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Effect of Organic and Inorganic Fertilizers Amendments on Inflorescence and Flower Morphology and Yield of Coconut (*Cocos nucifera* L.)

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Abstract

A study was conducted at the Plant Introduction Center (PIC), Southern Agricultural Research Center (SARC), Pakistan Agricultural Research Council (PARC), Karachi for the effect of Organic {Neem Seed Powder (NSP) and *Gliricidia sepium* leaves (GSL)} and Inorganic {(Urea (N), Di-ammonium phosphate (P) and Murait of potash (K), (NPK)} Fertilizers Amendments on Inflorescence and flower Morphology and Yield of Coconut. The experiment consist of eight treatments namely; T_1 (NPK + NSP + GSL), T_2 (NPK+ NSP), T_3 (NPK+ GSL), T_4 (NSP + GSL), T_5 (NPK), T_6 (GSL), T_7 (NSP), T_8 control without treatments. The experiment was laid down as Complete Randomized Block Design replicated three times. The results demonstrated that the number of spikelets with female flowers were significantly high in T_1 to T_7 as compared to T_8 treatment. The 1st spikelets with number of female flowers (48.97) were significantly ($p<0.05$) high in T_1 as compared to T_2, T_3, T_4 and T_8. In case of stalk length (38.05 cm) it was significantly ($p<0.05$) high in T_1 as compared to T_8. The findings of the study indicated that the number of nuts (99.33) and fruit weight (1490.77 g) were significantly ($p<0.05$) highest in T_1 as compared to T_3 to T_8 and T_2 to T_8 treatments, respectively. The T_1 treatment also showed better fruit length (25.75 cm), fruit breadth (42.97 cm), husk weight (448.66 g), shell weight (278.11 g), kernel weight (434.22 g) and nut water (188.77 ml) with significant differences in some of the treatments. The application of organic amended with inorganic fertilizers, enhanced the growth and nut production in nutrient deficient soils. It is therefore, recommended that treatment T_1 {NPK+NSP+GSL)}/palm/year was enough to improve the morphological, inflorescence, flower morphology, high nut production, better income to coconut farmers, economical and beneficial for conservation of coconut genetic resources in coastal area of Pakistan.

Keywords: Neem Seed Powder, *Gliricidia sepium* leaves, Growth, nut production, Coconut

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Introduction

Coconut, (*Cocos nucifera* L.) is grown in nearly 90 countries existence along the tropical belt. There are about 10 million families rely on coconuts as their main source of food and income. 11.9 million hectares of coconut are grown in the world, eight million hectares, or about 70% is in South East and East Asia (Harries, 1978; Carpio et al., 2005). The coconut is a perennial oil crop, rich in lauric acid and is one of the most important food and cash crop grown in the world. It is widely adapted to the environments and climatic conditions of many producing countries, notably occupying over 20% of the available arable land in most of these countries (Magat, 1996).

The Pakistan coast is an ecologically virgin area and has varied agroecological conditions suitable to grow various crop commodities. The area near the sea coast has a tropical climate and a number of tropical fruit plants are grown including coconut (Laghari and Solangi, 2005). Among the plantation crops of tropical humid areas, coconut occupies an important position in view of the commercial value of its oil on the international market. Coconut tree crop grows well in warm humid weather with an estimated 120 sunshine hours monthly (Murray, 1977). The ideal temperature is around 27 °C with a diurnal variation of 5 °C to 10 °C. Coconut is found in places where the annual precipitation is between 1300 and 2500 mm or above. An average monthly rainfall of 150 mm is ideal for good growth and high nut yield. A prolonged dry spell lasting from five to seven months adversely affects the palms (Rajagopal et al., 1990). Coconut is a cross - pollinated perennial crop and specially propagated through seeds. The coconut seed takes a long time before it attains a stable level of production. Proper selection and planting of good quality seed nuts must be done to ensure a productive plantation (Magat, 1999). Coconut is found to grow well between 20^0 North and South of the equator. Banzon and Velasco, (1982) stated that rainfall has been used as a guide on the suitability of locations for coconut production. The ideal mean rainfall is 150 mm per month or 1800 mm/year. 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). The coconut palm prefers certain climatic conditions and for its commercial viability climatic factors such as rainfall distribution, altitude, period of drought has to be given serious considerations, whereas the ecological factors are strongly interrelated one finds difficult to classify their influence on the performance of coconuts according to their importance (Karunanayake, 1996).

