EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON NUT PRODUCTION OF COCONUT (*Cocos nucifera* L.) AND SOIL ENVIRONMENT - A REVIEW

PARWAIZ AHMED BALOCH[1]*, INAYATULLAH RAJPAR[2] AND UBEDULLAH ANWAR TALPUR[3]

[1]Plant Introduction Centre, SARC, PARC, Karachi, Pakistan.
[2]Department of Soil Science, Sindh Agriculture University, Tando Jam, Pakistan.
[3]National Sugar Crops Research Institute, PARC, Thatta, Pakistan.

Abstract

With the adoption of new technology of intensive cropping with high yielding varieties, there is a considerable demand on soil for supply of nutrients. However, the native fertility of our soils is poor and cannot sustain high yields. Sustainable agricultural production incorporates the idea that natural resources should be used to generate increased output and incomes, without depleting the natural resources. The solution is application of integrated nutrient management (INM). It is the system, which envisages the use of organic wastes, biofertilisers and inorganic fertilisers in judicious combinations to sustain soil productivity. The conjunctive use of organic and inorganic sources improves soil health and helps in maximising production as it involves utilisation of local sources and, hence, turned to be rational, realistic and economically viable way of supply of nutrients. Coconut is a versatile tree and is the most popular home garden crop in the world. It is very beneficial for health because of its high nutrient status. Integrated nutrient management affects on its growth and yield characteristics to a great extent. This paper, therefore, presents a review on various aspects of INM used to improve soil environment, coconut growth and yield characters.

Keywords: Integrated nutrient management (INM), Sustainable agriculture, Soil environment, Coconut, Nut production.

Introduction

Coconut (*Cocos nucifera* L.) is currently grown in nearly 90 countries spread along the tropical belt amounting to 11.9 million hectares of eight million hectares, or about 70% Southeast and East Asia (Carpio et al., 2005). According to Indian Council of Agricultural Research (Anonymous, 2004) entire life span of coconut is 70-80 years. It is a highly exhaustive palm, yielding about 5,000 nuts per hectare per year (Table 1). The annual nutrient removal by the coconut palms through nuts, fronds, trunk, bunch, spathe, etc., varies from 20 to 174 kg N, 2.5 to 20.0 kg P_2O_5 and 35 to 49 kg K_2O ha^{-1} (Ouverier and Ochs, 1978; Anonymous, 2000). Consequently, it removes a considerable amount of nutrients from the soil within few years. The nutritional balance is essential to obtain high and a sustainable yield (Reddy et al., 2002). For a healthy growth and sustainable coconut production, nutrients must be available in correct quantities, proportion and in an uptakable form at right time (Mohandas, 2012; Nadheesha and Tennakoon, 2008). To fulfill these requirements, the addition of chemical fertiliser or natural manure is needed. The role of nutrient elements either alone or in combination with other sources, like, organic manure and fertiliser, has been well established for fruit crops (Zia et al., 2000).

An assortment of studies has been conducted globally in order to ascertain the nutritional requirements of coconut under nursery and field conditions (Balakrishna, 1975; Tennakoon and Bandara, 2003; Baloch et al., 2004; Solangi et al., 2010). Application of chemical fertilisers makes the soil fertile and increases productivity of crops, while introducing adverse effects on soil and environment (Attanayake et al., 2010). Therefore, it is needed that fertility and productivity of the soil be restored, using organic fertilisers in combination (Khan et al., 2009). There is a need to organise the supply of nutrients to the crop through organic and renewable sources and strengthen the initiative of integrated nutrient management (INM) (Anderson et al., 2002). Use of organic manures, apart from improving physical and biological properties of soil, helps in improving the use of efficiency of chemical fertilisers (Alam et al., 2003, 2005). Under such circumstances, an integrated approach is suggested through complementary use of inorganic and organic fertilisers to boost/sustain soil fertility and crop productivity (Lampe, 2000). This includes the use of mineral fertiliser combined to organic manures for environmentally safe, economically

*** pervezparc@gmail.com**

viable, socially feasible and ecologically sustainable production system.

This review paper focuses on the impact of INM on soil environment, coconut growth and nut yield, so that conclusions may be drawn pertaining to the adoption of INM sustainability of soil environmental health and the coconut nut production.

Table 1. N, P, K and Mg removed by Coconut at yield level of 7,500 nuts ha^{-1}.

