INFLUENCE OF NUTRITION AND VARIETIES ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

by

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DECLARATION

I, hereby declare that this thesis entitled **"INFLUENCE OF NUTRITION AND VARIETIES ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

Abbreviation	Expansion
et al.	And other co workers
Ca	Calcium
CAT	Catigan dwarf hybrid
COD	Chawghat orange dwarf
Cl	Chlorine
CIS	Coconut inflorescence sap
Cu	Copper
CD	Critical difference
^0C	Degree Celsius
dS m^{-1}	Desi Siemen per meter
DNS	Dinitro salicylic acid
EC	Electrolyte concentration
Fig	Figure
GI	Glycemic index
g $100ml^{-1}$	Gram per 100 milli liter
g cc^{-1}	Gram per cubic centimeter
g kg^{-1}	Gram per kilogram
Fe	Iron
KAU	Kerala agricultural university
kg ha^{-1}	Kilo gram per hectare
L	Liter
l day^{-1}	Liter per day
Mg	Magnesium
MYD	Malayan yellow dwarf
mg $100ml^{-1}$	Milli gram per 100 milli liter
mg kg^{-1}	Milli gram per kilo gram
mg l^{-1}	Milli gram per liter

ml	Milli liter
mg	Milli gram
Mn	Manganese
viz.	Namely
pH	Negative logarithm of hydrogen ions
N	Nitrogen
NS	Non significant
POP	Package of practices
%	Percent
P	Phosphorus
K	Potassium
RBD	Randomized block design
RARS	Regional agricultural research station
Sl. No.	Serial number
Na	Sodium
SAS	Statistical analysis software
S	Sulphur
vit C	Vitamin C
WCT	West coast tall
Zn	Zinc

INTRODUCTION

1. INTRODUCTION

Coconut (*Cocos nucifera* L.) is an important perennial crop cultivated in more than 93 countries. Globally it occupies 12.16 million hectares with an annual production of 61.08 billion nuts. India accounts for 15.58 % of area and 25.75 % of its production makes it the second largest producer of coconut in the world with an area of 1.89 million hectares and production of 15.72 million nuts during 2015 (Coconut Development Board, 2015). Being a small holders crop, it is of prime importance in the cultural, social and economic lives of millions of people in Asia and Pacific regions by providing food, livelihood security and employment opportunities.

Coconut the "Tree of life" is the most important crop of Kerala. In Kerala, it is cultivated in an area of 0.64 million hectares with annual production of 4896.61 million nuts (Coconut Development Board, 2015).

It is mainly used to produce copra (68 %), for culinary purpose (30 %) and is consumed as tender nuts (2 %). The popularity of coconut in the state is on the decline due to the high cost of cultivation and low price of nuts. Coconut cultivation can be made more profitable by value addition and product diversification which are areas least explored. Exploitation of coconut inflorescence sap and its products is a promising area due to advantages like regular production, reduced impact of pests and diseases and better returns to farmers and tappers (Naik *et al.*, 2013).

Coconut inflorescence sap (CIS) is extracted by a method called tapping which involves selective bleeding of unopened coconut inflorescence which is a traditional practice in all coconut growing countries. The exuding sap is a sweet translucent juice, oyster white in colour with high nutritive value. It is a rich source of reducing and non reducing sugars with plenty of minerals and vitamins. It is also a good source of iron, phosphorous and ascorbic acid.

The most significant characteristic of coconut inflorescence sap is its low glycemic index an indication of the extent of sugar absorbed into the blood which makes it suitable even for consumption for diabetic patients (Manohar *et al.*, 2007). In recent times there is a huge global demand for low GI sugars while its availability is limited. CIS which is a natural source of low GI sugars can fill up this gap.

CIS is susceptible to natural fermentation to toddy within a few hours of extraction. Changes occur in nutritional and biochemical properties such as pH, total electrolyte concentration, total sugars, reducing sugars, non reducing sugars, vitamin C, alcohol, mineral elements and phenols. The utilization of coconut inflorescence sap as a beverage depends on its preservation in non alcoholic form under ambient condition.

The available nutrient content of soil and tissue nutrient concentration influences the quantity and quality of coconut inflorescence sap. It is important to identify the nutrients such as N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Na and Cl content of soil and tissue that influence CIS output and its nutritional qualities. The nutrient requirement for coconut palms being tapped is much higher than palms maintained for nut production. The response of tapping palms to higher doses of fertilizers has to be evaluated. It will be helpful in developing specific nutrient management plans for tapping coconut palms.

Studies have revealed that coconut varieties differ with respect to sap yield and quality. It is important to identify varieties having superior sap characteristics for commercial utilization of coconut inflorescence sap.

With this background, the present study was undertaken with the following objective.

To study the influence of nutrition to coconut as different levels of fertilizers and varieties on yield, nutritional qualities and biochemical properties of coconut inflorescence sap.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Coconut palm is one of the most useful plants to mankind, because it supports the livelihood security of millions of small and marginal farmers. Every part of the plant is very useful in one way or another. Countries in South East Asia and Latin America produce large number of products from all parts of coconut tree (Borse *et al.*, 2007). Among the various products from coconut, coconut inflorescence sap attracts the maximum interest on view of the large number of by products that can be produced which are highly income generating (Cortazar *et al.*, 2010; Maravilla and Magat, 1993).

Coconut inflorescence sap is collected by tapping the unopened spathe of coconut palm which yields a sweet, oyster white and translucent sap (Gupta *et al.*, 1980). Literature related to the influence of nutrition and varieties on yield and qualities of coconut inflorescence sap are elaborated in this chapter.

2.1. IMPORTANCE OF UTILIZATION OF COCONUT INFLORESCENCE SAP

2.1.1. As a drink

Iwuoha and Eke (1996) and Gupta *et al.* (1980) stated that fresh coconut inflorescence sapgets easily fermented into a drink with 5 - 8 % alcohol and finally gets converted to an acidic liquid with 4 - 7 % acetic acid content. Aalbersberg *et al.* (1997) reported that fresh coconut inflorescence sap is used as a sugar and alcoholic beverages by local people and has high nutritive value and has good digestive properties. According to Jirovetz *et al.* (2001), fermented palm sap or palm toddy or palm wine is used as a alcoholic refreshing beverage. Tuley (1965) revealed that coconut inflorescence sap (CIS) is very popular as a drink with lower sections of the society. It is good for health with properties of improving eye sight and sedative actions.

2.1.2. High nutritive value

In Indonesia coconut sugar is a valuable ingredient in traditional cooking both in food and beverages (Purnomo, 1992; Purnomo and Suryoseputro, 2007). Kalaiyarasi *et al.* (2013) stated that coconut inflorescence sap is highly nutritious with great medicinal value. Chandrasekhar *et al.* (2012) reported that palm wine is rich in calories (300 calorie/l), proteins (0.5 - 2.0 g/l) and is a good source of vitamins. It also has the potential to improve eye sight and can be used to correct eye ailments.

2.1.3. Health benefits

Manohar *et al.* (2007) reported that coconut inflorescence sap and sugar have low glycemic index (< 35) which makes it ideal sugar source for diabetic patients. Trinidad *et al.* (1993) and Wolever *et al.* (1994) observed that CIS and palm sugar have low glycemic index (35 - 42) which makes them a good sugar source for both healthy people and patients with diabetes. Akochi *et al.* (1997) stated that coconut inflorescence sap contains sucrose, fructose and amino acids which are precursors of alkylpyrazines in food. Barh and Mazumder (2008) reported that the balanced administration of fresh and fermented date sap was found to improvise the treatment of hemoglobin deficient anaemic patients and to supplement vitaminB_{12} level in the vitamin deficient patients.

2.1.4. Production of palm sugar, alcohol, vinegar etc.

Coconut inflorescence sap is very nutritious and can be used as a raw material for alcohol and vinegar industries (Ezeagu and Fafunso, 2003; Van der Vossen and Chipungahelo, 2007). Purnomo (1992) reported that in South East Asia coconut inflorescence sap is used as a juice by local communities and in the manufacture of palm sugar, vinegar and acetic acid. Michael *et al.* (1988) noticed that the fermentation of CIS can be arrested and processed in jaggery industry.

Opara *et al.* (2014) also revealed that on natural fermentation coconut inflorescence sap can be converted into an alcoholic beverage and into vinegar and acetic acid. Ho *et al.* (2007) observed that coconut inflorescence sap on heat processing can be converted into a natural sweetener. Palm wine is rich in nutrients and can be utilized as a sweetener on cooking and baking (Ezeagu and Fafunso, 2003). Fresh coconut inflorescence sap contains 12 - 18 % sucrose which can be consumed as such or through alcoholic fermentation it can be converted into an alcoholic drink and vinegar (Nathanael, 1966; Pethiyagoda, 1978). Batra and Millner (1974) suggested that in Asia fermented coconut inflorescence sap can be used as a source of inoculum for cottage industries producing native leavened bread like nan and Sonnon.

2.2. MINERAL NUTRITION OF COCONUT

Sobral and Leal (1999) reported that nut yield in coconut was influenced by N and the critical level of nitrogen in index leaf of coconut (leaf 14) in 17.18 g kg^{-1}. Menon and Pandalai (1958) revealed that coconut responded positively to potassium application and K had beneficial effect on copra production compared to nitrogen which had an adverse effect. Sobral (2004) observed that there was an increase in nut yield in coconut variety green dwarf with N fertilization as urea. In coconut variety west coast tall, the nutrients N and P are utilized in equal quantities for growth and yield (Ouverier and Ochs, 1978; Pillai and Davis, 1963).

2.3. RESPONSE OF COCONUT TO FERTILIZER APPLICATION

2.3.1. Yield

Ouverier and Ochs (1978) suggested that the annual nutrient removal by coconut palms through nuts, fronds, trunk, bunch, spathe etc., varied from 20 - 174 kg N, 2.5 - 20.0 kg P_2O_5 and 35 - 49 kg K_2O ha^{-1}. John and Jacob (1959) stated that coconut varieties give differential yield response to fertilizer application.

Secretaria *et al.* (1994) conducted an experiment in Guisao, Zamboanga and observed that coconut fertilized with 3.0 kg of ammonium sulfate and 3.0 kg potassium chloride could result in 87 % increase in nut yield over the control. Khan (1993) observed that the requirements of N and P are more for hybrids compared to west coast tall (WCT) and they also utilize a higher proportion of the absorbed N and P for increased nut production. According to Pillai and Davis (1963), an adult palm of West Coast Tall producing 40 nuts and 12 - 13 fronds per year absorbed 321 g N, 69 g P and 406 g K. John and Jacob (1959) conducted an extensive fertilizer demonstration involving 24,000 coconut trees in the west coast of India and observed that application of additional dose of potash and higher doses of NPK resulted in increased yield where standard dose failed to elicit adequate response. Wahid *et al.* (1988) reported that increased levels of potassium application resulted in a early bearing and higher nut yield in coconut.