The coconut tree is known as the tree of life because of its range of environmentally sustainable uses (Foale, 2003). The uses and value of coconut palm to farmers are far greater than Kernel (copra) and oil. The wood or the trunk is used in the building of houses, bridges, cattle sheds and aqueducts (Channel). The root contains drug, recommended against diarrhea. The dry leaves are used for thatching baskets, hats, mats, and curtains. The petioles and midribs of the dry leaves are used for canes, brush, needles, pins, and fishhooks. The flowers opened inflorescences when cut, yield a liquid called toddy from which palm wine is prepared. About 70 percent of the female flowers a coconut palm produced are shed or lost. These buttons contain 10 to 12 percent tannins. The coconut water contains growth promoting substance, some ascorbic acid, protein, and carbohydrates. The fibrous husk yields important fiber called coir. Coir dust is used as insulating materials and for the reclamation of low-lying areas (Nathanael, 1961; Von- Uexhull, 1971). Balakrishna, (1975) studied that all the inorganic and organic fertilizers mixture treatments have consistent and significant effects on the yield. The non responsiveness to fertilization of seedlings in the early nursery stages could be due to the already sufficient levels of nutrients available while they were still in the endosperm stage. Inorganic and organic fertilizers, nevertheless, differ in the availability of mineral plant nutrient they contain. Nutrients in inorganic fertilizers are directly available to plant roots provided water or soil moisture ionized the fertilizers, whereas the nutrients of organic materials, particularly organic N are low availability.

The identification of specific characters in coconut which may contribute to its increased yield, adaptation to specific environment and production of products preferred by the consumers should be prioritized (Foale, 1992). Studies on coconut for morphological descriptions such as color, size and shape of the fruit, robustness of the trunk, and crown size carried out (Child, 1964; Ohler, 1984). Relation between leaf length and yield in coconut indicated that a palm with longer leaves and more leaflets per leaf would show higher yield (Abeywardena, 1976). Jayalekshmy and Rangasamy (2002) studied characters included both vegetative, inflorescence and fruit characters. Ratnambal et al., (2005) noticed that the popular cultivars known across the world (West Coast Tall, Tiptur Tall (both from India), West African Tall, Philippines Ordinary Tall and Sri Lanka Tall) have many fruit characters in common. In other words, in most of the coconut growing countries, the cultivators considered the fruit type of these cultivars as the ideal. The indigenous collections also exhibited enormous variability. The correlation among the fruit characters was attributed to three causative factor's, the first one related to weight measurements, second is for nut-constituents and third for the husk. The important characters that cause divergence as obtained from the canonical analysis were weight of fruit, length of fruit, volume of cavity, weight of shell and percentage of husk to fruit weight. The aim of the present research is to investigate the effect of organic and inorganic amendments on morphological diversity and yield of adult coconut along with comparative performance of different organic and inorganic soil amendments on the coconut nut production and to find out the suitable and economical dose of fertilizers for coconut palm.

Materials and methods

Selection of experimental site

A four years (2007 to 2010) study was conducted 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 26 ft above sea level) of Pakistan. The climate of Karachi is subtropical maritime desert (Chaudhry, 1961). Climatically, the study area 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^o N and 27^o S) but within these ranges the altitude higher than 600 m above sea level is some what the maximum limit for optimum coconut growth. The average temperature 33-35 °C and Yearly relative humidity was 80% of the past six years (2005 to 2010) (PMD, 2011). The physio-chemical properties of the soil was analyzed prior to the trial and the result showed mean amount of 0.78 EC (ds/m), 34.00% $CaCO_3$, 0.34 MO%,0.012ppm N, 12.72ppm P, 79.0ppm K . The soil was sandy loam alkaline with pH 8.47.