Palm Part	N (kg)	P (kg)	K (kg)	Mg (kg)
Inflorescence	7.9	1.9	16.3	3.2
Fronds	33.4	3.3	43.6	20.3
Nut water	0.3	0.1	3.3	0.1
Shell	1.8	0.1	3.1	0.2
Kernel	19.9	2.8	10.5	1.6
Husk	10.6	1.2	63.2	2.5
Total by nuts	32.6	4.2	80.1	4.4

Source: Gunathilake and Manjula (2006).

Effect on soil properties

The addition of organic manures and inorganic fertilisers results in multiple changes of relevant soil fertility characteristics frequently favouring physical, chemical and biological aspects.

Effect on physical properties

The application of organic manure has numerous advantages, such as, improving soil physical property parameters, i.e., water holding capacity, water movement, infiltration rate, bulk density, porosity, tilth, aeration, soil structure, aggregate stability, etc. (Saha et al., 2010; Ingle et al., 2004) and organic carbon content apart from supplying good quality of nutrients in sandy soils which have low CEC and poor physical properties. The addition of organic sources could increase the yield through improving soil productivity and higher fertiliser use efficiency (Santhi and Selvakumari, 2000).

Effect on chemical properties

Organic matter supplied by the manures to the soil keeps the plant nutrients bound on itself and supplies the plant in times of need (Table 2). It also counteracts the adverse effect of heavy metals supplied to the soil through pesticides and also neutralises acidity or alkalinity created by fertilisers. The positive effects of organic waste on coconut growing soils were reported in several studies (Odlare et al., 2007; Jedidi et al., 2004). While, application of chemical fertiliser results in decreased total organic carbon (TOC), basic cation contents, and lowering of soil pH (Reza and Jafar, 2007).

Table 2. Physico-chemical parameters in non-treated (NT), inorganic fertiliser mixture (IFM) applied and poultry litter (PL) applied in coconut growing soils.

Treatment	pH	EC (umhos/cm)	Organic C (%)	NH_4-N (mg/kg)	NO_3-N (mg/kg)	Available P (mg/kg)
NT	6.0+0.1	36.5+2.3	0.8+0.03	4.3+0.4	2.2+0.4	146.6+35.4
IFM	6.5+0.1	32.4+1.1	0.7+0.04	2.3+0.6	1.9+0.5	281.0+56.2
PL	7.0+0.1	79.7+9.4	1.4+0.21	4.3+0.6	2.2+0.6	951.5+137.4
LSD	0.24	19.49	0.43	1.80	1.81	228.36

Source: Karunasinghe et al. (2009).

Effect on biological properties

Organic matter serves as food as well as raw material for micro-organisms residing in soil and results in restoration of soil fertility, thereby, improving the crop growth (Table 3). In the past, scientists have expressed concerns on the danger of indiscriminate and/or continuous use of chemical fertilisers in the soil as it eventually reduces the soil biological activity (Tennakoon, 1990). The use of chemical fertilisers/agrochemicals kills the beneficial soil organisms and destroys their natural fertility. This is probably because of the adverse effects of high concentration of nutrients and salts in inorganic fertilisers (Huat et al., 2002). Chemically grown foods have adversely affected soil and human health (Jithya, 2010; Sujit, 2002).

Effect on growth and yield

Coconut is highly exhaustive palm and it is difficult to meet the demand of plant through fertilisers alone. Hence, to reduce the cost on inorganic fertilisers and to sustain yields, locally available organic resources and bio-fertilisers are recommended. Use of these organics in combination with appropriate ratio of fertilisers may be beneficial in increasing the crop yield and maintaining soil health.

Tennakoon and Bandara (2003) observed that organic materials such as cattle manure, goat manure, broiler and layer poultry manure, pig manure, farm yard manure, biogas residue, sewage sludge, compost, gliricidia, pueraria, calopogonium

and acacia have considerable amounts of macro- and micronutrients and these materials could be used as a source of plant nutrients for coconut to supply the N requirement in full and P, K and Mg requirements in part (Table 4).

Table 3. Means with standard errors of root colonisation, arbuscules, number of vesicles of arbuscular mycorrhiza, coconut yield in non-treated (NT), inorganic fertiliser mixture (IFM) applied and poultry manure (PL) applied coconut palms.

