 1975. *Soil Fertility and Fertilizers* (3rd ed). MacMillan Publishing Co., Inc. New York.

WAHID, P. A., C. B. KARNALA DEVI and M. HARIDASAN. 1977. A critical review of phosphate fertilization of coconut. *Philippine Journal of Coconut Studies* **2**(4):1-8.