2.3.2. Available nutrient status of soil

Mohandas (2012) studied the influence of NPK fertilization on mineral nutrition and yield of hybrid coconut palms. The results indicated that among the different levels of NPK the highest soil available NPK was significant at the highest nutrient level tried. The highest available nitrogen was associated with the application of nitrogen at the highest level is 1000 g/palm/year. Increasing the phosphorus level from 0 to 500 g/palm/year progressively enhanced the P availability in soil (Mohandas, 2012). According to Mohandas (2012), increasing the potassium level from 1000 to 2000 g/palm/year enhanced the soil available K content from 130 to 259 kg ha^{-1}.

2.4. EFFECT OF NUTRITION ON YIELD AND QUALITY OF COCONUT INFLORESCENCE SAP

2.4.1. CIS yield

Secretaria *et al.* (1998) reported that the differences in coconut varieties, climatic conditions and nutrition status of the palms contributed significantly to the differences in sap and nut yields.

According to Wasantha *et al.* (2009), sap flow in coconut depends on variety and soil condition on which palm is grown. The greater soil depth, water holding capacity of soil and larger leaf area of palm are reported to be positively correlated with higher sap flow. A study conducted by Marvilla and Magat (1993) on laguna tall variety revealed that leaf nutrient concentration in terms of N, P, K, Ca, Mg, Na, Cl, S and B concentrations was not affected by tapping for coconut inflorescence sap compared to palms maintained for nut production and those for sequential coconut toddy and nut production. The results indicate that there is no adverse affect of coconut inflorescence tapping on the nutrient status of coconut palms. Sunil *et al.* (2009) found that on an average a coconut palm yields 1.8 - 2.4 liters of neera. The sap yield from coconut palms varies from 2 - 4.5 liters depending on the health of palms and management practices adopted (Muralidharan and Deepthi, 2013).

2.4.2. Sap production duration

Cortazar *et al.* (2010) stated that the duration of production of inflorescence sap was about 20 - 30 days per spathe. Konan *et al.* (2013) assessed the sap production parameters from spathes of four coconut cultivars in Cote d' Ivora. The results indicated that the hybrid PB 113 had the highest sap production duration of 46.78 days, while the dwarf variety MYD registered the lowest sap production duration of 24 days. The sap production duration is a function of the length of spathe and regularity in sap flow during the tapping cycle.

Samsudeen *et al*. (2013) observed that the sap production duration of WCT, Laccadive ordinary tall, Chawghat orange dwarf and COD × WCT ranged from 60 - 70 days.

2.4.3. Index leaf tissue concentration

Mohandas (2012) reported that the index leaf nutrient concentration of coconut was significantly influenced by added levels of NPK. The highest leaf NPK content was observed with the application of NPK at their highest level viz., 1000, 500, 2000 g NPK respectively per palm per year.

Enhanced nutrient release at the highest level of NPK and its subsequent absorption by the palm would have ultimately resulted in higher NPK in the index leaf, which may help in better photosynthesis and leads to better palm productivity.

2.4.4. Biochemical composition

Purnamo (1992) stated that fresh coconut inflorescence sap contains sugar components and small amounts of protein, fat, minerals and vitamins. Muralidharan and Deepthi (2013) observed that neera has a pH of 3.9 - 4.7, total solids of 15.2 - 19.7 g $100ml^{-1}$, total sugars of 14.4 g $100ml^{-1}$, reducing sugar of 9.85 g $100ml^{-1}$ and no alcohol content. Naik *et al*. (2013) reported that Keramritham (Neera) is much superior to tender coconut water and contains 15 - 18% total sugars, 1.3 mg $100ml^{-1}$ vitamin C and 8.0 mg $100ml^{-1}$ of phenols. They also observed that neera has a pH of 6.8 and acidity of 10.0 m eql^{-1}. There is an influence of soil and climatic condition on the absorption of water and minerals which in turns affects photosynthesis and the production of carbohydrates by coconut palms (Konan *et al*., 2014). Hori *et al*. (2001) reported that the composition of fresh coconut inflorescence sap is influenced by variety, stage of maturity of spathe, climatic conditions and soil fertility status.

Sunil *et al.* (2009) observed that fresh coconut inflorescence sap contains 15.2 - 19.7 % total solids, 12.3 - 17.4 % sucrose, 0.11 - 0.41 % total ash, 16.0 - 30.0 % ascorbic acid and 0.23 - 0.32 % protein.

Ranasinghe and Silva (2007) reported that the high level of soluble sugar in leaf tissue and correspondingly in the sap producing coconut palms is due to the translocation of sugars from leaves and their conversion into soluble sugar in the sustaining leaf. They also suggested that coconut inflorescence sap exudation is as a result of the movement of the aqueous phase from sieve tube system of coconut trees to the bleeding site in the tapping inflorescence. Pethiyagoda (1978) observed that the high volume of CIS and its high sugar content points its origin to materials derived from stored resources rather than sugar currently synthesized.

Van Die (1974) reported that the requirement of assimilates for tapping coconut palms is much higher than palms maintained for nut production as the amounts of assimilates removed during tapping of coconut inflorescence is several times more than the assimilates removed had that inflorescence yielded nuts. There was no significant correlation between sap yield and the carbohydrate content in plant, net assimilation rate and nut yield before tapping (Ranasinghe and Silva, 2007). Pethiyagoda (1978) observed that high nut producing palms need not produce larger volumes of coconut inflorescence sap.

2.4.5. Nutritional composition

Muralidharan and Deepthi (2013) reported that coconut inflorescence sap is rich in iron (0.15 g $100ml^{-1}$), phosphorous (7.59 g $100ml^{-1}$) and vitamin-C (16-30 mg $100ml^{-1}$). Mineral content of neera was 90.5 ppm of potassium, 60.0 ppm of calcium, 15.0 ppm of phosphorous, 45.0 ppm of iron and 9.5 ppm of sodium (Naik *et al.*, 2013). Coconut inflorescence sap is rich in minerals with 90.6 mg $100ml^{-1}$ of sodium, 168.4 mg $100ml^{-1}$ of potassium, 3.9 mg $100ml^{-1}$ of phosphorous, 0.012 mg $100ml^{-1}$ of manganese, 0.031 mg $100ml^{-1}$ of copper, 0.020 mg $100ml^{-1}$ of zinc and 0.053 mg $100ml^{-1}$ of iron (Hebbar *et al.*, 2015).

2.5. EFFECT OF VARIETIES ON YIELD AND QUALITY OF COCONUT INFLORESCENCE SAP

2.5.1. CIS yield

Secretaria *et al.* (1998) conducted a study in Philippines on sequential production of nuts and coconut toddy in six coconut hybrids and cultivars at two experimental sites at Zamboanga City and observed that dwarf x tall hybrids and a local tall cultivar, Laguna gave significantly higher sap and nut yield compared to the Catigan dwarf and Catigan dwarf hybrid (CAT x CAT) and a dwarf cultivar Tacunan. The sap production depends on the variety and environment (Secretaria *et al.*, 1998; Wasantha *et al.*, 2009).

A study conducted by Samsudeen *et al.* (2013) at Central Plantation Crop Research Institute (CPCRI) showed that there is influence of variety and season on coconut inflorescence sap production. The highest average production of 960 ml day^{-1} was obtained in WCT followed by 880 ml in D x T hybrid. Lowest production of 104.2 ml day^{-1} was recorded for COD. In general, tall and hybrid cultivars yielded better than dwarf cultivars. The sap production potential of coconut palms is 1.5 - 3 liters per day. It is more in tall varieties and hybrids compared to dwarf varieties (Hebbar *et al.*, 2015). De Nuce and Rognon (1986) observed that the ability of the hybrids to provide greater volume of coconut inflorescence sap may be due to hybrid vigour. Konan *et al.* (2009) reported hybrid vigour in PB 121 hybrid in terms of both nut production and sap yield. Konan *et al.* (2013) conducted experiment on sap production potential of four coconut cultivars at Cote d' Ivorie and reported that the PB 113 hybrid provided highest sap production of about 4.24 l followed by PB 121 (3.26 l), WAT (0.83 l). MYD (0.26 l) produced lowest volume. Toddy yield is significantly influenced by factors like variety, season and management practices adopted (Nathanael, 1966; Ranasinghe, 1997). Konan *et al.* (2013) compared the yield of sap production from four different coconut varieties and observed higher quantity of sap from the hybrids than dwarf and tall coconut trees.

2.5.2. Biochemical composition

Konan *et al.* (2013) studied the coconut sap obtained from four coconut varieties and concluded that there was a difference in varieties with respect to physicochemical traits. Fresh coconut inflorescence sap contains sucrose, ash, protein, vitamin C and acids, such as succinic acid, and citric acid (Itoh *et al.*, 1982). Hebbar *et al.* (2015) reported that the fresh coconut inflorescence sap which is rich in sugars, minerals and proteins also contains phenolics and ascorbic acid.

2.5.2.1. pH

Nakamura *et al.* (2004) found that coconut inflorescence sap has a pH of near neutral. Hebbar *et al.* (2015) reported that fresh coconut inflorescence sap has nearly neutral pH of 7.18. Konan *et al.* (2014) observed that the pH of CIS varied with varieties. The pH was highest in variety MYD (7.32) while the hybrid PB 113 had the lowest pH (6.97). They attributed the lowest pH to the production of more hydronium ions in the sap of hybrid PB 113 than the sap of MYD. Aalbersberg *et al.* (1997) observed that fresh coconut inflorescence sap is at a nearly neutral pH.

2.5.2.2. Total soluble solids

Dwarf palms (MYD) have greater total soluble solids in sap than tall varieties and hybrids (Konan *et al.*, 2014).

2.5.2.3. Sugars

Samsudeen *et al.* (2013) reported that the biochemical properties of fresh coconut inflorescence sap varied with the varieties. Total sugar was the highest in WCT. Lowest total sugar content was recorded in COD. Nakamura *et al.* (2004) stated that the coconut inflorescence sap is rich in glucides mostly in the form of sucrose.

According to Konan *et al.* (2014), total sugar content of sap varies with varieties and was highest in the dwarf variety MYD due to the high rate of sugar synthesis in dwarf coconut types. Michael *et al.* (1988) reported that unfermented sap from oil palm has sucrose concentration of 10 % and glucose or fructose concentration of less than 1 %. The carbohydrates of the unfermented coconut sap had a greater proportion of sucrose (Konan *et al.*, 2014). Studies conducted by Samsudeen *et al.* (2013) revealed that there was no significant difference in reducing sugar content of CIS among the different varieties. Reducing sugar was slightly higher in Dwarf x Tall. Hebbar *et al.* (2015) reported that fresh CIS has reducing sugar content of 15.18 g 100 ml^{-1}. The coconut inflorescence sap has a carbohydrate content of 10 - 15 % (Borse *et al.*, 2007).