Treatment	Percent of root colonisation	Percent of root arbuscules	Number of vesicles/1 cm root length	Total number of spores/1 g of soil	Coconut yield nut/palm/month
NT	46.9+1.4	28.5+1.2	1.4+0.1	204.1+12.8	6.4+0.58
IFM	29.0+3.2	9.5+1.3	2.5+0.4	261.2+29.5	8.0+0.37
PL	42.0+1.2	13.1+0.5	0.9+0.1	151.6+23.1	11.6+0.29
LSD	7.49	3.69	0.79	79.14	0.75

Source: Karunasinghe et al. (2009).

Table 4. Macronutrient content (no.) of locally available organic sources (dry weigh basis).

Organic source	N	P	K	Mg	Ca
FYM	1.2-1.8	0.4-0.6	1.1-1.9	0.5-1.0	0.5-1.1
Cattle manure	1.2-1.9	0.2-0.5	0.5-1.1	0.5-0.6	1.3-1.8
Poultry manure	2.0-2.3	0.6-1.2	1.7-2.0	0.5-0.6	1.0-4.9
Compost	1.3-1.7	0.3-0.6	0.4-0.7	0.2-0.5	0.8-2.0
Gliricidia leaves	2.5-3.5	0.1-0.2	1.3-1.7	0.3-0.5	1.0-1.9

Source: Tennakoon and Bandara (2003).

Methods of fertiliser's application

Inorganic as well as organic materials can be added in the form of broadcasting on the soil surface, fertigation, trench and soil basin method.

Fertigation: It is the application of chemical fertilisers in liquid form or solid fertiliser granules already dissolved in water in order to irrigate all plants uniformly. It is found that the method is efficient, convenient for maintaining soil fertility as per requirement (Shirgure, 2000). Fertigation has a significant impact on vegetative growth and number of fruit and water quality of coconut (Teixeira et al., 2003).

Trench method: It is a traditional method of surface application of fertiliser round the palm, cheaper in its nature as it is widely adopted by the local farmers. It was found that application in full circles around the palm was about 40% more efficient than half circle application (de Silva, 1968).

Soil basin method: Application of fertilisers by farmers is proved to be uneconomical as leaching losses of nutrients are maximum (Dwivede et al., 1981).

Categories considered in INM

Compost: It is organic manure artificially prepared from plant residues and animal waste products. It is prepared from waste vegetables and other refuse mixed with animal excreta and also from town waste and night-soil. It may be rural compost prepared from farm waste products, e.g., wheat and rice straw, crop stubbles, crop residues, such as, sugarcane trash, groundnut husks and leaves, cotton stalks, etc., weeds, waste fodder, litter from cowshed and hedge clippings. Since compost is made of plant refuses, all nutrients needed by plants are made available to plants, when compost is added to soils (Kumar, 2006). Compost, alongwith improving the physical structure of soil, also adds millions of organisms already present in the soil. Indian Council of Agricultural Research (Anonymous, 2004) recommended the soils, poor in organic matter, the application of green manure or compost at 50 kg palm^{-1}.

Farmyard manure: The farmyard manure is a mixture of solid and liquid excreta of farm animals alongwith litter and left over material from cattle fodder. Farmyard manure is one of the most commonly used organic manure. Cow dung is valuable manure rich in nitrogen, phosphorus and potassium (Blair et al., 2006).

Poultry manure: It is also an extremely rich source of nitrogen and organic matter. Poultry manure contains 1.0-1.8 percent nitrogen, 1.4-1.8 percent phosphorous and 0.8-0.9 percent potassium. In a study, Karunasinghe et al. (2009) observed that soil nutrient status increased more with the application of poultry manure than the application of recommended inorganic fertiliser mixture.

Green manure: The practice of ploughing or turning into the soil un-decomposed plant tissues for the purpose of improving physical condition as well as fertility of the soil is referred to green manure. The green manure crop supplies organic matter as well as additional nitrogen (Subramanain

et al., 2005), particularly, if it is a legume crop which has the ability to acquire nitrogen from the air with the help of its root nodule bacteria. The coconut palms, where *Desmodium* and *Sun hemp* were incorporated registered 97.4 and 93.2 nuts, respectively, compared to 68.6 nuts/palm/year in the control (Vijayaraghavan and Ramachabdran, 1989).