Inflorescence and flower Morphology

The experiment was conducted to study the effect of organic and inorganic amendments on the adult palms at PIC, Karachi. For each treatment, three coconut palms were selected randomly from the experimental plots and each treatment was carried out in three replicates. Thus, in the whole study 72 adult coconut palms were characterized by the method of IPGRI (International Plant Genetic Resource Institute), (1995) and Santos, (2001).

The inflorescence length, number of spikelets, number of spikelets with female flowers, 1^{st} spikelet with number of female flowers and stalk length were measured. The stalk length is the distance between the point where the bunch is attached to the palm and the base of the first spikelet. The coconut fruit set and developed to maturity in about 12 months and yield is usually estimated in terms of the number of nuts produced per palm. The nut production of coconut (No. of nuts), fruit weight, fruit length, fruit breadth, husk weight, shell weight, kernel (meat) weight and quantity of nut water was recorded as described by Santos**,** (2001) and BI (Bioversity International), (2007).

Organic and Inorganic Fertilizers

The detail of amendments included Urea, Di-ammonium phosphate and Muriate of potash (NPK) in combination with Neem seed powder (NSP) and *Gliricidia sepium* leaves (GSL) at different levels is given below:-

Treatment	Ingredients used	Applied twice in a year for four years
T_1	Urea (N), Di-ammonium phosphate (P), Murait of potash (K), (NPK) + Neem Seed Powder (NSP) + *Gliricidia sepium* leaves (GSL)	1.0: 0.5: 1.0 kg + 10.0 kg + 20.0 kg/palm
T_2	NPK + NSP	1.0: 0.5:1.0 kg + 10.0 kg/palm
T_3	NPK + GSL	1.0: 0.5: 1.0 kg + 20 kg/palm
T_4	NSP + GSL	10.0 + 20.0 kg/palm
T_5	NPK	1.0: 0.5: 1.0 kg/palm
T_6	GSL	20.0 kg/palm
T_7	NSP	10.0 kg/palm
T_8	Untreated (Control)	Nil

Statistical Analysis

The experiments of organic and inorganic amendments were laid out in a Completely Randomized Block Design (CRBD). All the data were statistically analyzed by the analysis of variance (ANOVA) (Gomez and Gomez, 1984) and Duncan Multiple Range Test (DMRT**)** (Duncan, 1955 and Zar, 2010).

Results

The effects of organic and inorganic amendments on inflorescence length and total number of spikelets were non significant in all the treatments observed (Table 1). The results of the present investigations also revealed that the number of spikelets with female flowers were significantly ($p<0.05$) high in T_1 to T_7 as compared to T_8 treatment. The 1st spikelet with number of female flowers were significantly ($p<0.05$) high in T_1 as compared to T_2, T_3, T_4 and T_8, whereas non significant differences were recorded in T_2 to T_8. In case of stalk length, it was significantly ($p<0.05$) high in T_1 as compared to T_8. Moreover, no significant differences were found in T_2 to T_8 treatments.

The nut production of coconut was affected significantly ($p<0.05$) by the application of organic and inorganic amendments (Table 2). The findings of the study indicated that the number of nuts were significantly ($p<0.05$) higher in T_1 and T_2 as compared to rest of the treatments, whereas T_3, T_4 and T_5 treatments showed significantly ($p<0.05$) high number of nuts as compared to T_6, T_7 and T_8 treatments. Similarly, the number of nuts were significantly ($p<0.05$) high in T_6 as compared to T_7 and T_8 treatments. The fruit weight was significantly ($p<0.05$) high in T_1 as compared to rest of the treatments. The treatments T_2 to T_7 showed significantly ($p<0.05$) high yield as compared to T_8. The fruit length was significantly ($p<0.05$) high in T_1 as compared to T_4, whereas non significant results were found in T_2 to T_8 treatments. The fruit breadth was significantly ($p<0.05$) high in T_1 as compared to T_4, T_6 and T_7. Moreover, non significant differences were found in T_2 to T_8 treatments. The present study also reveals that husk weight of coconut was significantly ($p<0.05$) high in T_1, T_3 and T_4 as compared to T_6, T_7 and T_8. Similarly, the husk weight was found significantly ($p<0.05$) high in T_2 as compared to T_7. Moreover, non significant differences were found in T_1 to T_5 treatments. The husk weight was also found non significant in T_5 to T_8 treatments.