Barh and Mazumdar (2008) reported that the fresh coconut sap from the cut inflorescence has high sucrose content (12 - 15 %). Aalbersberg *et al.* (1997) also reported that fresh coconut inflorescence sap is rich in sugar (10 - 15 %). Singaravadivel *et al.* (2012) observed that fresh coconut inflorescence sap contains 12 - 15 % sucrose content (non reducing sugars). Coconut varieties varied with respect to total sugar content of coconut inflorescence sap. Dwarf variety (MYD) recorded highest total sugar content than tall variety and hybrids. This indicates more intensive sugar synthesis in dwarf coconut palms. The dwarf coconut palms have thinner stipes than the talls and hybrids. The weak root system associated with dwarf palms might not enable better uptake of water and minerals. To compensate this dwarf palms could have achieved greater photosynthesis resulting in higher production of carbohydrates (Konan *et al.*, 2014).

Nakumara *et al.* (2004) reported that sucrose a non-reducing di - saccharide is the predominant sugar present in coconut inflorescence sap (11.6 g 100ml^{-1}). Dwarf varieties have more non reducing sugars than tall varieties and hybrids. Konan *et al.* (2014) observed that in addition to non reducing sugar, coconut inflorescence sap also contains reducing sugars. They observed that the presence of reducing sugars may have resulted from two biochemical processes.

The first source might be the enzymatic hydrolysis of sucrose during fermentation of sap which starts spontaneously by microorganisms in the sap, while the second source could be physiological synthesis of reducing sugars by the coconut palms during photosynthesis.

2.5.2.4. Alcohol

Studies conducted by Singaravadivel *et al.* (2012) at IICPT, Thanjavur revealed that fresh coconut inflorescence sap contains 0.2 % alcohol. Ababio (1990) also reported an alcohol content of 2 - 8 % in palmyra wine.

2.5.2.5. Phenols

Naik et al. (2013) reported that Keramritham (Neera) contains 8.0 mg $100ml^{-1}$ of phenols.

2.5.2.6. Vitamin C

Aalbersberg *et al.* (1997) suggested that fresh coconut inflorescence sap contains 16 kinds of amino acids. Hebbar *et al.* (2015) observed that fresh coconut inflorescence sap contains 17.5 mg $100ml^{-1}$ of vitamin C.

2.5.3. Nutritional composition

Jatmika *et al.* (1990) observed that the major amino acids in fresh coconut inflorescence sap were glutamic acid, threonine, aspartic acid and serine. Studies conducted by Samsudeen *et al.* (2013) revealed that there was no significant difference is protein. Coconut inflorescence sap contains approximately 0.23 % protein, 0.02 % fat and is rich in Na and K content (Barh and Mazumdar, 2008). Sap also contains amino acids such as glutamine, vitamins (C, B) and minerals including potassium, phosphorus and iron. (Nakamura *et al.* 2004; Naik *et al.* 2013 and Konan *et al.* 2014).

2.6. EFFECT OF STORAGE ON BIOCHEMICAL PROPERTIES OF CIS

Fermentation of coconut inflorescence sap occurs in three stages which starts with lactic acid fermentation followed by alcoholic fermentation and finally acetic fermentation. The microbial activity at each stage helps the activity of the micro-organisms in the subsequent stage (Atputharajah *et al*., 1986).

2.6.1.pH

Samarajeewa *et al*. (1985) observed that coconut inflorescence sap contains lactic, acetic, tartaric and citric acids out of which volatile acid is mostly acetic acid.

Singaravadivel *et al*. (2012) reported that fresh coconut inflorescence sap on storage become more turbid and whitish. There is a reduction of pH of fresh toddy from 5.5 to 4.21 on 24 hours storage. Barh and Mazumdar (2008) observed that fresh sap from *Borassus flabellifer* has a pH of 7.20 which decreases to 6.00 on fermentation. Stringini *et al*. (2009) reported that fermented palm wine has a pH of 4.92. Konan *et al*. (2014) observed a significant increase of the titrable acidity at the beginning of palm sap. This is due to an acidification from lactic acid bacteria (LAB) as reported by Xia *et al*. (2011). Hebbar *et al*. (2015) confirmed that fresh sap is alkaline in reaction with a pH of 7.5 - 8. Fermentation starts in 2 - 3 hours and pH declines, finally reaching around 3.5 on complete fermentation.

2.6.2. Total soluble solids

According to Singaravadivel *et al*. (2012), the soluble solids present in coconut inflorescence sap is utilized by microorganisms during fermentation and declines to 11.4 % from the initial value of 14.1 % in fresh sap.

2.6.3. Sugar content

Fapurusi and Bassir (1972) reported a 50 % reduction in sucrose content of sap *of Elaeis guineensis, on* fermentation for seven days. Hebbar*et al.* (2015) observed that fresh sap has around 15 % sugars and starts fermentation in 2 - 3 hours. Atputharajah *et al.* (1986) reported that during fermentation of sap, sucrose is initially converted to glucose and fructose which will be utilized by microbes involved in fermentation for their energy requirements. This results in lower concentration of these reducing sugars in later stages of fermentation. Opara *et al.* (2014) suggested that the fluctuation observed in the sugar content in coconut inflorescence sap during fermentation may be due to the utilization of sugar by microbes for their energy needs and the conversion of sugar into other substances in the process. During fermentation of sap, inversion of sugars occurs. There is a steady drop in total sugars and increase in reducing sugars till day 3. Beyond day 3, reducing sugars declined. This can be attributed to the conversion of sucrose to glucose and fructose and their utilization by microbes at later stages of fermentation. There was an increase in ethanol content from day 1 to 5 beyond which it decreased (Xia *et al.*, 2011). Konan *et al.* (2014) stated that initial decrease of the reducing sugars contents could result from the direct use of the residual glucose. Xia *et al.* (2011) indicated highest reducing sugars content (0.8%) after two to three days of natural fermentation of palm sap. There was a decrease of the total sugars contents from 11.61 % to 0.23 % after 33 h of fermentation of saps produced by oil palm at 36 - 37°C. The total carbohydrates stabilized after four days which could be due to inhibition in the growth of the microorganisms. after the sugars become scarce and the environment hostile with the lower pH (Eze and Ogan, 1988).

2.6.4. Alcohol

Singaravadivel *et al.* (2012) found that alcohol content of coconut inflorescence sap increases on storage. It increased to 4.5 % after 24 hours against the initial value of 0.2 %.

Fermented palm sap has a pH 3.6 and alcohol content of 5 - 8 % depending on the stage of fermentation (Iwuoha and Eke, 1996). Fermented coconut inflorescence sap contains volatile organic compounds like ethanol, higher alcohols, acetic acid, esters and acetoin. (Uzochukwu *et al*., 1997; Jirovetz *et al*., 2001 and Lasekan*et al*., 2009). Nur Aimi *et al*. (2013) studied the volatile compounds in fresh and fermented palm sap. The study revealed that during fermentation ethanol content increases from initial value of 0.11 % - 6.6 % before declining to 5.73 % on day 63. They attributed the presence of alcohol in initial sample to the presence of naturally present yeast in tapping sap. Consequently the sap tends to start fermentation even while in the tapping process. Ingledew (1999) reported that during fermentation of palm sap, there is a decrease in alcohol content in the later stages due to the production of by products such as higher alcohols. Also the growth of yeast cells might have contributed metabolic intermediates to the system.

2.6.5. Phenol

Fresh coconut inflorescence sap has a total phenolic content of 0.34 g l^{-1}. On fermentation it increased to 0.6 g l^{-1} on day 2 and reached a peak of 1.24 g l^{-1} on day 3 (Syamala Devi *et al*., 2015). They attributed the increased phenolic content to plant polyphenols binding with cellulose, protein, sugar and starch to form glucosidic bonds. The increased microbial metabolism would have also contributed to production of phenolic substances. Landbo and Meyer (2004) observed the changes in total phenolic content of fresh coconut inflorescence sap on storage. They observed that fresh CIS has a total phenolic content of 0.33 g l^{-1} which increased slowly from day 1 to 2 and rapidly thereafter peaking at 1.24 g l^{-1} after 58 hours. They attributed this to the binding of plant polyphenols with sugar, protein, cellulose and starch forming glucosidic bonds which are degraded by the acids produced during natural fermentation and phenolic compounds are yielded. According to Xia *et al*. (2011), the polyphenols would be naturally bound with sugars, proteins, cellulose and starch in the sap.

Thus, the continuous acid hydrolysis of those bonds during fermentation increased the total polyphenols contents which reached a peak at 36 hours. However, after 48 hours, the decrease in total polyphenols contents could have resulted with oxidization by polyphenol oxidase and phenolase (Landbo and Meyer, 2004).

2.6.6. Vitamin C

Syamala Devi *et al.* (2015) studied the effect of storage on ascorbic acid content of coconut inflorescence sap. The study revealed that the ascorbic acid content decreased from the initial value of 20.6 - 19.6 mg l^{-1}. It increased on day 2 and reached 20.7 mg l^{-1} on day 3 which can be attributed to enhanced activity of yeast. However on day 5 the ascorbic acid fell sharply which may be because of decreased activity of yeast. Fresh coconut inflorescence sap has a vitamin C content of 20.4 mg l^{-1} which reduced slowly on day 1 and then increased on day 2 finally reaching a maximum of 20.7 mg l^{-1} on day 3.

The increase can be attributed to the activity of yeast which would have synthesized vitamin C during fermentation (Bremus *et al.*, 2006). Singaravadivel *et al.*, (2012) observed that the ascorbic acid content of coconut inflorescence sap increases from 3.5 to 5.8 mg 100 ml^{-1} on storage.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation entitled "Influence of nutrition and varieties on yield and qualities of coconut inflorescence sap" was undertaken with the objective of assessing the influence of nutrition and varieties on yield, nutritional qualities and biochemical properties of coconut inflorescence sap. The experiment details with special reference to the materials used and methods adopted are discussed in this chapter. The whole investigation was carried out as two field experiments.

3.1. EXPERIMENT 1: INFLUENCE OF FERTILIZER LEVELS ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

This field experiment was conducted at Instructional Farm, College of Agriculture, Vellayani under rainfed condition. Coconut palms of same age and morphological characters were selected for the study.

3.1.1. Experimental details

The experiment was laid out in RBD replicated 5 times with the test crop of coconut variety west coast tall. There were 4 treatments viz.

T_1 – POP Recommendation

T_2 – 125 % POP Recommendation

T_3 – 150 % POP Recommendation

T_4 – 175 % POP Recommendation

Fertilizers were applied as per package of practices recommendations (POP) of KAU (0.5:0.32:1.2 kg palm NPK) and as per the individual treatments. The other cultural practices were adopted as per POP, (KAU, 2011).

3.1.2. Collection of soil samples

A composite sample was collected from the experimental field before starting the experiment. Soil sample was drawn from surface 15 cm from 10 different places of the field, reduced to required quantity and air dried. The soil samples were also collected from the basin of each palm at the end of the experiment. The air dried soil samples were ground and passed through 2 mm sieve and stored in a polythene bags for analysis.