Oil cakes: Oil cakes are the by-products of oil seed crops. They are of two types, edible and nonedible. The nonedible oil cakes, such as, castor cake, karanja cake and neem cake, are used as organic nitrogenous fertilisers, due to their N, P and K content (Ramachandran et al., 2007). All oil cakes give result with almost every crop and on all types of soil. They can be applied a few days prior to sowing or at sowing or as a top dressing, after the crop has made a certain amount of growth.

Blood meal: It is an organic fertiliser produced by drying the blood of the slaughtered warm-blooded animals (Ciavatta et al., 1996). It contains 10 to 12 percent nitrogen, 1 to 1.5 percent phosphorous and 1.0 percent potassium. It is quick acting manure (Reddy, 2005).

Fish manure: It is available either as dried fish meal or powder. In areas where fish oil is extracted, the residues can be used as manure. It contains 4 to 10 percent of organic nitrogen, 3 to 9 percent phosphorous and 0.3-1.5 percent potassium. Like other animal residues fish manures have a potential use as fertilisers in agricultural soils, especially, in low fertility soils (Salazar and Saldana, 2007).

Wood ash: Wood ash, cattle dung ash, etc., are the indigenous sources of potassium. Wood ashes contain a very small percentage of nitrogen, 1.0 to 5.0 percent phosphorous and 0.5 to 36.0 percent potassium. Out of various ashes, ash of tobacco stem contains 36 percent potassium. Un-leached wood ash contains 5 to 6 percent potassium in the form of potassium carbonate, 1.0 to 2.0 percent phosphorous and 25 to 30 percent lime. Wood ashes are mainly applied to fruit crops and root vegetable crops. The chemical composition of wood ash matches the needs of different plant species and soil types on the content and ratio of the nutrients (Serafimova et al., 2011).

Sewage and sludge: Sewage and sludge are the products of sewage system of sanitation, a modern system of sanitation commonly adopted in cities. On an average, sludge contains 1.5-3.5 percent of nitrogen, 0.75-4.0 percent of phosphorous and 0.3-0.6 percent of potassium (Chen et al., 2002). Sewage and sludge can be used profitably as organic manure for producing crops. These can also be used as starter in the compost made by activated compost process.

Sugarcane press mud: Press mud or filter cake, a waste by-product from sugar factories, is a soft, spongy, amorphous and dark brown to brownish material, which contains sugar, fiber, coagulated colloids, including, cane wax, albuminoids, inorganic salts and soil particles. Ghulam et al. (2010) reported that the sugar press residue (SPR) or press mud is a potential source of major minerals (Ca -2.40%, P -1.27%, K -1.81%, Mg -1.28%, S -2.62%) as well as trace elements (Cu -22.6 ppm, Fe -2042.0 ppm, Zn -36.5 ppm, Mn -228.0 ppm). Razzaq (2001) also reported that substituting chemical fertilisers with sugarcane filter cake in crop production will add sulfur and boost up organic matter status of soil to satisfactory level within 5-6 years and improve and maintain soil health.

Coir pith: This is the raw material obtained from coconut. It acts as excellent mulch in young plantations and conserves moisture during the drought months. It has high moisture retention capacity of 500-600% and high cation exchange capacity (CEC) varying from 38.9 to 60 m eq/100 g, which enables it to retain large amounts of nitrogen and the absorption complex, has high content of exchangeable K, Na, Ca and Mg. It has also been valued for its high potassium content and low bulk density and particle density (George et al., 2013; Evans et al., 1996).

Coconut husk: The husk can either be piled at the base of the coconut trunk as mulch, or chopped and composted. A layer of husk with the convex side upward is placed 2m away from the base around the tree to minimise the loss of moisture and heavy growth of weeds. The husk of coconut was observed to supply 40.7% and 66.9% of Cl and K needs of the palm, respectively (Eroy, 1991).

Bio-fertilisers: Bio-fertilisers are low cost, effective and renewable source of plant nutrients to supplement chemical fertilisers. They are well recognised as an important component of integrated plant nutrient management for sustainable agriculture and hold a great promise to improve crop yield (Narula et al., 2005). These are biologically active inputs and contain one or more types of beneficial micro-organisms, such as, bacteria, algae or fungi (Boraste et al., 2009). Every micro-organism has a specific capability and function. These micro-organisms have the ability to fix atmospheric nitrogen either by living symbiotically with the roots of leguminous plants or non-symbiotically (free living) to transform atmospheric or nutrients from non-usable to usable form through biological processes (Amanullah et al., 2012).