The effect of organic and inorganic amendments on shell weight was significantly ($p<0.05$) high (278.11 g) in T_1 as compared to T_7 and T_8 treatments whereas, no significant difference was recorded in T_1 to T_6 (Table 3). Moreover, non significant differences were found in T_2 to T_8 treatments. The results indicated that, the kernel weight was significantly ($p<0.05$) high in T_1 and T_2 as compared to T_6 to T_8 treatments, whereas non significant differences were found in T_3 to T_8 treatments.

The present study also reveals that the quantity of nut water (188.77 ml) was significantly ($p<0.05$) high in T_1 as compared to rest of the treatments. Moreover, non significant

Table 1. Effects of organic and inorganic amendments on inflorescence length, total no. number of spikelets, No. of spikelets with female flowers, 1st spikelet with No. of female flowers and stalk length of coconut (*Cocos nucifera* L.)

Treatments	Inflorescence Length (cm)	Total No. of spikelets	No. of spikelets with female flowers	1st spikelet with No. of female flowers	Stalk length (cm)
T_1 (NPK + NSP + GSL)	*40.38 ± 1.58a	45.22 ± 1.85 a	35.66 ± 1.84 a	48.97 ± 0.69 a	38.05 ± 1.55 a
T_2 (NPK + NSP)	35.33 ± 1.64 a	41.22 ± 1.91 a	30.77 ± 1.79 a	43.74 ± 1.32 b	36.03 ± 1.35 ab
T_3 (NPK + GSL)	37.11 ± 1.62 a	41.66 ± 2.06 a	34.11 ± 1.57 a	44.17 ± 1.08 b	33.54 ± 2.33 ab
T_4 (NSP +GSL)	37.93 ± 1.20 a	43.22 ± 1.87 a	30.55 ± 2.14 a	44.01 ± 2.42 b	34.07 ± 2.29 ab
T_5 (NPK)	39.12 ± 1.31 a	40.77 ± 1.54 a	32.44 ± 1.69 a	46.90 ± 1.61 ab	36.24 ± 1.56 ab
T_6 (GSL)	36.23 ± 1.91 a	42.11 ± 2.16 a	31.11 ± 1.71 a	46.88 ± 1.78 ab	34.98 ± 1.32 ab
T_7 (NSP)	38.12 ± 2.00 a	43.33 ± 1.76 a	32.33 ± 1.33 a	45.76 ± 1.65 ab	35.31 ± 1.67 ab
T_8 (Control)	35.77 ± 1.00 a	41.22 ± 1.36 a	25.33 ± 1.50 b	42.46 ± 0.95 b	31.38 ± 1.52 b
LSDp<0.05	4.45	5.18	4.84	4.31	5.11

Symbol used: NPK (Nitrogen-Phosphorus-Potassium), NSP (Neem Seed Powder), GSL (*Gliricidia sepium* leaves). 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 2. Effects of organic and inorganic amendments on number of nuts, fruit weight, fruit length, fruit breadth and husk weight of coconut (*Cocos nucifera* L.)

