5.3 IPNMS Research on Coconut

Coconut (*Cocos nucifera*) a perennial vegetable oil crop rich in C_{12} or Lauric acid, is one of the most important food cash crops grown in the tropical belt of the world (Magat, 1997). In the Philippines a total of 3.38M ha is devoted to coconut and about 0.44M ha is devoted to coconut-based farming system (NAREA, 1991). According to Magat (1997), coconut is widely adapted to the environment and climatic factors of many coconut producing countries. There are many products that can be derived from coconut trees. Copra is the most important product of coconut because it serves as raw material for other processed products such as soap, lotion and oil among its many products.

The Philippine Coconut Authority (PCA) is a government agency which handles the different researches regarding the farm maintenance, copra production and marketing of the coconut derived products. It is also a governing body which formulates policies involving the coconut industry.

The significant reduction of farmland hectarage due to conversion into industrial, commercial and residential uses has likewise led to the reduction of area devoted to coconut and coconut-based farming system (Magat, 1997). Research has been focused in generating technologies that further increased coconut yield and at the same time maximized utilization and profitability of coconut lands. In 1972, the nut yield of coconut was 4 tons per hectare (computed from Labios and Labios, 1988) but Magat (1998) stated that the yield of coconut decreased to only 1.25 tons per hectare. The yield of 1.25 tons per hectare is common in small farms (less than 3 hectares) in all coconut producing countries. Bigger farms can achieve up to 2 to 2.5 tons per hectare. However, almost 80 to 85% of coconut areas are own by individual farmer with less than 3 hectares (individual farm) due may be to land reform and tenureship. The low yields could be attributed to inherent low soil fertility of most areas grown to coconut. The annual mineral nutrient demands of coconut are 95 kg K, 65 kg Cl, 50 kg N, 11 kg Na, 7 kg P, 8 kg Mg, 5 kg Ca, 4 kg S (estimated at per hectare basis) plus B, Zn, Cu, Fe and Mn (Magat,

1998). As early as 1972, the PCA has been involved in researches regarding the nutrition and management of coconut. Table 62 shows the research highlights from 1972 to 1995.

Table 62. Significant findings of the PCA from 1972 to 1995.

YEAR	SIGNIFICANT FINDINGS
1972	Growth and economic responses of coconut to KCl application in NPK fertilization studies started in 1964 and 1968 at Davao; first circumstantial evidence of the beneficial effect of Chlorine (Cl) on coconut was presented by several workers notably Mendoza and Prudente.
1975	Low yields of inland coconut were improved by correcting the Cl deficiency with KCl application and was confirmed by the positive relationship of leaf Cl and yield with quadratic response and linear response in terms of nut and copra (weight/nut, copra/tree) respectively. (Magat, Cadigal and Habana).
1977	Sodium chloride or common salt was effective and a cheaper fertilizer to control leaf spot disease of coconut seedlings (Magat, Margate and Prudente).
1978	KCl fertilizer significantly reduced the incidence of leaf spot fungus diseases in young palms indicating that the fungus disease is strongly associated with Cl deficiency (Abad, Prudente and Magat)
	In a long term KCl application (1972-1977), 2 kg KCl/tree proved to be the most economic rate while highest copra weight/nut and yield/tree was obtained at the rate of 8 kg KCl/tree/year (Margate, Prudente and Magat).
	The usefulness of leaf analysis in the conduct of field fertilizer trials in the Philippines was reported internationally for the first time (Magat).
1981	Inland coconut suffering from N, Cl, and S deficiencies were economically corrected with the application of 1.8kg $(NH_4)_2 + SO_4$ +1.8 kg NaCl or 1.8 kg$(NH_4)_2 + SO_4$ + 2 kg KCl/tree/year (Magat, Maravilla and Padrones).
	The nationwide land survey (1978-1980) revealed the widespread deficiency of N, Cl and S on the existing stands of local tall coconuts; and could be grouped into 10 distinct deficiencies classes, including K, P, and Mg deficiencies in some areas (Magat, Habana, Escoton, Labarcon and Froilan).
1988	KCl as fertilizer was confirmed that the common salt (NaCl) increases nut production, copra weight/nut and copra yield/tree, with leaf N as the main determinant of nut yield. The leaf Cl for copra (weight/nut, yield/tree), using NaCl rates: 0.88, 1.76 and 3.52 and 7.04/tree/year (Magat, Margate, and Habana).
	An estimate of the leaf Sulfur (S) critical and optimum levels for bearing coconuts were established at 0.12% and 0.19% respectively on leaf no.14 (Magat, Alforja and Margate).
	For the first time, an estimate of the critical and optimum levels of coconut leaf Cl was found