Fertilisers cannot be replaced by organic manures completely as the organic manures cannot meet the nutrients' requirement of most of the crops. But the use of organic manures, such as, farmyard manure (FYM), compost, green manure, and bio-fertilisers alongwith chemical fertilisers, is essential to suppress any possible negative impact

of fertilisers on the soil and to sustain soil productivity (Kurubar, 2007).

Integrated nutrient management (INM) lays emphasis on improving and maintaining soil fertility for sustained productivity in coconut (Khan et al., 2000). This proves the beneficial effect of INM in enhancing the number of female flowers and nut production (Table 5). Similar observation was made earlier by Ghosh and Bandopadhyay (2009).

Table 5. Growth and yield characters of coconut as affected by inorganic and organic fertilisers.

Treatment	Female flowers (no/palm/y)	Number of nuts (no/palm/y)	Weight of copra (kg/palm/y)
T1 (control)	**88**	**23**	**4.5**
T2 (inorganic NPK + dolomite)	**119**	**34**	**6.5**
T3 (organic manure + inorganic NPK + dolomite)	**139**	**40**	**7.6**
T4 (organic manure + inorganic K + dolomite)	**136**	**37**	**7.2**

Source: Tennakoon et al. (1995).

Effect on nut yield of coconut

In order to raise the total production from the limited or scarce natural resources, it is the most convenient way to utilise them properly. It has been experienced that, due to more exhaustion of soil nutrients, it becomes difficult to retain the nutrients through a single source alone (Singh et al., 2004). Therefore, a balanced use of chemical fertilisers may be helpful for achieving the high yield level (Magat et al., 2009), but soil physical and biological environments may be deteriorated, due to low organic matter content in soil. The use of integrated nutrient management as a tool for productivity increase, and its sustenance in coconut garden is beneficial (Khan, 2004). The adoption of INM system is based on conservation that improves soil fertility (Quamruzzaman, 2006) over the years or maintained without further deterioration (Krishnakumar and Maheswarappa, 2010). It improves growth as well as yield attributes significantly (Venkitaswamy and Khan, 2002; Attanayake et al., 2010; Reddy et al., 2001; Singh et al., 2004; Kikona et al., 2012; Ghosh and Bandopadhyay, 2009; Mohandas, 2012.

Conclusion

On the basis of literature cited above regarding the use of inorganic and organic fertilisers in the form of integrated nutrition management (INM) in coconut fields, it can be concluded that it has proved to become an important combination for sustainable agriculture. The addition of organic materials results in an increase of organic matter content of the soil which ultimately adds soil macro- and micronutrients besides improving soil physical and chemical properties. It stimulates soil biological activities which is necessary for soil health and fertility. On one hand, it has positive effect on coconut growth and yield characters while, on the other, it is environment friendly. It concluded that may be the use of organic manures, such as, farmyard manure (FYM), compost, green manure, and bio-fertilisers alongwith chemical fertilizers, is essential to suppress any possible negative impact of fertilisers on the soil and to sustain soil productivity.

References

Alam, S. M., S. A. Shah, S. Ali and M. M. Iqbal. 2003. Effect of integrated use of industrial wastes and chemical fertilizer on phosphorus uptake and crop yields. *Pak. J. Soil Sci*., 22: 81-86. 217.

Alam, S.M., S.A. Shah, S. Ali and M.M. Iqbal. 2005. Yield and phosphorus uptake by crops as influenced by chemical fertilizers and integrated use of industrial by-products. *Songkla. J. Sci. Tech*. 27: 9-16.

Amanullah, A., A. Kurd, S. Khan, M. Ahmed and J. Khan. 2012. Biofertilizer–A possible substitute of fertilizers in production of wheat variety Zardana in Balochistan. *Pak. J. Agric. Res*. 25(1): 44-49.

Anderson, J., M. Blackie, M. Eilitta, E. Fernandes, N. Sanginga, E. Smaling and D. Spencer. 2002. A consultative review of the Rockefeller foundation's activities to improve and sustain soil fertility in East and Southern Africa. New York: The Rockefeller Foundation.

Anonymous, 2000. I, kissan.com.

Anonymous. 2004. Handbook of Agriculture (New Delhi), India, 913.

Attanayake, S.R.M.R., C.M. Nanayakkara and N.A. Tennakoon. 2010. Effect of different fertilizers on the growth of coconut seedlings, availability of some nutrients and soil microbial activities.