Treatments	Number of nuts	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Husk weight (g)
T_1 (NPK + NSP + GSL)	*99.33 ± 0.84 a	1490.77 ± 40.33 a	25.75 ± 1.40 a	42.97 ± 1.58 a	448.66 ± 21.53 a
T_2 (NPK + NSP)	97.77 ± 0.82 a	1345.00 ± 39.69 b	24.02 ± 0.96 ab	40.07 ± 0.95 ab	421.11 ± 35.19 ab
T_3 (NPK + GSL)	89.44 ± 2.18 b	1328.77 ± 31.08 b	23.45 ± 1.39 ab	40.61 ± 0.86 ab	440.00 ± 17.4 a
T_4 (NSP +GSL)	88.33 ± 0.74 b	1309.22 ± 37.22 b	23.64 ± 1.15 b	39.61 ± 0.63 b	437.22 ± 9.79 a
T_5 (NPK)	87.77 ± 1.16 b	1254.00 ± 34.76 b	23.54 ± 0.86 ab	40.52 ± 0.63 ab	398.22 ± 12.89 abc
T_6 (GSL)	76.33 ± 2.00 c	1303.00 ± 32.99 b	24.46 ± 0.21 ab	39.47 ± 1.11 b	364.44 ± 13.70 bc
T_7 (NSP)	66.88 ± 1.17 d	1306.11 ± 51.79 b	22.73 ± 0.71 ab	38.73 ± 0.82 b	356.44 ± 18.92 c
T_8 (Control)	65.00 ± 1.50 d	1137.88 ± 45.35 c	22.44 ± 0.81 ab	39.88 ± 1.01 ab	364.11 ± 11.60 bc
LSDp<0.05	3.67	113.08	3.81	2.81	54.22

Symbol used: NPK (Nitrogen-Phosphorus-Potassium), NSP (Neem Seed Powder), GSL (*Gliricidia sepium* leaves). 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 Sgnificant Difference).

Table 3. Effects of organic and inorganic amendments on shell weight, kernel weight and quantity of nut water of coconut (*Cocos nucifera* L.)

Treatments	Shell weight (g)	Kernel weight (g)	Quantity of nut water (ml)
T_1 (NPK + NSP + GSL)	*278.11 ± 05.56 a	434.22 ± 13.75 a	188.77 ± 6.27 a
T_2 (NPK + NSP)	247.44 ± 09.35 ab	416.66 ± 12.67 a	170.33 ± 5.44 b
T_3 (NPK + GSL)	260.66 ± 10.75 ab	411.77 ± 15.17 ab	168.88 ± 10.93 b
T_4 (NSP +GSL)	247.33 ± 09.43 ab	389.22 ± 17.69 ab	156.88 ± 13.13 b
T_5 (NPK)	243.66 ± 15.12 ab	390.11 ± 15.11 ab	157.88 ± 18.99 b
T_6 (GSL)	244.77 ± 13.06 ab	365.55 ± 17. 84 b	154.66 ± 5.88 bc
T_7 (NSP)	242.77 ± 10.10 b	368.22 ± 11. 98 b	137.77 ± 4.00 cd
T_8 (Control)	241.44 ± 11.09 b	366.55 ± 12.70 b	134.55 ± 3.21 d
LSDp<0.05	30.75	41.75	17.79

Symbol used: NPK (Nitrogen-Phosphorus-Potassium), NSP (Neem Seed Powder), GSL (*Gliricidia sepium* leaves).Statistical significance determined by analysis of variance. Numbers followed by the same letters in the same column arenot significantly ($p<0.05$) different, according to Duncan's Multiple Range Test. *Mean ± Standard Error. LSD (Least Significant Difference).

differences were found in T_2 to T_6 treatments. The quantity of nut water was also significantly ($p<0.05$) high in T_6 as compared to T_8 treatment, whereas, non significant results were found in T_7 and T_8 treatments.

Discussion

The effects of organic and inorganic amendments on inflorescence length and total number of spikelets were non significant in all the treatments. The number of spikelets with female flowers were significantly ($p<0.05$) high in T_1 to T_7 as compared to T_8 treatment. The 1st spikelet with number of female flowers were significantly ($p<0.05$) high in T_1 as compared to T_2, T_3, T_4 and T_8, whereas non significant differences were recorded in T_2 to T_8. In case of stalk length, it was significantly ($p<0.05$) high in T_1 as compared to T_8. Moreover, no significant differences were found in T_2 to T_8 treatments. The results confirmed with the findings of Emmanual, (2002) and Uddin, (2003) who reported moderate diversity in vegetative characters of coconut populations. Selection based on these morphological characters might be immense value in the coconut improvement program.