	to vary with yield indices, i.e. leaf 14 critical level (both nuts and copra)- 0.30% Cl; optimum levels: nut/tree 0.51% Cl; copra/nut 0.55% Cl and copra/tree-0.63% Cl (Magat, Alforja and Oguis).
1989	The optimum leaf-K of bearing palms was established: 0.81% K (in terms of nut yield); 1.0% K (copra/nut); and 0.90% (copra yield/tree) of leaf rank 14 (Magat and Padrones).
1990	The chlorine needs of coconut (from nursery to bearing stage) presented by PCA-DRC, based on the 15 years of research work on coconut from nursery to full bearing (1974-1988) (Magat and Margate).
	The use of salt (sodium chloride) generally recognized for public dissemination through PCARRD's technology series (Magat).
1992	PCA-DRC reported a computerized fertilizer recommendation for coconut based foliar analysis using a Lotus 123 Software Package Sysytem, aimed at facilitating formulation of specific fertilizer recommendation (Margate, Secretaria, Magat and Alforja).
	The positive residual effects of common salt (NaCl) fertilizer on yield and leaf nutrient of coconuts revealed, indicating adequate leaf Cl and stable yields within 3 years after 3-5 regular annual fertilization (Magat, Habana and Alforja).
1993	Three chloride sources (KCl, NaCl and NH4Cl) showed similar positive residual effects when applied at 0.80 kg Cl/tree/year. High yield as maintained by palms attributed to the maintenance of leaf Cl at 0.50-0.60% even after the three consecutive years of fertilizer applications (Magat, Padrones and Alforja)
1995	Findings on the agronomic effectiveness of single fertilizers as $(NH_4)_2$ + SO4KCl. NaCl used in the rehabilitation of SCFDP farms, resulting in average increase of 142% (nuts) and 179% (copra), 241% (net income) by 3-4 annual fertilizer applications (Magat).
	In along term nationwide on-farm fertilizer trials (OFFTs), as in local tall, hybrids produced significantly higher yields only when adequate Cl fertilizers supplied to farms or organic fertilizers must be combined with inorganic Cl fertilizers as NaCl or KCl to be cost-effective(Margate, Secretaria, Padrones, Maravilla, Magat, Mantiquilla, Siva, Corsane, Borromeo and Rivera).

Source: Magat, 1997

Dr Severino Magat, the Director of Agricultural Research and Development Branch of PCA conceptualized the Integrated Soil Fertility Management (ISFM) in Coconut and Coconut-Based farming System (CBFS). ISFM is defined as the combined use of organic/natural and inorganic/mineral fertilizers aimed at reaching maximum economic yield through a sustainable, economical, environment friendly and socially acceptable production system (Mantiquilla, et., al. 1994 as cited by Magat, 1998). The concept of ISFM is related to IPNMS but Dr. Magat stressed that ISFM is paying more attention to the soil as a medium of plant growth not only on

plant nutrient itself. He added that the application of any organic or inorganic fertilizers should take into account the inherent soil fertility status of the soil. The ISFM study in coconut and CBFS started in 1985 and lasted up to 1995. The study aimed to determine the agronomic effectiveness and the cost-efficiency in determining the economic viability of the ISFM in coconut production especially in a long term fertilization program (regular and continual) (Magat, 1997). Table 63 below shows the field response of coconut on different farm trials all over the country.

Table 63. Summary of Yield Response (Copra/Tree/year) to ISFM in Eleven (11) Nationwide Trials (1985-1996), Philippines.