Balakrishna, M.T.S. 1975. Inorganic and organic sources of nitrogen and phosphorus fertilizers for coconut. *Ceylon Coconut Quarterly*, 26: 104-107.

Baloch, P.A., M. Moizuddin, M. Imam, B.A. Abro, J.A. Lund and A.H. Solangi. 2004. Effect of NPK fertilizers and farmyard manure on nut

production of coconut (*Cocos nucifera* L.). *Asian J. Plant Sci.*, 3(1): 91-93.

Blair, N.R., D. Faulkner, A.R. Till and P.R. Poulton. 2006. Long-term management impacts on soil C, N and physical fertility. *Soil and Tillage Res.*, 91: 30-38.

Boraste, A., K.K. Vamsi, A. Jhadav, Y. Khairnar, N. Gupta, S. Trivedi, P. Patil, G. Gupta, M. Gupta, A.K. Mujapara and B. Joshi. 2009. Biofertilizers: a novel tool for agriculture. *Int. J. Microbiol. Res.*, 1(2): 23-31.

Carpio, C.B., G.A. Santos, E.E. Emmanue and H. Novarianto. 2005. Research on coconut genetic resources in South and East Asia. Coconut Genetic Resources. IPGRI- Regional office for Asia, the Pacific and Oceania (IPGRI-APO), Serdang, Selangor DE, Malaysia, 533-545.

Chen, S., S. Summerfelt, S. Summerfelt, T. Losordo and R. Malone. 2002. Recirculating systems, effluents, and treatments. In: Tomasso, J. (Ed.), Aquaculture and the environment in the United States. In: A Chapter of the World Aquaculture Society US Aquaculture Society, Baton Rouge, LA, 119–140.

Ciavatta, C., M. Govi., L. Sitti and G. Gessa. 1996. Identification of blood meal in fertilizers. *Fertilizer Res.* 44: 249-253.

Coconut Research Institute, Lunuwila Sri Lanka. COCOS (1990), 8: 26- 32.

de Silva, M.A.T. 1968. Recommended methods of fertilizer application for coconut palms. *Ceylon Coconut Planter's Rev.*, 3: 108-111.

Dwivedi, R.S., P.K. Ray and S. Ninan. 1981. Studies on the methods of inorganic nutrient application in coconut. *Plant and Soil*, 63: 449-456.

Eroye, M.N. 1991. Highlights 91. PCARRD-DOST, Los Baños, Laguna.

Evans, M.R., S. Konduru and R.H. Stamps. 1996. Source variation in physical and chemical properties of coconut coir dust. *Hortic. Sci.*, 31: 965–967.

George, V.T., C. Palaniswami, S.R. Prabhu, M. Gopal and A. Gupta. 2013. Co-composting of coconut coir pith with solid poultry manure. *Curr. Sci.*, 104: 2, 25.

Ghosh, D.K. and A. Bandopadhyay. 2009. Studies on the influence of integrated nutrient management on growth and yield of young coconut palm. *Indian Coconut J.*, LII: 17-21.

Ghulam, S., M.J. Khan, K. Usman and H. Rehman. 2010. Impact of press mud as organic amendment of physico-chemical characteristics of calcareous soil. *Sarhad J. Agri.*, 26(4): 565.

Gunathilake and Manjula. 2006. Balanced fertilization for sustainable coconut and coconut-intercrop systems in Sri Lanka. 415-425. In: Balanced fertilization for sustaining crop productivity. D.K. Benbi, M.S. Brar and S.K. Bansal (eds.). IPI proceedings, ISBN 978-3-9523243-2.

Huat, O.K., K. Awang, A. Hashim and N.M. Majid. 2002. Effect of fertilizer and vesicular-arbuscular mycorrhizas on the growth and photosynthesis of Azadirachta excelsa (Jack) Jacobs's seedlings. *Forest Ecol. Manag*. 158 (1-3): 51-58.

Ingle, S.N., S.V. Malode, R.M. Ghodpage and S.D. Jadhav. 2004. Effect of long term use of vegetative barriers and FYM on yield and soil fertility under cotton-sorghum rotation in vertisol. *Annal. Plant Physiol*. 18(1): 42-44.

Jedidi, N., A. Hassen, O.V. Cleemput and A.M. Hiri. 2004. Microbial biomass in a soil amended with different types of organic wastes. *Waste Manag. Res*., 22: 93-99.

