Cord 2017, **33** (1)

Study of some Morphological Characters in Coconut (*Cocos nucifera* L.) as Effected by Organic and Inorganic Fertilizers Amendments in Sandy Loam Soil of Karachi, Pakistan

Abdul Hameed Solangi[1], M.Z. Iqbal[2] and Parwiaz Ahmed Baloch[3]

Abstract

A comparison is made on the effect of organic and inorganic fertilizers on the some morphological characters of coconut. The study demonstrated that the treatments T_1 {Nitrogen, Phosphorus and Muriate of potash (NPK) + Neem seed powder (NSP) + *Gliricidiasepium* leaves (GSL)} and T_2 (NPK+ GSL) significantly increased most of the morphological characters (stem girth, number of leaves, petiole and leaflets). The study revealed that vegetatively the coconut was grown well on soil amended with organic and inorganic fertilizers. The morphological characters i.e the stem girth (173.77 cm) of coconut at 20 cm height T_1 (NPK + NSP + GSL) treatment produced maximum girth as compared to T_2 to T_8 {T_2 (NPK+ NSP), T_3 (NPK+ GSL), T_4 (NSP + GSL), T_5 (NPK), T_6 (GSL), T_7 (NSP), T_8 (Control)} treatments. The 11 leaf scars length (80.44 cm) was significantly ($p<0.05$) highest in T_1 as compared to T_3 to T_8 treatments. The present study also revealed that the number of leaves (28.77) were significantly ($p<0.05$) greater in T_1 as compared to T_5 to T_8 treatments. The petiole length (139.44 cm) and thickness (3.27 cm), were found significantly ($p<0.05$) highest in T_1 as compared to T_8 treatment. Leaflets length and number of leaflets were significantly high in T_1 and T_2 as compared to T_3 to T_8 treatments while, the leaflets width (5.04 cm) was significantly high in T_1 as compared to other treatments. It is therefore, recommended that treatment T_1 {NPK (1.0:0.5:1.0kg) + NSP (10.0kg) + GSL (20.0kg)}/palm/year was enough to improve the morphological characters to enhance future productivity.

Key words: Coconut, morphological characters, stem, leaf, organic, inorganic, fertilizers

Introduction

Coconut (*Cocos nucifera* L.) is a perennial cross-pollinated plant that is grown in nearly 92 countries spread along the tropical belt, where it is used for domestic use, as a source of food, oil production and construction materials. 11.9 million hectares of coconut are grown in the world, 8 million hectares, or about 70% is in South East and East Asia (FAOSTAT, 2008; Perera *et al*. 2015, Carpio *et al*. 2005 and Harries, 1978). The coconuts are produced 83% in Asia where Indonesia is the largest producer with 3.0 million ha that produce about 18.3 million tons of nuts, followed by Philippines that has an area of 3.5 million ha with production of 15.35 million tons of nuts. India has an area of 2.1 million ha that produce about 11.9 million tons of nuts (FAOSTAT, 2014). The coconut palm is known as "The Tree of Life" because of its range of environmentally sustainable uses (Foale, 2003).

[1]Institute of Plant Introduction, SARC, PARC, Karachi, Pakistan.

[2]Department of Botany, University of Karachi-75270, Pakistan.

[3]Food Quality and Safety Research Institute, SARC, PARC, Karachi, Pakistan.

Email: drahsolangi@gmail.com

According international criteria (FAO, 1980) only 30 percent of the total fields contained adequate organic matter. Beside many beneficial effects on soil properties and plant growth, soil organic matter is also indicative of N supply status of soils. In soils which are poor in organic matter, the green manuring crops usually grown are cow pea, Sunhemp, *Crotalaria juncea* and *Calopogoniummucunoides* (ICAR, 2004). As such, palm spends entire life span of 70-80 years or more rooted in one place. Consequently it removes most of the available nutrients in the soil within a few years. Annually, a palm removes large quantities of nutrients from the soil.