The findings of the study indicated that the number of nuts were significantly ($p<0.05$) higher in T_1 and T_2 as compared to rest of the treatments, whereas T_3, T_4 and T_5 treatments showed significantly ($p<0.05$) high number of nuts as compared to T_6, T_7 and T_8 treatments. Kalpana et al., (2006) also studied the effect of two integrated nutrients treatments, 50% organics + inorganics 50% and 100% organics on yield, soil and plant nutrient status in coconut based cropping system and observed that the highest nut yields/palm/year (113) was recorded in the first treatment as compared to only 89 nuts/palm/year in second treatment. According to Longanathan (1977) investigated that the fertilizer is the most important and costly input to enhance crop yield. There is no doubt that fertilizers play a very active role in increasing

crop yield. Systematic manuring with balanced fertilizer mixtures is an essential practice in the cultivation of coconut. The present study also reveals that the quantity of nut water (188.77 ml) was significantly ($p<0.05$) high in T_1 as compared to rest of the treatments. Secretaria and Maravilla, (1997) found that the application of the recommended rats of inorganic fertilizers and goat manure during the early stage of coconut growth significantly improved the vegetative growth characters of palms. Kalpana et al., (2006) studied the effect of two integrated nutrients treatments, 50% organics + inorganics 50% and 100% organics on yield, soil and plant nutrient status in coconut based cropping system. The results showed that the highest nut yields/palm/year (113) was recorded in the first treatment as compared to only 89 nuts/palm/year in second (control) treatment. Devasenapathy *et al*., (1996) studied that the application of sodium chloride at 1kg/palm/year along with the recommended dose of NPK had significantly influenced the growth, nut characteristic and nut yield. Marimuthu et al., (2001) reported that application of 50 kg farm yard manure, along with the recommendation dose of NPK, recorded the highest N, P and K contents in soil and leaf, with 47% high nut yield compared to the control.

Conclusion

The study demonstrated that the treatments T_1 {Nitrogen, Phosphorus and Muriate of potash (NPK) + Neem seed powder (NSP) + *Gliricidia sepium* leaves (GSL)} and T_2 (NPK+ NSP) significantly ($p<0.05$) increased most of the morphological characters (number of spikelets with female flowers, 1st spikelets with number of female flowers, stalk length, number of nuts, fruit characters and quantity of nut water).

In this investigation, it is concluded that the application of organic amended with inorganic fertilizers, enhanced the growth and nut production in nutrient deficient soils in growing sites of coastal areas. 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 Inflorescence and flower Morphology high nut production, better income to coconut farmers, economical in coastal area of Pakistan.

References

Abeywardena V (1976). Relationship between leaf length and yield in coconut. *Ceylon Coconut Quarterly* 27: 47.

Balakrishna MTS (1975). Inorganic and organic sources of nitrogen and phosphorus fertilizers for Coconut. *Ceylon Coconut Quarterly* 26:104-107.

Banzon JA, Velasco JR (1982). *Coconut production and utilization*. Philippine Coconut-Research and Development Foundation (PCRDF), Manila. pp 27-31.

BI (Bioversity International) (2007). Key access and utilization descriptors for Coconut genetic Resources. Bioversity International Via dei Tre Denari 472 / a–00057 Maccarese, Rome, Italy. pp 1–4.

Carpio CB, Santos GA, Emmanaul EE, Novarianto H (2005). Resaerch 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. pp. 533-545.

Chaudhry II (1961). The vegetation of Karachi. *Vegetatio* 10: 229-246.

Child R (1964). *Coconuts*. 2nd Ed. Longmans, London. pp. 216.