3.1.3. Analysis of soil sample

The physical and chemical properties of collected soil samples were analyzed by following standard procedures given in Table 1.

3.1.4. Collection of plant samples for analysis

Index leaf samples were collected from 14^{th} frond (Chew 1982; Magat 1992) of coconut palms at the end of the experiment. It was washed and dried for two days in shade and later in an oven at 70^{0} C. The oven dried samples were powdered, labelled and stored for further analysis.

3.1.5. Analysis of plant samples

A suitably weighed quantity of ground plant material from each treatment was taken in digestion tube and digested in the digestion chamber with single acid (H_2SO_4) and digestion mixture. Single acid digested samples were analysed for nitrogen by microkjeldhal distillation method.

A weighed quantity of ground plant material from each treatment was taken in digestion tube and digested in the digestion chamber with di-acid mixture (HNO_3-$HClO_4$) in 9:4 ratio as per the procedure outlined by Jackson (1958). The digested material was cooled, diluted with distilled water, filtered and made up to 100 ml and labelled.

Table 1. Analytical methods followed in soil analysis

Sl. No	Parameter	Method	Reference
1	Bulk density	Undisturbed core sample	Black *et al.* (1965)
2	Particle density	Pycnometer method	Black *et al.* (1965)
3	Porosity		Black *et al.* (1965)
4	Textural analysis	International pipette method	Robinson (1922)
5	Electrical conductivity	Conductivity meter	Jackson (1958)
6	pH	pH meter	Jackson (1958)
7	Available N	Alkaline Permanganate method	Subbaiah and Asija (1956)
8	Available P	Bray extraction and photoelectric colorimetry	Jackson (1958)
9	Available K	Flame photometry	Pratt (1965)
10	Available Ca	Atomic absorption spectroscopy	Jackson (1958)
11	Available Mg	Atomic absorption spectroscopy	Jackson (1958)
12	Available S	Photoelectric colorimetry	Massoumi and Cornfield (1963)
13	Available Fe	Atomic absorption spectroscopy	Sims and Johnson (1991)
14	Available Cu	Atomic absorption spectroscopy	Sims and Johnson (1991)
15	Available Mn	Atomic absorption spectroscopy	Sims and Johnson (1991)
16	Available Zn	Atomic absorption spectroscopy	Sims and Johnson (1991)
17	Available Na	Flame photometry	Pratt (1965)
18	Available Cl	Titration with Silver nitrate using chromate indicator	Chapman and Pratt (1961)

Di-acid digested plant samples were used for the analysis of nutrients *viz.*, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, Na and Cl by standard procedures given in Table 2.

Table 2. Analytical methods followed for plant analysis

Sl. No.	Parameter	Method	Reference
1	Total N	Modified kjeldhal method	Jackson (1958)
2	Total P	Vanodo molybdate yellow colour method	Piper (1966)
3	Total K	Flame photometry	Jackson (1958)
4	Total Ca and Mg	Atomic Absorption Spectroscopy	Issac and Kerber (1971)
5	Total S	Turbidimetric method	Bhargava and Raghupathi (1995)
6	Total Fe and Mn	Atomic Absorption Spectroscopy	Emmel *et al.* (1977)
7	Total Cu and Zn	Atomic Absorption Spectroscopy	Emmel *et al.* (1977)
8	Total Na	Flame photometry	Jackson (1958)
9	Total Cl	Titration with Silver nitrate using chromate indicator	Chapman and Pratt (1961)

3.1.6. Collection of coconut inflorescence sap

Tapping of palms was started 11 months after treatment application. Fully emerged unopened bunches were selected for tapping. The bunch was tied at many places to prevent opening of inflorescence and to facilitate sap flow. The first cut was made after four days. After the first cut, every day the cut surface was opened twice by slicing the cut edge again and the inflorescence was delicately beaten or tapped twice a day to stimulate flow of sap. The sap flow started 8 - 12 days after the first cut and the flow continues for 40 - 60 days. Slicing the cut edge and tapping were repeated every day. The sap was collected in a plastic container tied to the bunch. The sap volume was measured with a measuring cylinder for the harvesting on 21st day after starting of tapping.

The sap production duration was the number of days for which it produced the sap. This was assessed by counting days since the first bleeding until the end of the sap flow from the spathe. Sample for analysis was collected in the morning on the 21^{st} day in plastic bottles kept for 2 hours. The collected samples were immediately stored in refrigerator and used for analysis of nutritional qualities and biochemical properties of coconut inflorescence sap.

3.1.7. Analysis of nutritional and biochemical properties in coconut inflorescence sap

3.1.7.1. pH

The pH of sap was recorded using electronic pH meter (Saini *et al*., 2001).

3.1.7.2. Total electrolyte concentration

The total electrolyte concentration of sap was measured by using Conductivity Bridge (Jackson, 1958).

3.1.7.3. Total sugars

The estimation of total sugars in sap was done by following the Anthrone method (Mc Cready *et al*., 1950).

3.1.7.4. Reducing sugar

The estimation of reducing sugars in sap was done by dinitro salicylic acid (DNS) method (Somogyi, 1952).

3.1.7.5. Non reducing sugar

The observation under total sugars and reducing sugars were used for calculating non reducing sugars based on the procedure suggested by Ranganna (1977).

Non reducing sugars = Total sugars – Reducing sugars

3.1.7.6. Vitamin C

The vitamin C content of sap was estimated by the volumetric method (Sadasivam and Manickam, 2008).

3.1.7.7. Alcohol

Alcohol content of sap was estimated by titration method using potassium dichromate and sodium thiosulphate (William and Darwin, 1950).

3.1.7.8. Phenol

Phenols content was estimated by Folin - Ciocalteau method (Mayr *et al.*, 1995).

3.1.8. Analysis of mineral constituents in coconut inflorescence sap

3.1.8.1. Nitrogen (Protein and non protein nitrogen)

A suitably weighed quantity (2 ml) of CIS from each treatment was taken in conical flask and digested in the hot sand bath by adding 15 ml single acid (H_2SO_4) and digestion mixture. Single acid digested samples were used for analyzing nitrogen by microkjeldhal distillation method which is expressed as protein nitrogen (Sadasivam and Manickam, 2008).

Non protein nitrogen content of coconut inflorescence was estimated by volumetrically by ferrous sulphate zinc soda method (Kanwar and Chopra, 1995) without digestion.

3.1.8.2. P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, Na and Cl

A suitably weighed quantity (2 ml) of CIS from each treatment was taken in conical flask and digested in the hot sand bath with di-acid mixture (HNO_3 - $HClO_4$) in 9:4 ratio as per the procedure outlined by Jackson (1958).

The digested material was cooled, diluted with distilled water, filtered and made up to 100 ml and labeled.

Di-acid digested CIS samples were used for the analysis of nutrients *viz.*, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, Na and Cl by standard procedures given in Table 3.

Table 3. Analytical methods followed for coconut inflorescence sap analysis.

Sl. No.	Parameter	Method	Reference
1	Total P	Vanodo molybdate yellow colour method	Piper (1966)
2	Total K	Flame photometry	Jackson (1958)
3	Total Ca and Mg	Atomic Absorption Spectroscopy	Issac and Kerber (1971)
4	Total S	Turbidimetric method	Bhargava and Raghupathi (1995)
5	Total Fe and Mn	Atomic Absorption Spectroscopy	Emmel *et al.* (1977)
6	Total Cu and Zn	Atomic Absorption Spectroscopy	Emmel *et al.* (1977)

3.1.8.3. Total mineral content

Total mineral content of coconut inflorescence sap was estimated by adding all mineral nutrients and it was expressed in percentage.

3.2. EXPERIMENT 2: INFLUENCE OF VARIETIES ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

This experiment was conducted at College of Agriculture, Padannakkad and Nileswaram farm, RARS Pilicode under irrigated condition. Four varieties were selected for evaluation. Palms with similar age and morphological characters were selected as experiment units.

3.2.1. Experimental details

The experiment was laid out in RBD replicated 5 times with four varieties as treatments viz.

T_1 – Malayan Yellow Dwarf

T_2 – Keraganga

T_3 – West Coast Tall

T_4 – Kerasree

3.2.2. Collection of coconut inflorescence sap

Fully emerged unopened bunches were selected for tapping. The tapping was done as discussed in the first experiment. The sap volume of each harvesting was measured with a measuring cylinder 21^{st} day after starting of tapping. Samples for analysis were collected adopting the same procedure explained in the case of first experiment. The collected samples were immediately stored in refrigerator and used for analysis of nutritional qualities and biochemical properties of coconut inflorescence sap.

3.2.3. Analysis of CIS for biochemical and nutritional properties

The biochemical and nutritional properties of collected fresh coconut inflorescence sap were analyzed by following procedure as discussed earlier.

3.2.4. Evaluation of changes in biochemical and nutritional qualities of CIS on storage

The sap collected from each variety was stored at refrigerated condition for one week and biochemical properties viz., pH, electrolyte concentration, reducing sugars, non-reducing sugars, total sugars, alcohol, phenol and vitamin C were assessed on 1^{st} (D_1), 3^{rd} (D_2) and 7^{th} (D_3) days of storage by following procedures as discussed earlier.

3.3. Statistical analysis

The data obtained from both experiments was subjected to statistical analysis using statistical analysis software (SAS) (Hatcher, 2003). The data after statistical analysis were used for comparison and interpretation of the results.

RESULT

4. RESULTS

The present investigation entitled "Influence of nutrition and varieties on yield and qualities of coconut inflorescence sap" was undertaken with the objective of assessing the influence of nutrition to coconut as different levels of fertilizer and varieties on yield, nutritional qualities and biochemical properties of coconut inflorescence sap. The results obtained from the two experiments are presented in this chapter.

4.1. EXPERIMENT 1: INFLUENCE OF FERTILIZER LEVELS ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

A field experiment was conducted at Instructional farm, College of Agriculture, Vellayani, to study the influence of nutrition as different fertilizer levels on yield, nutritional quality and biochemical properties of coconut inflorescence sap.

The soil analysis data of initial soil sample is presented in Table 4 and 5.

Table 4. Physical properties of experiment soil

Sl. No.	Parameter	Content
1	Bulk Density (Mg m^{-3})	1.30
2	Particle Density (Mg m^{-3})	2.65
3	Pore space (%)	50.94
4	Coarse sand (%)	55.50
5	Fine sand (%)	7.25
6	Silt (%)	9.5
7	Clay (%)	26.5
8	Texture	Sandy clay loam

Table 5. Chemical properties of experiment soil

Sl. No.	Parameter	Content
1	pH	5.90
2	Electrical Conductivity (dS m^{-1})	0.45
3	Available Nitrogen (kg ha^{-1})	178.27
4	Available Phosphorus (kg ha^{-1})	119.26
5	Available Potassium (kg ha^{-1})	177.75
6	Available Calcium (mg kg^{-1})	43.05
7	Available Magnesium (mg kg^{-1})	35.23
8	Available Sulphur (mg kg^{-1})	36.58
9	Available Iron (mg kg^{-1})	199.81
10	Available Manganese (mg kg^{-1})	1.14
11	Available Copper (mg kg^{-1})	1.09
12	Available Zinc (mg kg^{-1})	1.92
13	Available Sodium (kg ha^{-1})	26.20
14	Available Chlorine (mg kg^{-1})	600

4.1.1. Available nutrient status of soil

4.1.1.1. Primary nutrients (N, P and K)

The results of the influence of fertilizer levels on the available primary nutrient content in soil are presented in Table 6.