Trial Sites	Period	Control Unfert (UF)	Inorganic Fertilizer (IF)	Organic Fertilizer (OF)	IF + OF
1.Tupi, South Cotabato	1985-93	7.2	26.6 (269%)	6.8 (-6%)	17 (136%)
2. Solana, Tuguegarao	1985-93	2.5	5.6 (124%)	4.2 (68%)	6.0 (140%)
3.Guisao, Zamboanga City	1985-93	1.3	8.1 (573%)	3.4 (162%)	8.0 (515%)
4. Tabaco, Albay	1985-93	8.8	14.8 (78%)	12.5 (58%)	15.4 (84%)
5.Batan, Aklan	1986-93	9.6	11.6 (21%)	10.4 (8%)	10.3 (7%)
6.Cogon, Dipolog City	1986-94	5.1	8.3 (63%)	9.5 (86%)	10.4 (104%)
7.Mauban, Quezon	1986-94	11.2	12.1 (8%)	15.1 (35%)	15.1 (35%)
8.Baliangao, Misamis Occ.	1986-94	9.2	14.6 (60%)	15.4 (68%)	16.8 (84%)
9. Lale, Samar	1987-95	19.9	27.1 (36%)	26.4 (33%)	30.5 (54%)
10.Sipocot, Camarines Sur	1987-97	6.2	10.0 (61%)	10.0 (61%)	11.7 (89%)
11. Bayugan Agusan Sur	1987-95	8.0	16.9 (111%)	16.6 (108%)	18.9 (136%)
Range		1.3-19.9	5.6-27.1 (8% -573%)	3.4-26.4 (-6%-162%)	6- 30.5 (7%-515%)
Mean		8.1	14.2 (128%)	11.8 (6%)	14.6 (126%)

Source: Magat, 1997.

From the table given, it can be noted that for most of the trial sites, the inorganic/mineral fertilizer application is a better option particularly if farm supply of organic materials are limited and expensive (Magat, 1997). The application of mineral fertilizer increases the farm products and at the same time the farm residue, thus, the availability of organic materials will not limit the farm derived use of organic fertilizers. The importance of organic matter in plants has been recognized long time ago (Cosico, 1982). Padrones et., al. (1996) stated that the greatest concerns in farming is how to maintain the fertility of the soil so as to be able to continually

supply the necessary nutrients to the plants. Recycling of plant residue is very important component in the management of soil fertility.

5.3.1 Integrated Soil Fertility Management on Coconut

The conceptualization of ISFM on coconut lead to the numerous researches related to integrated plant nutrient management system in coconut and coconut-based farming system. The highlights of these researches were presented during the 35th COCOTECH Meeting held in Bali, Indonesia which was sponsored by the Asian and Pacific Coconut Community. The paper also tackled the rehabilitation and post-rehabilitation technologies in sustaining coconut production.

Magat (1998) claimed that most coconut areas gave strong indications that the inherent soil fertility is not adequate to supply the annual nutrients needed by the coconut. The inadequate fertility of the soil lead to significant losses of nut production estimated to be 50% or more.

The rehabilitation of unproductive coconut lands is very important in increasing the nut production of coconut. Without rehabilitation measures, continuous decrease nut production will be observed because even the high producing regions will eventually decline in their production because of the continuous depletion of soil nutrients and also the degradation of the soil. Magat (1998) claimed that rehabilitation could be achieved through fertilization of coconut trees of less than 60 years. He further stated that the unproductive senile plants (60 years or older) can be rehabilitated by replanting or replacement of old stands with superior early bearing and high yielding varieties.

Fertilization is the main technique that should be adopted to restore the low yielding areas. Dr. Magat stated that effective fertilizer application increase yield. The field response of coconut across sites differed due to diverse agroclimatic conditions, nature and extent of nutrient deficiencies as indicated by leaf N, K, P, Cl, S and B (Magat, 1997). The addition of inorganic fertilizer significantly increase the yield of coconut over the unfertilized control (Margate, et. al.,

1994, Secretaria, et. al, 1994 and Padrones,et. al., 1996). In a long term experiment done in Guisao, Zamboanga, results showed that the application of 3.0 kg ammonium sulfate + 3.0 kg potassium chloride increased the copra/palm by 87% over the control (Secretaria, et. al., 1994). In similar experiment done in South Cotabato, 1.0 kg ammonium sulfate + 1.8 kg sodium chloride + 1.5 kg dolomite significantly increased the nut production over the unfertilized control by 24.7 nuts per tree starting from the third year of fertilization to a maximum of 61.5 nuts per tree and 42.8 nuts per tree at the end of the 8 year-duration of the study (Table 64) (Margate, et. al., 1994). Application of 2.0 kg AS + 3.6 kg dolomite produced the highest yield increase, as much as 70.1 nuts per tree over the control. Combination of corn cob + 1.8 kg NaCl + 1.5 kg dolomite did not produced yields comparable to pure chemical fertilizer. In fact, applying corn cob alone at 10 kg per tree decreased nuts per tree.

Table 64. Yield of palms (number of nuts per tree) as influenced by the different fertilizer treatments.