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

Devasenapathy, P., A.C. Lourduraj, F. Salalrajan, C.S. Sridharan, R. Mohan and R. Mathiazhagan. 1996. Sodium chloride nutrition in Coconut. *Madaras Agricultural Journal*, 83(8): 493-495.

Duncan BD (1955). Multiple ranges and multiple F-tests. *Biometrics*, 11:1-42.

Emmanual EE (2002). Morphometric traits and DNA profiles of three generations of selected coconut genotypes. MS Thesis, UPLB, Philippines. pp 98.

Foale MA (1992). Coconut genetic diversity present knowledge and future research needs. International Board of Plant Genetic Resources (IBPGR), Rome, Italy. pp. 46- 66.

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

Gomez KA, Gomez AA (1984). Statistics for Agricultural Research (2nd Edition), John Willey and Sons, New York. pp. 680.

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

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

IPGRI (International Plant Genetic Resource Institute) (1995). Descriptors for coconut (*Cocos nucifera* L). International plant genetic resources institute, Rome, Italy. pp. 17-29.

Jayalekshmy VG, Rangasamy SRS (2002). Cluster analysis in coconut (*Cocos nucifera* L.). *Journal of Plantation Crops* 2: 18-22.

Kalpana M, Rao DVR, Srinivasulu B (2006). Integrated nutrient management in coconut based cropping system under coastal ecosystem of Andhra Pradesh. *Journal of Plantation Crops* 34: 258-261**.**

Karunanayake K (1996). Climatic requirements for coconut production. *Journal of the Coconut Cultivation Board* 01: 28-29.

Laghari MH, Solangi AH (2005). Status of coconut genetic resources research in Pakistan. Coconut genetic resources. IPGRI-Regional office for Asia and Pacific and Oceana, Serdang, Malaysia. pp 604 - 607.

Longanathan P (1977). Profitability of fertilizing young coconut. *Ceylon Coconut Quarterly* 28: 68-72.

Magat SS (1999). Handbook of fertilizer recommendations for coconut and selected intercrops. Asian and Pacific coconut community. Jakarta, Indonesia. pp. 106.

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

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

Murry DV (1977). *Coconut palm*. In: Ecophysiology of Tropical Crops. (Eds.): P.T. Alvin and T.T. Kozlowski. Academic Press New York. pp. 24 -27.

Nathanael WRN (1961). Coconut nutrition and fertilizers requirements - The plant Approach. *Ceylon Coconut, Quarterly* 12: 101-120.

Ohler JG (1984). *Coconut, tree of life*. FAO (Food and Agriculture Organization) plant production and protection, paper - 057, United Nation, Rome, Italy. pp. 347.

PMD (Pakistan Meteorological Department) (2011). Computerized Data Processing Center, Pakistan Meteorological Department, University Road, Karachi. pp. 1-4.

Rajagopal V, Kasturibai KV, Voleti SR (1990). Screening of coconut genotypes for drought tolerance. *Oleagineux* 45: 215-223.

Ratnambal MJ, Muralidharan K, Krishnan M, Amarnath CH (2005). Diversity of coconut accessions for fruit components. *Journal of Plantation Crops* 33 (1): 1-8.

Santos GA (2001). *The coconut palm* (Botany). STANTECH (Standardized Research Techniques in Coconut Breeding) Training Course. 02–06 April, Philippines coconut Authority, Zamboanga Research Institute, Zamboanga, Philippines. pp. 1-18.

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

Uddin MS (2003). Genetic diversity and on-farm conservation of coconut (*Cocos nucifera* L.) in Northern Luzon, Philippines. MS Thesis , University of Philippine Los Bons, Laguna , Philippines. pp.137.

Von -Uexhull HR (1971). Manuring of coconut. Proceedings of the conference on cocoa and coconut. Kuala Lumpur, Malaysia. pp. 386-399.

Zar JH (2010). Biostatistical Analysis. 5th ed. Prentice-Hall, Englewood Cliffs, New Jersey. pp. 960.