The results revealed that the T_4 (175 % POP recommendation) recorded the highest available nitrogen content in soil (245.30 kg ha^{-1}) which was significantly higher from T_1 (160.52 kg ha^{-1}) and on par with T_3 (230.76 kg ha^{-1}) and T_2 (225.72 kg ha^{-1}).

The available phosphorous status of soil was also influenced by treatments. It was the highest in T_4 (157.72 kg ha^{-1}) which was significantly superior to all other treatments.

The highest available potassium content in soil of 324.82 kg ha^{-1} was recorded in T_4 (175 % POP recommendation) which was significantly higher than T_3 (255.72 kg ha^{-1}), T_2 (237.30 kg ha^{-1}) and T_1 (167.40 kg ha^{1}).

Table 6. Influence of fertilizer levels on status of available primary nutrients in soil

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T1 - POP recommendation	160.52	107.64	167.40
T2 - 125 % POP recommendation	225.72	124.46	237.30
T3 - 150 % POP recommendation	230.76	142.04	255.72
T4 - 175 % POP recommendation	245.30	157.72	324.82
CD (0.05)	44.54	12.54	40.93

4.1.1.2. Secondary nutrients (Ca, Mg and S)

The data on available secondary nutrient content in soil are presented in Table 7.

Available calcium content in soil ranged from 35.56 mg kg^{-1} (T_3) to 42.38 mg kg^{-1} (T_1). There was no significant difference between the treatments with respect to available calcium content in soil.

The available magnesium content of soil did not differ significantly with the different fertilizer treatments. It was the highest in T_4 (40.66 mg kg^{-1}) and the lowest in T_2 (31.68 mg kg^{-1}).

The available sulphur content in soil ranged from 49.50 mg kg^{-1} (T_1) to 29.70 mg kg^{-1} (T_4). There was no significant difference between the treatments regarding the available sulphur content in soil.

Table 7. Influence of fertilizer levels on status of available secondary nutrients in soil

Treatments	Ca (mg kg^{-1})	Mg (mg kg^{-1})	S (mg kg^{-1})
T1 - POP recommendation	42.38	36.06	49.50
T2 - 125 % POP recommendation	36.16	31.68	39.98
T3 - 150 % POP recommendation	35.56	33.92	47.34
T4 - 175 % POP recommendation	39.58	40.66	29.70
CD (0.05)	NS	NS	NS

4.1.1.3. Micronutrients (Fe, Mn, Zn, Cu and Cl) and Na

The analytical results on the available micronutrients content of soil with respect to various treatments are presented in Table 8.

The results showed that available iron content in soil ranged from 411.64 mg kg^{-1} (T_2) to 70.64 mg kg^{-1} (T_1). There was no significant difference between the treatments with respect to available iron in soil.

The available manganese content in soil ranged from 10.18 mg kg^{-1} (T_3) to 19.22 mg kg^{-1} (T_1). There was no significant influence of treatments on available manganese content in soil.

There was no significant difference between the treatments with respect to available zinc content in soil. It ranged from 7.8 mg kg^{-1} (T_3) to 7.01 mg kg^{-1} (T_2).

The available copper content in soil was the highest in T_2 (2.09 mg kg^{-1}) and the lowest in T_1 (0.96 mg kg^{-1}). All the treatments were on par.

The treatments could not significantly influence the available sodium content in soil. It ranged from 19.71 kg ha^{-1} (T_4) to 28.22 kg ha^{-1} (T_2).

The available chlorine content in soil ranged from 612 mg kg^{-1} (T_1) to 717 mg kg^{-1} (T_2). There was no significant difference between the treatments with respect to available chlorine content in soil.

Table 8. Influence of fertilizer levels on status of available micronutrients and sodium in soil

Treatments	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Na (kg ha^{-1})	Cl (mg kg^{-1})
T1 - POP recommendation	70.64	19.22	7.46	0.96	25.53	612
T2 - 125 % POP recommendation	411.64	16.33	7.01	2.09	28.22	633
T3 - 150 % POP recommendation	369.04	10.18	7.80	1.80	22.40	654
T4 - 175 % POP recommendation	164.08	12.52	7.28	1.59	19.71	717
CD (0.05)	NS	NS	NS	NS	NS	NS

4.1.2. Index leaf tissue concentration

4.1.2.1. Primary nutrients (N, P and K)

The results of concentration of primary nutrients in index leaf tissue of coconut as influenced by fertilizer levels are presented in Table 9.

The nitrogen content ranged from 1.17 % (T_1) to 1.50 % (T_4). However, there was no significant difference between the treatments.

The highest phosphorous content was recorded in T_4 (0.36 %) and lowest in T_1 (0.26 %). All the treatments were on par.

The potassium content in plant ranged from 1.21 % (T_1) to 1.36 % (T_3). There was no significant difference between the treatments with respect to index leaf tissue concentration of potassium.

Table 9. Influence of fertilizer levels on index leaf tissue concentration of primary nutrients

Treatments	N (%)	P (%)	K (%)
T1 - POP recommendation	1.17	0.26	1.21
T2 - 125 % POP recommendation	1.29	0.29	1.22
T3 - 150 % POP recommendation	1.38	0.32	1.36
T4 - 175 % POP recommendation	1.50	0.36	1.32
CD (0.05)	NS	NS	NS

4.1.2.2. Secondary nutrients (Ca, Mg and S)

The influence of fertilizer levels on index leaf tissue concentration of secondary nutrients is presented in Table 10.

The calcium content in plant ranged from 0.20 mg kg^{-1} (T_4) to 0.28 mg kg^{-1} (T_1). There was no significant variation between the treatments with respect to calcium content in plant.

The treatments could not show any significant effect on magnesium concentration in plant. It was the highest in T_1 (0.21 mg kg^{-1}) and the lowest in T_2 (0.15 mg kg^{-1}).

The results showed that sulphur content in plant ranged from 0.16 % (T_3) to 0.25 % (T_4). There was no significant difference between the treatments with respect to sulphur content in plant.

Table 10. Influence of fertilizer levels on Index leaf tissue concentration of secondary nutrients

Treatments	Ca (%)	Mg (%)	S (%)
T1 - POP recommendation	0.28	0.21	0.18
T2 - 125 % POP recommendation	0.20	0.15	0.17
T3 - 150 % POP recommendation	0.22	0.19	0.16
T4 - 175 % POP recommendation	0.20	0.17	0.25
CD (0.05)	NS	NS	NS

4.1.2.3. Micronutrients (Fe, Mn, Zn, Cu and Cl) and Na

The experimental results with respect to content of micronutrients (Fe, Mn, Zn, Cu, and Cl) and sodium in index leaf tissue of coconut as influenced by fertilizer levels are presented in Table 11.

The iron content in plant ranged from 997 mg kg^{-1} (T_1) to 1674 mg kg^{-1} (T_2). There was no significant difference between the treatments with respect to iron content in plant.

There was no significant difference between the treatments with respect to manganese content in index leaf tissue of coconut. It was the highest in T_1 (23.12 mg kg^{-1}) and lowest in T_4 (19.41 mg kg^{-1}).

The zinc content in index leaf tissue of coconut was significantly influenced by the treatments. The application of 175 % POP recommendation (T_4) recorded the highest zinc content in plant (193.76 mg kg^{-1}) which was on par with T_3 (189.84 mg kg^{-1}) and significantly higher than T_1 (187.12 mg kg^{-1}) and T_2 (187.36 mg kg^{-1}).

The copper content in plant ranged from 198.32 mg kg^{-1} (T_3) to 363.84 mg kg^{-1} (T_2). There was no significant difference between the treatments with respect to copper content in plant.

The sodium content in plant was not significantly influenced by the treatments. It was the highest in T_2 (0.12 %) and the lowest in T_3 and T_4 (0.10 %).

The chlorine content in soil ranged from 4232 mg kg^{-1} (T_1) to 4945 mg kg^{-1} (T_4). There was no significant variation between the treatments with respect to chlorine content in plant.

Table 11. Influence of fertilizer levels on Index leaf tissue concentration of micronutrients and sodium

Treatments	Fe ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Na (%)	Cl ($mg\ kg^{-1}$)
T1 - POP recommendation	997.61	23.12	187.12	223.90	0.11	4232
T2 - 125 % POP recommendation	1674.43	22.32	187.36	363.84	0.12	4524
T3 - 150 % POP recommendation	1524.81	20.43	189.84	198.32	0.10	4813
T4 - 175 % POP recommendation	1178.45	19.41	193.76	225.12	0.10	4945
CD (0.05)	NS	NS	4.78	NS	NS	NS

4.1.3. Yield, biochemical properties and nutritional qualities of coconut inflorescence sap

4.1.3.1. CIS yield

The results on yield of coconut inflorescence sap (CIS) as influenced by fertilizer levels are presented in Table 12.

The treatment T_4 (175 % POP recommendation) recorded the highest CIS yield (3.32 l day^{-1}) which was significantly higher than all the treatments. This was followed by T_3 (2.78 l day^{-1}) which was significantly higher than the remaining treatments. T_2 recorded CIS yield of 2.32 l day^{-1} which was significantly higher than T_1 (1.42 l day^{-1}).

4.1.3.2. Sap production duration

Table 12 also depicts sap production duration of coconut inflorescence sap as influenced by treatments.

The sap production duration ranged between 45.4 days (T_4) to 48.2 days (T_2). There was no significant difference between the treatments.

Table 12. Influence of fertilizer levels on CIS yield and Sap production duration

Treatments	Yield (l day^{-1})	Sap production duration (days)
T1 - POP recommendation	1.42	46.0
T2 - 125 % POP recommendation	2.32	48.2
T3 - 150 % POP recommendation	2.78	47.6
T4 - 175 % POP recommendation	3.32	45.4
CD (0.05)	0.26	NS

4.1.3.3. pH and electrolyte concentration

The analytical results of pH and electrolyte concentration of coconut inflorescence sap are presented in Table 13.

The pH of CIS was the highest in T_1 (6.70) which was on par with T_3 (6.64) and significantly higher than T_2 (6.40) and T_4 (6.40) which were on par.

The electrolyte concentration of sap was significantly influenced by the treatments. It was the highest in T_4 (3.96 dS m^1) which was on par with T_3 (3.85 dS m^{-1}) and significantly higher than other treatments. This was followed by T_2 (3.37 dS m^{-1}) which was significantly higher than T_1 (1.31 dS m^{-1}).