Treatments	Year 3*	Year 4	Year 5	Year 6	Year 7	Year 8
1. Control	28.3 c	33.6 b	32.2 b	37.7 c	36.8 b	33.8 c
2. 1.0 kg AS + 1.8 kg NaCl + 1.5 kg Dolomite	53.0 ab	84.7 a	80.3 a	99.2 a	95.0 a	76.6 ab
3. 2.0 kg AS + 3.6 kg NaCl + 3.0 kg Dolomite	56.0 a	89.2 a	93.6 a	97.3 a	106.9 a	85.2 a
4. 10 kg Corn cob	26.6 c	28.4 b	32.0 b	35.7 c	35.1 b	30.6 c
5. 10 kg Corn cob + 1.8 kg NaCl + 1.5 kg Dolomite	37.9 bc	54.4 ab	67.5 a	63.9 b	63.9 b	57.1 b

AS = Ammonium Sulfate
*In a column, means followed by the same letter is not significant.
**Source: Margate, et. al., 1994.

Commercial organic fertilizer application in coconut was also included in the long term experiment done by the PCA in 11 different locations in the country. Organic fertilizers not only give the needed nutrients of the crop but also improved the physical properties of the soil. In the study of ISFM, the application of organic fertilizer alone did not significantly increased the nut and copra production on coconut (Magat, 1997, Padrones, et. al., 1996, Secretaria, et. al., 1994 and Margate, et. al, 1994). However, combining the organic fertilizer with inorganic fertilizers (NaCl, NH_4Cl or KCl) significantly increased the yield of coconut which is

comparable to those treated with pure inorganic/mineral fertilizers (Padrones, et. al, 1996) This finding suggests that the organic fertilizer combined with inorganic chloride could substitute for ammonium sulfate as source of N for coconut. The presence of Cl in all the experiments greatly enhanced the copra development of the fertilized trees (Padrones, et. al. 1994). These findings confirmed the earlier findings of Secretaria, et. al and Margate et. al. in 1994.

The agronomic characteristics of the trees were greatly affected by the different fertilizer treatments in most of the areas. In Guisao, Zamboanga, the application of 1.5 kg ammonium sulfate + 1.5 kg KCl and 3.0 kg ammonium sulfate and 3 kg KCl produced 13% and 19% increase in girth over the control on the second year of the experiment (Table 65) (Secretaria, et. al, 1994).

Table 65. Effect of different fertilizer treatments on pH, organic matter and N content of the soil grown to coconut.

Treatment	pH	Organic Matter	Nitrogen
1. Control	5.9 a	1.66 ns	0.08 ns
2. 1.5 kg AS + 1.5 kg KCl	4.6 b	1.66	0.08
3. 3.0 kg AS + 3.0 kg KCl	4.4 b	1.66	0.08
4. 10 kg Sagana 100	5.7 ab	2.17	0.11
5. 10 kg Sagana 100 + 1.5 KCl	5.8 a	2.17	0.11

AS = Ammonium sulfate
ns = not significant
*In a coluumn, means followed by the same letter is not significant.
**Source: Secretaria, et. al., 1994.

The fertility status of the soil also changed after fertilization (Table 65). The inorganic fertilizers showed lower pH compared to the other treatment (Secretaria, et. al., 1994). This findings was also claimed by Margate, et. al.(1994). Organic fertilizers maintain favorable soil pH while continuous application of inorganic fertilizers tended to make the soil more acidic (Margate, 1994). The results also indicate that the organic matter content of soils applied with organic fertilizer was higher than those applied with inorganic fertilizers although the difference was not significant (Table 65). The same result is true for the N content of the soil.

5.3.2 SUMMARY

- The use of organic fertilizer helps provide the nutrient need of the coconut but the available nutrients in OF is not enough to significantly increase the yield of coconut. These OF alone are not sufficient to increase and sustain yield of coconut.

- Combining chloride with organic fertilizer appeared to be the most practical way of increasing yield of coconut.

- The inorganic fertilizers to be applied contain chloride because most coconut areas are chloride deficient.

- The application of chloride fertilizers (KCl, NaCl and NH_4Cl) makes fertilization, argonomically effective.

- Organic fertilizers should not be applied singly on coconut, especially if palms are deficient in chlorine (Magat, 1997). The use of what is available organic materials in the farm as soil conditioner plus inorganic fertilizer (under the ISFM), can maintained soil fertility.