The organic materials (cattle manure, goat manure, broiler and layer poultry manure, farm yard manure, biogas residue, sewage sludge, compost (*Gliricidiasepium, Pueraria, Calopogonium*and *Acacia*) have considerable amounts of macro and micro-nutrients 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 (Tennakoon and Bandara, 2003). The soils of the rain fed area are particularly less fertile because of low organic matter contents. Its heath and sustainability can be enhanced through incorporating different organic fertilizers such as farm yard manure, poultry manure, neem cake, compost green manure (Gupta, 2003). The manure and fertilizer requirements of ridge and sponge gourd grown in interspaces of coconuts, the highest yield of the crop and the benefit cost ratio was recorded in recommended dose of NPK + 50% of farmyard manure (Nair and Nair, 2006). The integrated use of organic and inorganic fertilizers did not only increase mutual efficiency but also help in the substitution of chemical fertilizers (Hussain *et al*. 1988; Ghosh and Sharma, 1999).

Maheswarappa *et al.* (1998) noted that among organic manures, farmyard manure and vermicompost applied alone, and a combination of farmyard and NPK treatments promoted growth compared with the other treatments and the control. Tennakoon (1990) observed that applying 20 kg goat manure/palm annually increased soil nutrient content by 45%. It also improved the microbiological activity and water holding capacity. Organic fertilization dates back to the old practice of Chinese farmers who used it to conserve soil fertility and to ease soil cultivation. The soil properties are significantly improved due to organic matters which bettered the soil physical conditions, soil nutrients status, and soil biological properties (Tennakoon, 1988). Agyarko *et al*. (2006) reported that soil nutritional levels increased with poultry manure and increasing levels of neem leaves.

Marimuthu *et al.* (2001) reported that application of 50 kg farm yard manure, along with the recommended dose of NPK, recorded the highest N, P and K contents in soil and leaf, with 47% high nut yield compared to the control. Subramanian *et al.* (2005) investigated that the leaves of *Gliricidiasepium* decomposed relatively fast, providing nitrogen and potassium and the application also improved the soil moisture availability as compared to application of inorganic fertilizers alone. Solangi and Iqbal (2012) investigated that combined treatment of inorganic and organic ({Nitrogen, Phosphorus and Muriate of potash (NPK) + Neem seed powder (NSP) + *Gliricidiasepium* leaves (GSL)} significantly increased most of the morphological characters of coconut seedling. Therefore, it is needed that according to Khan *et al*. (2009) the fertility and productivity of the soil be restored, using organic fertilizers in combination.

Leal *et al*. (1994) observed that the vegetative growth and disease incidence were evaluated by the number of missing and live leaves, stem girth and the number of stomata in 6 leaflets of leaf 7 in the first year and leaf 10 in the second year. P and K had an effect on vegetative growth. Nath *et al.* (2003) investigated the significant influence of the main effect of N, P and K on mean number of fully opened leaves in the crown, number of female flowers/palm, nut setting, nut yield/palm/year and cumulative nut yield for eight years. The available soil K increased with increasing levels of K application at all soil depths.

The aim of the present research is to investigate of some morphological characters in coconut as affected by organic and inorganic fertilizers amendments in sandy loam soil of Karachi. Therefore, this study was under taken to find out the suitable and economical dose of fertilizers for the coconut palm. This study also aimed, to increase the farm productivity and enhancing farmer's income.

Material and Methods

Description of Experimental site

The experimental area was at the Plant Introduction Center (PIC), Southern Agricultural Research Center (SARC), Pakistan Agricultural Research Council (PARC), Karachi. Karachi is situated on the coast along the Arabian Sea (Latitude 24° 50` - 25° 15` North and Longitude 65° 51` -67° 40` East, altitude 26ft above sea level) of Pakistan. The climate of Karachi is subtropical maritime desert (Chaudhry, 1961). The fast urbanization and construction of new industrial units in Karachi are affecting the vegetation growing around these areas (Iqbal *et al*. 2001). Climatically, it falls under humid type, and forms a part of the coastal area. The sensitivity to temperature not only limits coconut in terms of the latitude (27° N and 27° S) but within these ranges the altitude higher than 600 m above sea level.

Coconut is found to grow well between 20^0 North and South of the equator. As for the light requirements for coconut crop, the optimum ranges are between 2000 to 2200 hours/ annum (120 hours/month was the minimum) (ICAR, 2004).

Physico-chemical characteristics of soil of coconut palm experimental site, PIC, Karachi were observed *i.e*. soil texture of the experimental site was sandy loam, pH.8.47, electrical conductivity {EC} (dS/m) 0.48, calcium carbonate {$CaCO_3$} (%) 34.00, organic matter {OM} (%) 0.34, nitrogen {N} (ppm) 0.012, phosphorus {P} (ppm) 12.72 and potassium {K} (ppm) 79.00 (Solangi, 2013).