Table 13. Influence of fertilizer levels on pH and electrolyte concentration of coconut inflorescence sap

Treatments	pH	Electrolyte concentration (dS m^{-1})
T1 - POP recommendation	6.70	1.31
T2 - 125 % POP recommendation	6.40	3.37
T3 - 150 % POP recommendation	6.64	3.85
T4 - 175 % POP recommendation	6.40	3.96
CD (0.05)	0.22	0.33

4.1.3.4. Biochemical properties

4.1.3.4.1. Reducing sugars, non reducing sugars and total sugars

The results of influence of fertilizer levels on reducing sugars, non reducing sugars and total sugar content of coconut inflorescence sap are presented in Table 14.

The application of 175 % POP recommendation (T_4) resulted in a significant increase in reducing sugar of coconut inflorescence sap (0.57 g 100ml^{-1}) which was significantly higher than other treatments. T_3 (0.53 g 100ml^{-1}) recorded significantly higher reducing sugar than T_2 (0.44 g 100ml^{-1}) and T_1 (0.42 g 100ml^{-1}) which were on par.

The treatment T_3 (150 % POP recommendation) recorded the highest non reducing sugar content of 10.29 g 100ml^{-1}. However, it was on par with T_4 (10.27 g 100ml^{-1}). This was followed by T_2 (10.11 g 100ml^{-1}) and T_1 (9.69 g 100ml^{-1}) which were significantly different from one another.

The total sugar content followed the similar trend as non-reducing sugars with T_4 (10.84 g $100ml^{-1}$) and T_3 (10.82 g $100ml^{-1}$) giving on par values which were significantly superior to T_2 (10.56 g $100ml^{-1}$) and T_1 (10.12 g $100ml^{-1}$).

Table 14. Influence of fertilizer levels on sugar content of coconut inflorescence sap

Treatments	Reducing sugar (g $100ml^{-1}$)	Non reducing sugar (g $100ml^{-1}$)	Total sugars (g $100ml^{-1}$)
T1 - POP recommendation	0.42	9.69	10.12
T2 - 125 % POP recommendation	0.44	10.11	10.56
T3 - 150 % POP recommendation	0.53	10.29	10.82
T4 - 175 % POP recommendation	0.57	10.27	10.84
CD (0.05)	0.02	0.1	0.11

4.1.3.4.2. Alcohol

The results of alcohol content of coconut inflorescence sap as influenced by fertilizer levels are presented in Table 15.

Among the treatments, T_4 (175 % POP recommendation) recorded the highest alcohol content of 0.09 %, which was on par with T_3 (0.08 %) and significantly higher than T_2 (0.06 %) and T_1 (0.05 %) which were on par.

Table 15. Influence of fertilizer levels on alcohol content of coconut inflorescence sap

Treatments	Alcohol (%)
T1 - POP recommendation	0.05
T2 - 125 % POP recommendation	0.06
T3 - 150 % POP recommendation	0.08
T4 - 175 % POP recommendation	0.09
CD (0.05)	0.01

4.1.3.4.3. Phenol and vitamin C

The analytical results of influence of fertilizer levels on phenol and vitamin C content of coconut inflorescence sap are presented in Table 16.

Application of 175 % POP recommendation (T_4) recorded the highest phenol content of coconut inflorescence sap (2.56 mg $100ml^{-1}$) which was on par with T_2 (2.51 mg $100ml^{-1}$) and significantly higher than the other treatments T_3 (2.05 mg $100ml^{-1}$) and T_1 (1.54 mg $100ml^{-1}$).

The treatments significantly influenced the vitamin C content of CIS. T_4 (2.19 mg $100ml^{-1}$) recorded the highest vitamin C content which was on par with T_3 (1.98 mg $100ml^{-1}$), T_2 (1.89 mg $100ml^{-1}$) and significantly superior to T_1 (1.74 mg $100ml^{-1}$). The treatments T_1 and T_2 were however on par.

Table 16. Influence of fertilizer levels on phenols and vitamin C content of coconut inflorescence sap

Treatments	Phenol (mg $100ml^{-1}$)	Vitamin C (mg $100ml^{-1}$)
T1 - POP recommendation	1.54	1.74
T2 - 125 % POP recommendation	2.51	1.89
T3 - 150 % POP recommendation	2.05	1.98
T4 - 175 % POP recommendation	2.56	2.19
CD (0.05)	0.19	0.21

4.1.3.5. Nutritional qualities

4.1.3.5.1. Primary nutrients (N, P and K)

The analytical results of N, P, and K content of coconut inflorescence sap are presented in Table 17.

The application of 175 % POP recommendation (T_4) recorded the highest protein nitrogen content in coconut inflorescence sap of 0.45 % which was significantly higher than T_2 (0.40 %), T_3 (0.39 %) and T_1 (0.36 %).

Non protein nitrogen could not be detected in any of the samples in spite of higher doses of fertilizer application.

There was significant difference between all the treatments with respect to P content of CIS. T_4 (0.31 %) recorded the highest value followed by T_3 (0.29 %), T_2 (0.23 %) and T_1 (0.20 %), which were all significantly different from one another, Among the treatments, T_4 (175 % POP recommendation) recorded the highest potassium content of coconut inflorescence sap (1.05 %) which was significantly higher than T_3 (0.78 %), T_2 (0.72 %) and T_1 (0.69 %) which were on par.

Table 17. Influence of fertilizer levels on content of nitrogen (protein and non protein) phosphorous and potassium in coconut inflorescence sap

Treatments	Nitrogen (%)		Phosphorous (%)	Potassium (%)
	Protein	Non-protein		
T1 - POP recommendation	0.36	Nil	0.20	0.69
T2 - 125 % POP recommendation	0.40	Nil	0.23	0.72
T3 - 150 % POP recommendation	0.39	Nil	0.29	0.78
T4 - 175 % POP recommendation	0.45	Nil	0.31	1.05
CD (0.05)	0.03	Nil	0.01	0.09

4.1.3.5.2. Secondary nutrients (Ca, Mg and S)

The results with respect to Ca, Mg and S content of coconut inflorescence sap are presented in Table 18.

The highest calcium content in CIS was recorded with the application of 175 % POP recommendation (294.96 mg l^{-1}) which was significantly higher than other treatments. This was followed by T_3 (260.40 mg l^{-1}), which was superior to T_2 (235.20 mg l^{-1}) and T_1 (184.00 mg l^{-1}) which were on par.

Results of magnesium content in CIS revealed that T_3 (298.86 mg l^{-1}) recorded the highest value which was on par with T_4 (290.84 mg l^{-1}) and significantly higher than T_2 (267.23 mg l^{-1}) and T_1 (253.21 mg l^{-1}).

The application of 175 % POP recommendation (T_4) recorded the highest sulphur content of coconut inflorescence sap (0.30 %) which was significantly higher than other treatments. This was followed by T_3 (0.28 %), T_2 (0.22 %) and T_1 (0.19 %).

Table 18. Influence of fertilizer levels on status of secondary nutrients in coconut inflorescence sap

Treatments	Calcium (mg l^{-1})	Magnesium (mg l^{-1})	Sulphur (%)
T1 - POP recommendation	184.00	253.21	0.19
T2 - 125 % POP recommendation	235.20	267.23	0.22
T3 - 150 % POP recommendation	260.40	298.86	0.28
T4 - 175 % POP recommendation	294.96	290.84	0.30
CD (0.05)	70.74	13.2	0.01

4.1.3.5.3. Micronutrients (Fe, Mn, Zn and Cu)

The results on Fe, Mn, Zn and Cu content of coconut inflorescence sap as influenced by treatments are presented in Table 19.

The application of 175 % POP recommendation (T_4) showed the highest iron content of coconut inflorescence sap (70.20 mg l^{-1}) which was significantly higher than T_2 (50.00 mg l^{-1}) and T_1 (33.04 mg l^{-1}) and on par with the T_3 (67.08 mg l^{-1}).

The manganese content in CIS was not influenced by treatments. It was the highest in T_3 (1.50 mg l^{-1}) and the lowest in T_1 (1.21 mg l^{-1}).

Among the treatments, T_1 recorded the highest zinc content of coconut inflorescence sap (9.32 mg l^{-1}) which was significantly higher than T_3 (9.20 mg l^{-1}), T_4 (9.18 mg l^{-1}) and T_2 (9.05 mg l^{-1}) which were on par.

The copper content of CIS ranged from 2.41 mg l^{-1} (T_1) to 2.70 mg l^{-1} (T_3). There was no significant difference between the treatments with respect to copper content.

Table 19. Influence of fertilizer levels on status of micronutrients in coconut inflorescence sap

Treatments	Iron (mg l^{-1})	Manganese (mg l^{-1})	Zinc (mg l^{-1})	Copper (mg l^{-1})
T1 - POP recommendation	33.04	1.21	9.32	2.41
T2 - 125 % POP recommendation	50.00	1.43	9.05	2.62
T3 - 150 % POP recommendation	67.08	1.50	9.20	2.70
T4 - 175 % POP recommendation	70.20	1.31	9.18	2.53
CD (0.05)	6.29	NS	NS	NS

4.1.3.5.4. Total mineral content

The results of total mineral content of coconut inflorescence sap are presented in Table 20.

There was significant difference between all the treatments with respect to total mineral content of CIS. T_4 recorded the highest value of 1.47 % which was significantly higher than all other treatments. It was followed by T_3 (1.25 %), T_2 (1.12 %) and T_1 (1.02 %).

Table 20. Influence of fertilizer levels on total mineral content in coconut inflorescence sap

Treatments	Mineral content (%)
T1 - POP recommendation	1.02
T2 - 125 % POP recommendation	1.12
T3 - 150 % POP recommendation	1.25
T4 - 175 % POP recommendation	1.47
CD (0.05)	0.01

4.2. EXPERIMENT2: INFLUENCE OF VARIETIES ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

Results of the experiment on the influence of varieties on yield and qualities of coconut inflorescence sap are presented below.

4.2.1. Yield, biochemical properties and nutritional qualities of coconut inflorescence sap

4.2.1.1. CIS yield

The results on yield of coconut inflorescence sap (CIS) as influenced by varieties are presented in Table 21.

The treatment T_3 (West coast tall) recorded the highest CIS yield of 3.14 l day^{-1} which was significantly higher than all other treatments. This was followed by T_4 (2.09 l day^{-1}), T_2 (1.80 l day^{-1}) which were on par. CIS yield was the lowest in T_1 (0.84 l day^{-1}).

Table 21. Influence of varieties on CIS yield

Treatments	CIS Yield (l day^{-1})
T1 - Malayan yellow dwarf	0.84
T2 – Keraganga	1.80
T3 - West coast tall	3.14
T4 - Kerasree	2.09
CD (0.05)	0.32

4.2.1.2. pH and electrolyte concentration

The analytical results on pH and electrolyte concentration of coconut inflorescence sap are presented in Table 22.