Jithya. 2010. Effect of different fertilizers on the growth of coconut seedlings, availability of some nutrients and soil microbial activities. http:// environmentlanka.com/blog/2010.

Karunasinghe, T.G., W.C. Fernando and L.R. Jayasekera. 2009. The effect of poultry manure and inorganic fertilizer on the arbuscular mycorrhiza in coconut. *J. Nat. Sci. Found. Sri Lanka*, 37(4): 277-279.

Khan, A., M.T. Jan, K.B. Marwat and M. Arif. 2009. Organic and inorganic nitrogen treatment effects on plant and yield attributes of maize in a different tillage systems. *Pak. J. Bot.*, 41(1): 99-108.

Khan, H.H. 2004. Initiatives towards improving coconut productivity. *J. Plant. Crops*. 32:173-185.

Khan, H.H., A.K. Upadhay, A.K. and C. Palaniswami. 2000. Integrated nutrient management of plantation crops. In *Plantation Crop Res. and Dev. Proc.* Placrosym XIV, CDB Kochi, 9-22.

Kikona, Y.Y., A.K. Singha and V.B. Singha. 2012. Nutrient budgeting under Coconut based patchouli farming system on Hapludalf. *J. Plant Nutr..*, 35(7): 975-989.

Krishnakumar, V. and H.P. Maheswarappa. 2010. Integrated nutrient management for root (wilt) diseased coconut (*Cocos nucifera*) palms. *Ind. J. Agri. Sci.*, 80 (5): 394-398.

Kumar, G.P. 2006. Comparative evaluation of coconut waste compost. *Agri. Sci. Digest*, 26(4): 276 – 278.

Kurubar, A.M. 2007. Studies on integrated nutrient and post harvest management of Fig (*Ficus carica*, L.,). PhD Thesis submitted to the

University of Agricultural Sciences, Dharwad, India.

Lampe, S. 2000. Principle of integrated plant nutrition management system. In: Proc. of Symp. Integrated Plant Nutrition Management (Nov. 8-10), NFDC, Islamabad, 1999.

Magat, S.S., M.I. Secretaria, J.A. Mantiquilla and R.Z. Margate. 2009. Integrated soil fertility management (ISFM) on coconut + Lanzones (Lansium domesticum Corr) agro-ecosystem in Southern Mindanao, Philippines (1993-2007): with Emphasis on the Multi-Nutrient Coconut - Specific Mineral Fertilizer. Part II. Influence on Leaf Nutrient Levels and Selected Soil Properties. Cord, 25 (2).

Mohandas, S. 2012. Effect of NPK fertilizer levels on mineral nutrition and yield of hybrid (Tall x Dwarf) coconut. *Madras Agri. J.*, 99 (1-3): 87-91.

Nadheesha, M.K.F and A. Tennakoon. 2008. Removal of micronutrients from high and moderate yielding coconut plantations in Sri Lanka. In Proc. of Sec. Symp. on Plantn. Crop Res., pp: 164-169, held at Colombo, Sri Lanka, Oct. 16 -17, 2008.

Narula, N. V. Kumar, B. Singh, R. Bhatia and K. Lakshminarayana. 2005. Impact of biofertilizer on grain yield in spring wheat under varying fertility condition and wheat cotton rotation. *Archiv. Agro. Soil Sci*. 51:79-89.

Odlare, M., M. Pell and K. Svensson. 2007. Changes in soil chemical and microbiological properties during 4 years of application of various organic residues. *Waste Manag.*, doi:10.1016/j.wasman.2007.06.005

Ouverier, M. and R. Ochs. 1978. Mineral exportation of the hybrid coconut. PB. 121. *Oleaginous*, 33: 437-443.

Quamruzzaman, M. 2006. Improving plant nutrient management for better farmer livelihoods, food. Available at: http://www.fao.org/docrep/010/ag120e/AG120E08.htm.

Ramachandran, S., S.S.K. Singh, C.L. Carlos, R. Soccol and A. Pandey. 2007. Oil cakes and their biotechnological applications–a review. *Bioresource Tech.*, (98): 2000-2009.

Razzaq, A. 2001. Assessing sugarcane filter cake as crop nutrients and soil health Ameliorant. *Pak. Sugar. J.*, 16(3): 15-17.