Morphological Characteristics

Three coconut palms (Variety: Sri Lanka Tall) were selected randomly from the experimental plots and each treatment was carried out in three replicate for each treatment. Thus, in the whole study 72 adult coconut palms were characterized by the method of IPGRI (1995) and Solangi (2001). The morphological characteristics included girth measurement at 20 cm and 1.5 m above soil level and length of stem with 11 leaf scars, measured starting from the bottom of the first leaf scar to the bottom of the 11^{th} leaf scar. The leaf morphology observed was normally made on leaf number 09. Number of leaves, petiole length, width and thickness, rachis length, leaflet length, leaflet width and leaflets number were recorded. For leaflet characteristics, four leaflets (two on each side) near the middle of the rachis were taken for measurements.

Organic and inorganic amendments

Preparation of test material

The dry neem (***Azadirachtaindica*** A. juss.) fruits were collected under the neem trees from suburb of the experimental site, after collection, the seeds were crushed for use as test material. The leaves of *Gliricidia* trees (***Gliricidiasepium*****)** were also collected from the experimental site as test material.

The inorganic fertilizers additives like urea for nitrogen, di-ammonium phosphate for phosphorus and muriate of potash for potassium having NPK fertilizer doses were applied in the ratio of 1.0:0.5:1.0 kg/palm in two annual (July and December) split applications for four years. There were three replications of eight treatments.

The detail of amendments included urea, di-ammonium phosphate and muriate of potash (NPK) in combination with Neem seed powder (NSP) and *Gliricidiasepium* leaves (GSL) at different levels is given in Table 1.

Statistical Analysis

The experiment was laid out in a Completely Randomized Block Design (CRBD). ANOVA and difference among the treatments means were compared using LSD test at 5%

Table 1. Kinds and fertilizers rates applied

Treatment	Ingredients used	Applied twice in a year for four years
T_1	Urea (N), di-ammonum phosphate (P), muriate of potash (K), (NPK) + Neem seed powder (NSP) + *Gliricidiasepium* leaves (GSL)	1.0: 0.5: 1.0 kg + 10.0 kg +20.0 kg/palm
T_2	NPK+ Neem seed powder	1.0: 0.5:1.0 kg +10.0 kg/palm
T_3	NPK+ *Gliricidiasepium* leaves	1.0: 0.5: 1.0 kg + 20 kg/palm
T_4	Neem seed powder + *Gliricidiasepium* leaves	10.0 + 20.0 kg/palm
T_5	NPK	1.0: 0.5: 1.0 kg/palm
T_6	*Gliricidiasepium* leaves	20.0 kg/palm
T_7	Neem seed powder	10.0 kg/palm
T_8	Untreated (control)	Nil

Table 2. Effects of organic and inorganic amendments on stem girth (at 20 cm and 1.5 m height), 11 leaf scar length and number of leaves of coconut (*Cocos nucifera* L.)

Treatments	Stem girth (cm) at 20 cm	Stem girth (cm) at 1.5 m	11 Leaf scar length (cm)	Number of leaves
T_1 (NPK + NSP + GSL)	*173.77 ± 6.62 a	96.33 ± 2.07 a	80.44 ± 0.78 a	28.77 ± 0.95 a
T_2 (NPK + NSP)	163.55 ± 4.23 a	92.33 ± 3.10 ab	75.22 ± 2.75 ab	26.88 ± 1.13 ab
T_3 (NPK + GSL)	168.33 ± 6.24 a	89.11 ± 5.20 ab	68.88 ± 2.79 bc	26.55 ± 0.83 ab
T_4 (NSP +GSL)	170.88 ± 4.91 a	82.11 ± 4.04 b	61.11 ± 3.12 cd	26.33 ± 1.05 ab
T_5 (NPK)	166.33 ± 5.53 a	90.88 ± 4.33 ab	61.44 ± 4.88 cd	24.44 ± 0.91 bc
T_6 (GSL)	170.33 ± 6.92 a	94.55 ± 1.66 a	56.22 ± 2.73 d	24.11 ± 0.99 bc
T_7 (NSP)	168.55 ± 8.05 a	94.44 ± 2.35 a	59.11 ± 3.90 d	24.44 ± 1.08 bc
T_8 (Control)	158.11 ± 9.65 a	81.55 ± 3.32 b	58.11 ± 3.15 d	22.00 ± 1.17 c
LSDp<0.05	18.95	9.76	8.07	2.82