The pH of coconut inflorescence sap ranged from 6.6 (T_2 and T_3) to 6.8 (T_1). There was no significant difference between the varieties.

The electrolyte concentration of coconut inflorescence sap was significantly influenced by varieties. It was the highest in T3 (0.21 dS m^{-1}) which was on par with T_4 (0.20 dS m^{-1}) and T_2 (0.19 dS m^{-1}) and significantly higher than T_1 (0.18 dS m^{-1}). T_4, T_2 and T_1 were on par.

Table 22. Influence of varieties on pH and electrolyte concentration of coconut inflorescence sap

Treatments	pH	Electrolyte concentration (dS m^{-1})
T1 - Malayan yellow dwarf	6.8	0.18
T2 – Keraganga	6.6	0.19
T3 - West coast tall	6.6	0.21
T4 - Kerasree	6.7	0.19
CD (0.05)	NS	0.02

4.2.1.3. Biochemical properties

4.2.1.3.1. Reducing sugars, non reducing sugars and total sugars

The results of influence of varieties on reducing sugars, non-reducing sugars and total sugar content of coconut inflorescence sap are presented in Table 23.

The variety west coast tall (T_3) recorded the highest reducing sugar content of 0.52 g $100ml^{-1}$ which was on par with the variety Kerasree (0.51 g $100ml^{-1}$). This was followed by the variety Keraganga (0.43 g $100ml^{-1}$) and MYD (0.40 g $100ml^{-1}$) which were on par.

The treatment T_1 (MYD) gave the maximum non reducing sugar content of 10.23 g $100ml^{-1}$ which was on par with T_3 (WCT). T_4 (Kerasree) recorded the lowest non reducing sugar content of 9.91 g $100ml^{-1}$ which was on par with T_2 (Keraganga).

The highest total sugar content of 10.66 g $100ml^{-1}$ was associated with the variety WCT (T_3) which was on par with MYD (T_1) and Keraganga (T_2). The lowest total sugar content was seen in variety Kerasree (10.42 g $100ml^{-1}$).

Table 23. Influence of varieties on sugar content of coconut inflorescence sap

Treatments	Reducing sugar (g $100ml^{-1}$)	Non reducing sugar (g $100ml^{-1}$)	Total sugars (g $100ml^{-1}$)
T1 - Malayan yellow dwarf	0.40	10.23	10.64
T2 – Keraganga	0.43	10.02	10.50
T3 - West coast tall	0.52	10.15	10.66
T4 - Kerasree	0.51	9.91	10.42
CD (0.05)	0.03	0.19	0.18

4.2.1.3.2. Alcohol

The results of alcohol content of coconut inflorescence sap as influenced by varieties are presented in Table 24.

Among the treatments, T_1 (Malayan yellow dwarf) recorded the highest alcohol content of 0.09 % which was on par with T_4 (0.08 %) and significantly higher than T_3 (0.06 %) and T_2 (0.05 %) which were on par.

Table 24. Influence of varieties on alcohol content of coconut inflorescence sap

Treatments	Alcohol (%)
T1 - Malayan yellow dwarf	0.09
T2 – Keraganga	0.05
T3 - West coast tall	0.06
T4 - Kerasree	0.08
CD (0.05)	0.01

4.2.1.3.3. Phenol and vitamin C

The analytical results pertaining to phenol and vitamin C content of coconut inflorescence sap are presented in Table 25.

There was no significant difference between the treatments with respect to phenol content of coconut inflorescence sap. It was the highest in T_3 (5.71 mg $100ml^{-1}$) and the lowest in T_1 (4.02 mg $100ml^{-1}$).

The vitamin C content of CIS was the highest in T_3 (1.87 mg $100ml^{-1}$) which was on par with T_1 (1.76 mg $100ml^{-1}$) and T_4 (1.65 mg $100ml^{-1}$) and significantly higher than T_2 (1.38 mg $100ml^{-1}$). T_2 and T_4 were on par.

Table 25. Influence of varieties on phenols and vitamin C content of coconut inflorescence sap

Treatments	Phenol (mg $100ml^{-1}$)	Vitamin C (mg $100ml^{-1}$)
T1 - Malayan yellow dwarf	4.02	1.76
T2 – Keraganga	5.53	1.38
T3 - West coast tall	5.71	1.87
T4 - Kerasree	5.56	1.65
CD (0.05)	NS	0.30

4.2.1.4. Nutritional qualities

4.2.1.4.1. Primary nutrients (N, P and K)

The analytical results of N, P, and K content of coconut inflorescence sap are presented in Table 26.

There was no significant difference between the treatments with respect to protein nitrogen content in CIS. It was the highest in T_4 (0.30 %) and the lowest in T_2 (0.14 %).

Non protein nitrogen could not be detected in the sap from any of the varieties.

The treatment T_1 (Malayan yellow dwarf) recorded the highest phosphorous content in sap of 0.43 % which was significantly higher than T_3 (0.36 %), T_2 (0.34 %) and T_4 (0.26 %). T_3 and T_2 were on par.

The potassium content of coconut inflorescence sap was the highest in T_3 (1.40 %) which was significantly higher than T_2 (1.32 %), T_4 (1.26 %) and T_1 (1.18 %).

Table 26. Influence of varieties on content of nitrogen (protein and non protein) phosphorous and potassium in coconut inflorescence sap

Treatments	Nitrogen (%)		Phosphorous (%)	Potassium (%)
	Protein	Non protein		
T1 - Malayan yellow dwarf	0.20	Nil	0.43	1.18
T2 – Keraganga	0.17	Nil	0.34	1.32
T3 - West coast tall	0.20	Nil	0.36	1.40
T4 - Kerasree	0.30	Nil	0.26	1.26
CD (0.05)	NS	Nil	0.04	0.06

4.2.1.4.2. Secondary nutrients (Ca, Mg and S)

The results with respect to Ca, Mg, and S content of coconut inflorescence sap as influenced by varieties are presented in Table 27.

The highest calcium content was associated with T_1 (579.20 mg l^{-1}) which was significantly higher than T_2 (541.60 mg l^{-1}), T_3 (541.20 mg l^{-1}) and T_4 (538.20 mg l^{-1}).

The magnesium content of coconut inflorescence sap ranged from 25.80 mg l^{-1} (T_1) to 30.76 mg l^{-1} (T_3). There was no significant difference between the treatments with respect to magnesium content of coconut inflorescence sap.

The results of sulphur content in CIS revealed that the treatment T_3 recorded the highest sulphur content of 0.30 % which was significantly higher than all other treatments. This was followed by T_1, T_4 and T_2.

Table 27. Influence of varieties on status of secondary nutrients in coconut inflorescence sap

Treatments	Calcium ($mg\ l^{-1}$)	Magnesium ($mg\ l^{-1}$)	Sulphur (%)
T1 - Malayan yellow dwarf	579.20	25.80	0.28
T2 – Keraganga	541.60	28.20	0.19
T3 - West coast tall	541.20	30.76	0.30
T4 - Kerasree	538.20	27.68	0.22
CD (0.05)	29.94	NS	0.01

4.2.1.4.3. Micronutrients (Fe, Mn, Zn and Cu)

The results on Fe, Mn, Zn and Cu content of coconut inflorescence sap as influenced by varieties are presented in Table 28.

The iron content of coconut inflorescence sap ranged from 58.32 mg l^{-1} (T_1) to 96.68 mg l^{-1} (T_3). There was no significant difference between the treatments with respect to iron content of coconut inflorescence sap.

The manganese content in CIS was also not influenced by varieties. It ranged from 1.82 mg l^{-1} (T_2) to 1.43 mg l^{-1} (T_3).

There was no significant difference between the treatments with respect to zinc content in CIS. It was the highest in T_1 (7.81 mg l^{-1}) and the lowest in T_4 (6.82 mg l^{-1}).

The variety Malayan yellow dwarf (T_1) recorded the highest copper content of coconut inflorescence sap (2.31 mg l^{-1}) which was significantly higher than T_3 (1.23 mg l^{-1}), T_2 (1.09 mg l^{-1}) and T_4 (0.58 mg l^{-1}).

Table 28. Influence of varieties on status of micro nutrients in coconut inflorescence sap

Treatments	Iron (mg l^{-1})	Manganese (mg l^{-1})	Zinc (mg l^{-1})	Copper (mg l^{-1})
T1 - Malayan yellow dwarf	58.32	1.51	7.81	2.31
T2 – Keraganga	90.68	1.82	7.52	1.09
T3 - West coast tall	96.68	1.43	7.13	1.23
T4 - Kerasree	79.72	1.62	6.82	0.58
CD (0.05)	NS	NS	NS	0.35

4.2.1.4.4. Total mineral content

The results of total mineral content of coconut inflorescence sap are presented in Table 29.

All the varieties significantly differed with respect to total mineral content. The treatment T_3 (West coast tall) recorded the highest total mineral content of 2.32 % which was significantly higher than T_1 (2.15 %), T_4 (2.12 %) and T_2 (2.06 %).

Table 29. Influence of varieties on total mineral content in coconut inflorescence sap

Treatments	Mineral content (%)
T1 - Malayan yellow dwarf	2.15
T2 – Keraganga	2.06
T3 - West coast tall	2.32
T4 - Kerasree	2.12
CD (0.05)	0.02

4.2.2. Biochemical properties of coconut inflorescence sap one week after collection

4.2.2.1. pH

The results on influence of storage on pH of coconut inflorescence sap from different coconut varieties are presented in Table 30.

There was a significant reduction in pH of coconut inflorescence sap on storage. All the varieties behaved in the similar manner. The lowest pH of 3.72 was obtained in variety Kerasree one week after storage.

4.2.2.2. Electrolyte concentration

The results on influence of storage on electrolyte concentration of coconut inflorescence sap are presented in Table 30.

The electrolyte concentration of coconut inflorescence sap was significantly increased on storage. It increased from 0.19 dS m^{-1} on day 1 to 2.93 dS m^{-1} on day 3 and finally reached 3.92 dS m^{-1} on day 7. The highest

Table 30. Changes in pH and electrolyte concentration in coconut inflorescence sap one week after storage.

Treatment combinations	pH	Electrolyte concentration ($dS\ m^{-1}$)
T1	5.56	2.17
T2	5.51	2.55
T3	5.54	2.01
T4	4.94	2.65
D1	6.7	0.19
D2	5.17	2.93
D3	4.29	3.92
T1D1	6.88	0.18
T1D2	5.42	2.60
T1D3	4.38	3.74
T2D1	6.6	0.19
T2D2	5.44	3.34
T2D3	4.5	4.14
T3D1	6.6	0.21
T3D2	5.44	2.40
T3D3	4.58	3.42
T4D1	6.72	0.19
T4D2	4.4	3.38
T4D3	3.72	4.38
CD – T (0.05)	0.09	0.07
CD – D (0.05)	0.07	0.06
CD - T D (0.05)	0.15	0.13

electrolyte concentration of 4.38 dS m^{-1} was recorded in the variety Kerasree (T_4) one week after storage, which was significantly higher than other varieties.