Reddy, D.V.S., A.K. Upadhyay, P.H. Gopalasundaram and H. Khan. 2002. Response of high yielding coconut variety and hybrids to fertilization under rain fed and irrigated conditions. *Nutr. Cycl. Agro-ecosys.*, 62: 131-138.

Reddy, S. 2005. Principles of Agronomy, Kalyani Publisher, Ludhiana, India.

Reddy, D.V.S., S.N. Kumar and S.R. Prabhu. 2001. Evaluation of alternative media to potting mixture for raising coconut seedlings in poly bags. *Plant. Crop.*, 29(1): 62-65.

Reza, M.T. and K. Jafar. 2007. Influence of organic and chemical fertilizers on growth and yield of tomato (*Lycopersicon esculentum* L.) and soil chemical properties. Annual Report. Shahid Beheshti University, Tehran, Iran.

Saha, R., V.K. Mishra, B. Majumdar, K. Laxminarayana and P.K. Ghosh. 2010. Effect of integrated nutrient management on soil physical properties and crop productivity under a maize (*Zea mays* L.) – mustard (*Brassica campestris* L.) cropping sequence in acidic soils of northeast India. *Commun. Soil Sci. Plant Analy.*, 41(18): 2187-2200.

Salazar, F.J. and R.C. Saldana. 2007. Characterization of manures from fish cage farming in Chile. *Biores. Tech.*, (98): 3322-3327.

Santhi, R. and G. Selvakumari. 2000. Use of organic sources of nutrients in crop production. In: Theme papers on integrated nutrient management (ed.) Kannaiyan, published by Tamil Nadu Agric. Univ. and Tamil Nadu Department of Agriculture. 87-101.

Serafimova, E.K., M. Mladenov, I. Mihailova and Y. Pelovski. 2011. Study of the characteristics of waste wood ash. *J. Uni. Chem. Tech. Metal.*, 46(1): 31-34.

Shirgure. 2000. *In:* Proc. National Seminar on Hi-tech Horticulture, IHR, Bangalore, 73.

Singh, S.P., B.L. Manjunath, H.H. Khan and B. Shalini. 2004. Integrated nutrient management of coconut based-farming systems for sustained productivity. *J. Plant. Crops*, 32(2): 16-20.

Solangi, A.H., B. Mal, A.R. Kazmi and M.Z. Iqbal. 2010. Preliminary studies on the major characteristic, agronomic feature and nutrient value of Gliricidia sepium in coconut plantations of Pakistan. *Pak. J. Bot*., 42(2): 825-832.

Subramanain, P., R. Dhanapal, P. Sanil, C. Palaniswmi, C.V. Sairm and H.P. Maheswarappa. 2005. Gliricidia as green manure in improving soil fertility and productivity of coconut under coastal littoral sandy soil. *J. Plant. Crops*, 33(3): 179-183.

Sujit, A. 2002. Vermicompost, the story of organic gold: A review. *Agri. Sci*., 3(7): 905-917.

Teixeira, L.A.J., C. Ruggiero and W. Natale. 2003. Changes in some soil chemical properties resulting from irrigation and nitrogen and

potassium fertilization on banana after two crop cycles. *RBF Magazine*, 23: 684-689.

Tennakoon, N.A. and S.D.H. Bandara. 2003. Nutrient content of some locally available organic materials and their potential as alternative sources of nutrients for Coconut. *COCOS*, 15: 23-30.

Tennakoon, N.A. 1990. Goat manure as a soil ameliorant and yield 'Stimulant' in Coconut.

Tennakoon, N.A, R. Mahindapala and S. Widanapathirana. 1995. Effects of organic manure on the quality of Coconut soils. *J. Nat. Sci. Council, Sri Lanka*. 23(4): 171-182.

Venkitaswamy, R. and H.H. Khan. 2002. Integrated nutrient management in coconut. Conference Proc. of the 15th Plantation Crops Symposium Placrosym XV, Mysore, India, 410-413.

Vijayaraghavan, H. and T.K. Ramachabdran. 1989. Effect of *in situ* cultivation and incorporation of green manure crops on the yield of Coconut. *COCOS*, 7: 26-29.

Zia, M. S., R. A. Mann, M. Aslam, M. A. Khan and F. Hussain. 2000. The role of green manuring in sustaining rice-wheat production. In: Proc. Symp. "Integrated Plant Nutrition Management" NDFC, Islamabad, Pakistan. 130-149.