Statistical significance determined by analysis of variance. Numbers followed by the same letters in the same column are not significantly ($p<0.05$) different, according to Duncan's Multiple Range Test. *Mean ± Standard Error. LSD (Least Significant Difference).

probability level (Steel *et al.* 1997)**.**Other statistical techniques like Duncan Multiple Range Test (DMRT) (Gomez and Gomez, 1984 and Zar, 2010) at $p<0.05$ on personal computer software package, Costat Version 3.

Results and Discussion

The study of some morphological characters in coconut (*Cocos nucifera* L.) as affected by organic and inorganic fertilizers amendments in sandy loam soil of Karachi were summarized in Tables 2 to 4. The results showed that the stem girths at 20 cm had no significant difference among all the treatments (Table 2). Based on the stem girth at 20 cm height, T_1 (NPK + NSP + GSL) produced maximum girth (173.77 cm) as compared to all other treatments. The study indicated that the stem girth at 1.5 m was non-significant in T_1, T_2 (NPK+ NSP), T_3 (NPK+GSL), T_5 (NPK), T_6 (GSL) and T_7 (NSP). Moreover, non-significant differences were also found in T_2 to T_5 and T_8 (Control). However, the stem girth at 1.5 m was significantly ($p<0.05$) high in T_1, T_6 and T_7 as compared to T_4 (NSP + GSL**)** and T_8. The results of the present study based on the stem girth at 20 cm height T_1 produced maximum girth (173.77cm) as compared to all other treatments. However, the stem girth at 1.5 m was significantly ($p<0.05$) high in T_1, T_6 and T_7 as compared to T_4 (NSP + GSL) and T_8**.** Secretaria and Maravilla (1997) found that the application of the recommended rates of inorganic fertilizers and goat manure during the early stages of coconut growth significantly improved the vegetative growth characters of the palms. Santos (1990), however, reported that the morphological characters recorded in the field should be highly heritable, not influenced by age and easy to record with sufficient precision. The enlargement of stem base in some palm species is partially due to the growth of root system that a forced out the tissues at the stem base (Tomlison, 1961). An advantage of stem base enlargement is that it offers additional stability in regions subjected to storms, storming winds and hurricanes. Tomlison (1964) identified that the simple descriptive morphology requires no expensive facilities, although it may require a wealth of plant material.

The 11 leaf scars length (80.44 cm) was significantly ($p<0.05$) highest in T_1 as compared to T_3 to T_8 treatments. The results showed that the 11 leaf scar length was significantly ($p<0.05$) high in T_2 as compared to T_4 to T_8. This study reveals that the number of leaves (28.77) was significantly ($p<0.05$) greater in T_1 as compared to T_5 to T_8 treatments. The results also showed that the number of leaves were significantly ($p<0.05$) high in T_2, T_3 and T_4 as compared to T_8 treatment, whereas non-significant result were recorded in T_2 to T_7 treatments.

The results showed that the 11 leaf scar length was significantly ($p<0.05$) high in T_1 andT_2 as compared to T_4 to T_8. This study reveals that number of leaves (28.77) were significantly ($p< 0.05$) greater in T_1 as compared to T_5 to T_8 treatments. The results also showed that the number of leaves were significantly ($p<0.05$) high in T_2, T_3 and T_4 as compared to T_8 treatment. An advantage of stem base enlargement is that it offers additional stability in regions subjected to storms, storming winds and hurricanes. The production of leaves in coconut is slow during the first year, increases up to the early bearing stage and then remains steady until senescence when the rate decline. This is influenced by variety, soil fertility, seasonal conditions and management practices. The investigations indicated that the optimum number of leaves for maintenance of productivity is about eighteen (Magat, (1996).

The effects of organic and inorganic amendments on Petiole length (139.44 cm) of coconut were found significantly ($p<0.05$) highest in T_1 as compared to T_6 and T_8 (Table 2). Similarly, the petiole width also showed non-significant differences in all treatments. In case of petiole thickness it was significantly ($p<0.05$) highest (3.27cm) in T_1 as compared to T_8, whereas non-significant differences were found in T_1 to T_7.

The effects of organic and inorganic amendments on rachis length, leaflets length, leaflets width and number of leaflets of coconut were recorded (Table 3). The results showed that the rachis length was not significantly affected among all the treatments. Leaflets length was

Table 3. Effects of organic and inorganic amendments on petiole length, petiole width petiole thickness of coconut (*Cocos nucifera* L.)

Treatments	Petiole length (cm)	Petiole width (cm)	Petiole thickness (cm)
T_1 (NPK + NSP + GSL)	*139.44±2.18 a	7.37 ± 0.35 a	3.27 ± 0.20 a
T_2 (NPK + NSP)	138.33±2.02 ab	7.13 ± 0.26 a	3.18 ± 0.16 a
T_3 (NPK + GSL)	134.88±3.04 abc	7.01 ± 0.26 a	3.06 ± 0.13 a
T_4 (NSP +GSL)	134.55±1.27 abc	6.94 ± 0.27 a	3.11 ± 0.22 a
T_5 (NPK)	138.88±2.68 ab	7.21 ± 0.26 a	3.16 ± 0.12 a
T_6 (GSL)	132.66±2.36 bc	6.92 ± 0.26 a	3.12 ± 0.17 a
T_7 (NSP)	134.00±2.70 abc	6.92 ± 0.20 a	2.92 ± 0.27 ab
T_8 (Control)	131.33±1.04 c	6.88 ± 0.25 a	2.41 ± 0.27 b
LSDp < 0.05	5.71	0.76	0.58

Statistical significance determined by analysis of variance. Numbers followed by the same letters in the same column are not significantly ($p<0.05$) different, according to Duncan's Multiple Range Test. *Mean ± Standard Error. LSD (Least Significant Difference).

Table 4. Effects of organic and inorganic amendments on rachis length, leaflet length leaflet width and number of leaflets of coconut (*Cocos nucifera* L.)

Treatments	Rachis length (cm)	Leaflet length (cm)	Leaflet width (cm)	Number of leaflets
T_1 (NPK + NSP + GSL)	*487.00 ± 12.30 a	116.22 ± 1.30 a	5.04 ± 0.08 a	128.33 ± 2.09 a
T_2 (NPK + NSP)	470.88 ± 10.58 a	115.77 ± 1.93 a	4.40 ± 0.10 b	123.22 ± 4.08 a
T_3 (NPK + GSL)	456.00 ± 14.50 a	108.11 ± 2.78 b	4.47 ± 0.15 b	113.11 ± 5.15 b
T_4 (NSP +GSL)	460.77 ± 13.80 a	107.00 ± 3.01 bc	4.32 ± 0.14 b	107.33 ± 2.10 bcd
T_5 (NPK)	462.88 ± 17.50 a	103.22 ± 2.19 bcd	4.19 ± 0.14 b	110.55 ± 2.17 bc
T_6 (GSL)	455.11 ± 11.43 a	104.66 ± 3.83 bcd	4.22 ± 0.24 b	100.44 ± 2.85 d
T_7 (NSP)	463.00 ± 12.06 a	99.77 ± 2.26 cd	4.39 ± 0.13 b	101.88 ± 2.59 cd
T_8 (Control)	460.55 ± 13.82 a	98.00 ± 3.55 d	4.16 ± 0.09 b	100.88 ± 2.54 d
LSDp < 0.05	37.89	7.48	0.41	8.83

Statistical significance determined by analysis of variance. Numbers followed by the same letters in the same column are not significantly ($p<0.05$) different, according to Duncan's Multiple Range Test. *Mean ± Standard Error. LSD (Least Significant Difference).

significantly ($p<0.05$) high in T_1 and T_2 as compared to rest of the treatments. T_3 treatment was significantly ($p<0.05$) high as compared to T_7 and T_8. The leaflets width (5.04cm) was significantly ($p<0.05$) high in T_1 as compared to rest of the treatments. Moreover, non-significant differences were recorded in T_2 to T_8 treatments. The number of leaflets was significantly ($p<0.05$) highest in T_1 and T_2 as compared to all other treatments. Similarly, T_3 showed significantly ($p<0.05$) high number of leaflets as compared to T_6, T_7 and T_8. The number of leaflets were also significantly ($p<0.05$) high in T_5 as compared to T_6 and T_8 treatments.

The coconut palm can adapt to a wide range of soil types. Although coarse sand is its natural habitat, best growth is obtained on deep soils with good physical structure and chemical properties. The need to apply phosphorus is also inevitable recognizing that almost 90% of soils in Pakistan are deficient in phosphorus at different severity levels (Alam *et al*.1994). A chemical balance of inorganic elements in living organisms is a basic condition for their proper growth and development (Markert, 1990). Blair *et al.* (2006) reported the application of farmyard manure to soil has been practiced for many centuries and its application to soil has increased crop yield, improved soil fertility, increased soil organic matter, increased microbiological activities and improved soil structure for sustainable agriculture. Bonneau *et al.* (1993) indicated that growth and fruit set increased significantly when the standard N fertilizer rate was double and were greater with P and K at standard rates than with no fertilizer.

Long term studies in many cropping systems have clearly indicated that, neither chemical fertilizer nor organic sources of nutrient alone could sustain high productivity of intensive cropping systems. Nevertheless integrated use of fertilizers and inorganic sources have helped in maintaining yield stability through correlation of marginal deficiencies of secondary and micronutrients, enhancing the efficiency of applied nutrients and providing the favorable soil physical environment.

The effects of organic and inorganic amendments on Petiole length (139.44 cm) of coconut were found significantly ($p<0.05$) highest in T_1 as compared to T_6 and T_8 treatments. In case of petiole thickness it was significantly ($p<0.05$) highest (3.27cm) in T_1 as compared to T_8, whereas non-significant differences were found in T_1 to T_7. Morphometric characterization revealed that substantial variation were existing in stem base, crown shapes, petiole, young inflorescence and weight size of nut as well as types of treatments. Heterogeneous characters of the parents could have contributed to the observed variation (Foale, 1992). Moreover, the petiole, which extends to form the rachis, which bears leaflets on both sides, numbers about 200 to 230 in both sides.

Result showed that the Leaflets length was significantly ($p<0.05$) high in T_1 and T_2 as compared to the rest of the treatments, whereas T_3 was significantly ($p<0.05$) high as compared to T_7 and T_8. The leaflets width (5.04 cm) was significantly ($p<0.05$) high in T_1 as compared to the rest of the treatments. The number of leaflets was significantly ($p<0.05$) highest in T_1 and T_2 as compared to all other treatments. The number of leaflets were also significantly ($p<0.05$) high in T_5 as compared to T_6 and T_8 treatments. Amalu (1999) investigated that the growth performance was generally poor in the un-fertilized palms compared to combined application of 4.41kg ammonium sulfate/palm/ year plus 2.52kg KCl/palm/year which resulted in the best growth over 21 months. The results confirmed the finding of Mohandas, 2012. Nadheesha and Tennakoon, 2008 who reported that for a healthy growth and sustainable coconut production, nutrients must be available in correct quantities, proportion and in an uptakable form at the right time. Cecil and Khan, (1993) observed that in general the effect of N on vegetative growth of young palms was maximum, followed by K, whereas P showed favorable interaction with N and K. Emmanuel, (2002) and Uddin, (2003) who reported moderate diversity in vegetative characters of coconut populations. Selection

based on these characters might be of immense value in coconut improvement programs.

Conclusion

The cultivation of the coconut palm recently received considerable attention in many countries where it is grown. The maintenance of soil organic matter is important for the long term productivity of agro ecosystems. The benefits of balanced fertilization using crop residues, organic manures and green manuring in maintaining the levels of organic matter in agricultural soils have been increasingly emphasized. The soil amendment has value as a fertilizer and as a systemic pesticide.

In this investigation, it is concluded that the soil of coastal areas is sandy loam and low in macro and micro nutrients especially on the Karachi Coast. The application of organic amended with inorganic fertilizers, enhanced the growth of morphological characters in nutrient deficient soils. It is therefore, recommended that treatment T_1 {NPK (1.0:0.5:1.0kg) + NSP (10.0kg) + GSL (20.0kg)}/palm/year was enough to improve the morphological characters specially the maximum number of leaves for high productivity, better income to coconut farmers and also economical.

References

Agyrko K, Kwakye P K, Bonus M, Osei B A. 2006. Impact of application of neem leaves and poultry manure on nutrient dynamics of a Haplic Acrisol. *Archives of Agronomy and Soil Science,* 52: 687-695

Alam S.M, Latif A. and Iqbal Z. 1994. Phosphorus –Zinc interaction in wheat and maize crops. Proc. 4th National Congress of Soil Science, Islamabad.239-243.

Amalu UC. 1999. Effects of nitrogen and potassium fertilizers on vegetative growth of young coconut palm trees. *Global Journal of Pure Applied Science,* 5(2):152-158.

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

Bonneau X, Ochs R, Qusairi L. and Lubis LN. 1993. Hybrid coconut mineral nutrition on peat from the nursery to the start of production. *Oleagineux,* 48(1): 9-26.

Carpio CB, Santos G A, Emmanuel EE. and Novarianto H. 2005. Research on coconut genetic resources in South East and East Asia. Coconut Genetic Resources International Plant Genetic Resources Institute-Regional office for Asia, the Pacific and Oceania (IPGRI-APO), Serdange, Selangor DE, Malaysia. 533-545.

Cecil SR. and Khan HH. 1993. Nutritional requirements of crops and pastures. *Journal of Agriculture Meteorology,* 48: 775-778.

Emmanuel E E. 2002. Morphometric traits and DNA Profiles of three generations of selected coconut genotypes. MS Thesis, UPLB, Philippine. 98.

FAOSTAT. 2014. Food and Agricultural Organization of the United Nations-Statistics. Retrieved January, 2015 from [http://faostat3.fao.org].

FAOSTAT. 2008. Food and Agriculture Organization of the United Nations. Economic and Social Department: The Statistical Division.

FAO (Food and Agriculture Organization). 1980. Soil and plant testing as a basis for fertilizer recommendations. Food and Agriculture Organization of the United Nations. Food and Agriculture Organization. FAO *Soils Bulletin*, 38 / 2.

Foale MA. 2003. The coconut Odyssey: The bounteous possibilities of the Tree of life. ACIAR, Monograph No.101, Canberra, Australia.132.

Foale MA. 1992. Coconut genetic diversity present knowledge and future research needs. International Board of Plant

Genetic Resources (IBPGR), Rome, Italy. 46- 66.

Ghosh A. and Sharma A R. 1999. Effect of combined use of organic manure and fertilizer on the performance of rice under flood-prone lowland conditions. *Journal of Agricultural Sciences*, 23(4): 461-465.

Gomez K A. and Gomez AA. 1984. Statistics of agricultural research (2nd edition), John Willy and Sons, New York. 680.

Gupta PK. 2003. Soil, plant, water and fertilizer analysis. Agrobios, New Delhi, India.186.

Harries HC. 1978. The Evolution Dissemination and Classification of Coconut. In.: The Botanical Review, 44 (3): 256-319.

Hussian T, Jillani G. and Iqbal M Z. 1988. Integrated use of organic and inorganic fertilizer in rice- wheat cropping system, *Pakistan Journal of Soil Science,* 3: 19-23.

ICAR (Indian Council of Agricultural Research). 2004. *Hand book of agriculture*. New Delhi, India. 908.

IPGRI (International Plant Genetic Resources Institute). 1995. Descriptors for coconut. International Plant Genetic Resources Institute, Rome, Italy.17-29.

Iqbal M Z, Ajaz S. and Shafiq M. 2001. Effects of saline conditions on germination of perennial salt bush and Mung bean. *Pakistan Journal of Agriculture agricultural Engineering and Veterinary Science*, 17(1-2): 24-27.

Khan A, Jan M.T, Marwat K.B. and Arif M. 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.

Leal EC, Santos ZG dos, Warwick R.A.M.C, Leal D.R.N, Das ML. and Renard JL. 1994. Effect of mineral nutrition on Lixas incidence in coconut. *Oleagineux,* 49(5): 213-220.

Magat S.S. 1996. Field notes on an update of coconut fertilizer use efficiency and productivity of SCFDP Farms. *Philippines Journal of Coconut Studies*, 19(1): 14-24.

Maheswarappa H.P, Nanjappa H.V. and Hegde M. R. 1998. Effect of sett size, plant population and organic manure's on growth component of arrow root grown as inter-crop in coconut garden. *Mysore Journal of Agricultural Science,* 32(4): 257-263.

Marimuthu R, Athmanathan U, Mohandas S. and Mohan S. 2001.Integrated nutrient management for coconut. *South Indian Horticulture,* 49: 145-148.

Markert B. 1990. Elements Constructions Cadsters in Ecosystems. V.C.H Federal Republic of Germany.448.

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 Tennakoon A. 2008. Removal of micronutrients from high and moderate yielding coconut plantation in Sri Lanka. In. Proc. of 2nd. Symp. on Plantation. Crop Res., Sri Lanka. 164-169.

Nair A. K. and Nair S.A. 2006. Influence of farm yard manure and nutrients on ridge and sponge gourd yield inter-cropped with coconut palm in south Andaman. *International Journal of Agriculture Science*, 2(1): 284-285.

Nath J. C, Chowdhary D. and Deka K.K. 2003. Nutritional requirement of COD x WCT Hybrid coconut in alluvial clay - loam soil of Asam. *Journal of Plantation Crops*, 31(2): 37-40.

Perera SA.C.N, Ekanayake G.K. and Herath, H.M.N.B. 2015. An investigation of the tender nut potential of diverse coconut (*Coco nucifera* L.) varieties / forms in Sri Lanka. CORD, 31(1):39-45.

Santos GA, Batugal P.A, Othman L, Baudouin L. and J. P. Labouisse. 1996. Manual on standardized research techniques in

coconut breeding. IPGRI-COGENT, Singapore, 6-46.

Secretaria M.I. and Maravilla J.N. 1997. Response of hybrid coconut palm to application of manures and fertilizers from field planting to full-bearing stage. *Plantations, Recherche & Développement*, 4(2): 126-138.

Solangi AH, Iqbal M. Z. and Shafiq M. 2014. Effect of Organic and Inorganic Fertilizers Amendments on Inflorescence and flower Morphology and Yield of Coconut (*Cocos nucifera* L.). CORD, 3(2):10-18.

Solangi AH. 2013. Thesis entitled "Determination of Morphological Diversity and Yield of Coconut (*Cocos nucifera* L.) by Organic and Inorganic Fertilizers Amendments". Department of Botany, University of Karachi, Karachi-75270, Pakistan, for the Degree of Doctor of Philosophy (Ph. D) in Botany.

Solangi AH. and Iqbal M Z. 2012. Preliminary studies on morphological diversity of coconut seedlings by organic and inorganic fertilizers amendments at Karachi, Pakistan. *Pakistan Journal of Botany*, 44(1): 161-164.

Solangi A H. 2001. Characterization of Twenty Coconut (*Cocos nucifera* L.) varieties based on leaf Morpho-Physiological markers. MS Thesis, University of Philippine, Los Banos, Philippines.28-34.

Steel R G.D, Torrie J H. and Dickey D. 1996. *Principles and procedures of Statistics*. A Biometrical approach, 3rd edn. McGraw Hill Book Co. Inc. Singapore.34.

Subramanian P, Dhanapal R, Sanil P, Palaniswami C, Sairam C.V. and Matheswarappa H.P. 2005. *Gliricidia* as green manure in improving soil fertility and productivity of coconut under coastal littoral sandy soil. *Journal of Plantation Crops*, 33(3): 179-183.

Tennakoon N A. and Bandara S.D.H. 2003. Nutrient content of some locally available organic material as alternative sources of nutrients for coconut. *Cocos,* 15(10): 23-30.

Tennakoon N A. 1990. Goat manure as a soil ameliorant and yield "stimulant" in Coconut. *Cocos*, 8: 26-32.

Tennakoon N A. 1988. Organic manure for crop production. *Coconut Bulletin*, 5(2): 13-14.

Tomlison P B. 1964. The vascular skeleton of coconut leaf base. *Phytomorphology*, 14 (2): 218-230.

Tomlison P B. 1961. Palmae, in Mercalfe C. (ed.) Anatomy of the Monocotyledons. Oxford University Press.2: 453.

Uddin M S. 2003. Genetic diversity and on-farm conservation of coconut in Northern Luzon, Philippines. MS Thesis, University of Philippines Los Banos, Laguna, Philippines. 137.