4.2.2.3. Reducing sugars

The results on concentration of reducing sugars in coconut inflorescence sap as influenced by storage are presented in Table 31.

There was a significant reduction in reducing sugar content from day 1 (0.47 g $100ml^{-1}$) to day 3 (0.38 g $100ml^{-1}$). Beyond day 3 there was a sharp decline and it reached zero on day 7. All the varieties behaved in a similar manner.

4.2.2.4. Non reducing sugars

The results on influence of storage on non-reducing sugars in coconut inflorescence sap are presented in Table 31.

Non reducing sugars content decreased significantly from day 1 (10.06 g $100ml^{-1}$) to day 3 (8.67 g $100ml^{-1}$) and finally reached 6.31 g $100ml^{-1}$ on day 7.

4.2.2.5. Total sugars

The results on influence of storage on total sugar content of coconut inflorescence sap are presented in Table 31.

There was a significant reduction in total sugars of coconut inflorescence sap on storage. All the varieties behaved in the similar manner.

4.2.2.6. Alcohol

The results on influence of storage on alcohol content of coconut inflorescence sap are presented in Table 32.

Table 31. Changes in reducing sugars, non reducing sugars and total sugar in coconut inflorescence sap one week after storage.

Treatment combinations	Reducing sugars (g/100ml)	Non reducing sugars (g/100ml)	Total sugars (g/100ml)
T1	0.24	8.95	9.19
T2	0.28	8.58	8.86
T3	0.29	7.74	8.04
T4	0.30	8.14	8.44
D1	0.47	10.70	10.55
D2	0.38	8.68	9.05
D3	0.00	6.31	6.31
T1D1	0.40	9.51	9.87
T1D2	0.33	8.81	9.12
T1D3	0.00	7.63	7.75
T2D1	0.47	9.32	9.70
T2D2	0.38	8.63	8.95
T2D3	0.00	7.44	7.58
T3D1	0.49	8.90	9.29
T3D2	0.40	8.21	8.54
T3D3	0.00	7.02	7.17
T4D1	0.51	9.10	9.49
T4D2	0.40	8.41	8.74
T4D3	0.00	7.22	7.37
CD – T (0.05)	0.016	0.17	0.15
CD – D (0.05)	0.014	0.14	0.13
CD - T D (0.05)	0.03	0.30	0.26

The alcohol content of coconut inflorescence sap was significantly increased on storage. It increased from 0.07 % on day1 to 1.93 % on day 3 and finally reached 2.74 % on day 7. The variety WCT recorded the highest alcohol content (3.38 %) on day 7 which was significantly higher than all other varieties.

4.2.2.7. Phenol

The results with respect to phenol content of coconut inflorescence sap on storage are presented in Table 32.

The phenol content of coconut inflorescence sap was significantly influenced by storage. It increased from 0.49 mg $100ml^{-1}$ on day 1 to 0.94 mg $100ml^{-1}$ on day 3 and finally reached 1.43 mg $100ml^{-1}$ on day 7. All the varieties showed similar trend of results.

4.2.2.8. Vitamin C

The results on vitamin-C content of coconut inflorescence sap as influenced by storage are presented in Table 32.

There was a significant influence of storage on vitamin C content of CIS. It increased sharply from day 1 (1.64 mg $100ml^{-1}$) to day 3 (15.93 mg $100ml^{-1}$) and further increased to 16.78 mg $100ml^{-1}$ on day 7. The highest value was associated with T_2 (17.18 mg $100ml^{-1}$) on day 7, which was on par with T_3 (17.08 mg $100ml^{-1}$) on the same day.

Table 32. Changes in alcohol, phenol and vitamin C in coconut inflorescence sap one week after storage.

Treatment combinations	Alcohol (%)	Phenol (mg/100ml)	Vitamin C (mg/100ml)
T1	1.28	0.92	11.23
T2	1.58	0.97	11.58
T3	2.00	0.95	11.78
T4	1.45	0.97	11.16
D1	0.07	0.49	1.64
D2	1.93	0.94	15.93
D3	2.74	1.43	16.75
T1D1	0.08	0.39	1.64
T1D2	1.48	0.94	15.54
T1D3	2.28	1.43	16.52
T2D1	0.04	0.54	1.36
T2D2	1.96	0.94	16.22
T2D3	2.76	1.43	17.18
T3D1	0.06	0.48	1.84
T3D2	2.56	0.94	16.44
T3D3	3.38	1.43	17.08
T4D1	0.08	0.55	1.72
T4D2	1.74	0.94	15.54
T4D3	2.54	1.43	16.22
CD – T (0.05)	0.05	0.04	0.17
CD – D (0.05)	0.05	0.04	0.14
CD - T D (0.05)	0.10	0.08	0.30

DISCUSSION

5. DISCUSSION

The results generated from the study on influence of nutrition and varieties on yield and qualities of coconut inflorescence sap are discussed in this chapter.

5.1. EXPERIMENT 1

5.1.1. Available nutrient status of soil

5.1.1.1. Primary nutrients (N, P and K)

The treatments showed significant influence on available N status of soil. It was the highest in 175 % POP recommendation but was on par with the other treatments namely 150 % POP recommendation and 125 % POP recommendation.

There was a progressive increase in available P status of soil with increasing levels of NPK fertilizer application. The available P content of soil was the highest in the application of 175 % POP recommendation which was significantly higher than all the other treatments.

As expected the availability of potassium in soil also showed concomitant increase with increased levels of fertilizer application. The treatment receiving 175 % POP recommendation was superior to all other treatments. This was followed by the treatments receiving 150 % POP recommendation and 125 % POP recommendation which were on par but superior to POP recommendation.

The perusal of results obtained on available primary nutrients indicate that in spite of the enhanced removal of N, P and K for increased production of coconut inflorescence sap, there was an increase in alkaline $KMnO_4$ - N, Bray P and neutral normal ammonium acetate extractable K in soil in the case of application of higher levels of NPK fertilizers over treatment receiving POP recommendation of fertilizers (Fig. 1).

This may be due to the positive effect of N, P and K application at higher levels on the availability of N, P and K in the soil. Therefore after meeting the requirement of the crop, the added N, P and K might have helped to increase the status of these nutrients in soil. Similar results have also been reported by Mohandas (2012).

5.1.1.2. Secondary nutrients, micro nutrients and sodium

The availability of secondary nutrients (Ca, Mg and S), micro nutrients (Fe, Mn, Zn, Cu and Cl) and sodium were not significantly influenced by the treatments. There was no definite trend with respect to the availability of these nutrients.

5.1.2. Index leaf tissue concentration

The concentration of nutrients (primary, secondary, micro nutrients and sodium) in index leaf tissue of coconut was not significantly influenced by treatments. However a positive but non significant influence of fertilizer levels was obtained in the case of N, P, K, S and Zn, while an irregular trend was observed in the case of Ca, Mg, Fe, Mn, Cu, Na and Cl.

The enhanced nutrient release at the highest level of NPK and its subsequent absorption by the palm would have ultimately resulted in higher N, P and K in the index leaf, which would have lead to better photosynthesis and better palm productivity. A similar result was reported by Mohandas (2012).

5.1.3. Yield, biochemical properties and nutritional qualities of coconut inflorescence sap

5.1.3.1. CIS yield

The yield of coconut inflorescence sap was significantly influenced by the application of increased levels of NPK fertilizers. Application of 175 % POP recommendation recorded the highest CIS yield which was significantly higher than all other treatments (Fig. 2). The tune of increase was 133 % when compared to the treatments receiving POP recommendation of fertilizer. This was followed by the treatments receiving 150 % POP recommendation and 125 % POP recommendation respectively. The positive trend of results for coconut inflorescence sap yield obtained for higher levels of NPK fertilization is quite reasonable because there was a significant increase in available status of N, P and K in soil as well as a positive but insignificant increase in the index leaf tissue concentration of nutrients. Similar results on increased CIS yield in better managed palms was reported by Muralidharan and Deepthi (2013) who found that a coconut palm yields on an average 2 liters of neera per day, which may go even up to 4.5 liters per day based on health of the palm and management of the garden. The results are also in line with the findings of Wasantha *et al.* (2009) who found that sap flow in coconut depends on soil depth, water holding capacity of soil and leaf area of palm which inturn depend on the proper nutrition of coconut palms.

5.1.3.2. Sap production duration

The perusal of results on sap production duration of coconut palms as influenced by levels of fertilizer application revealed that there was no significant influence of fertilizer levels on sap production duration. This may be due to the fact that tapping is done on already existing spathe and so the duration of tapping is dependent on inherent palm characters rather than nutrition of the palms.

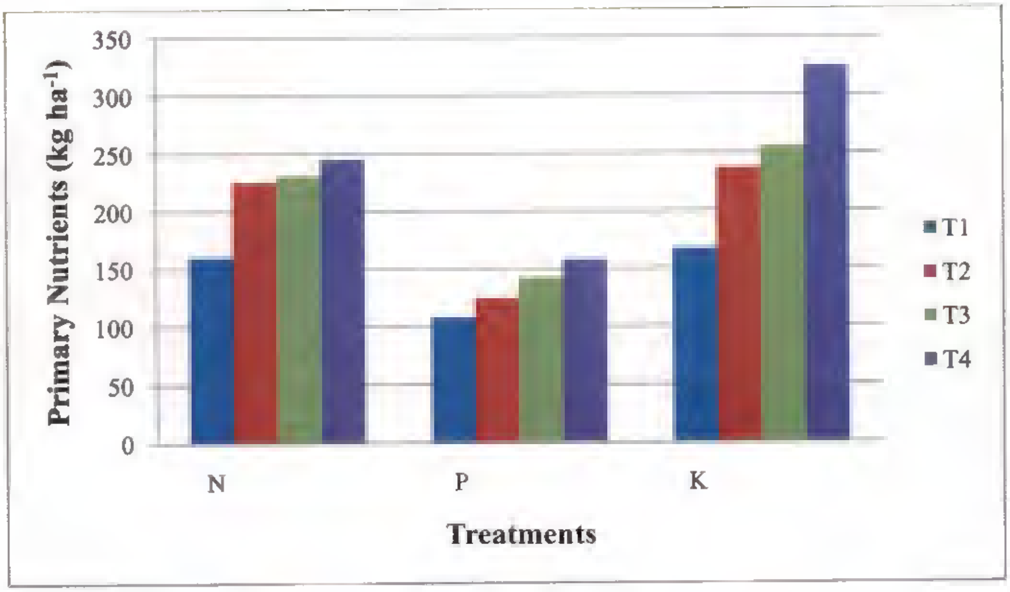

Fig 1. Influence of fertilizer levels on status of available primary nutrients of soil

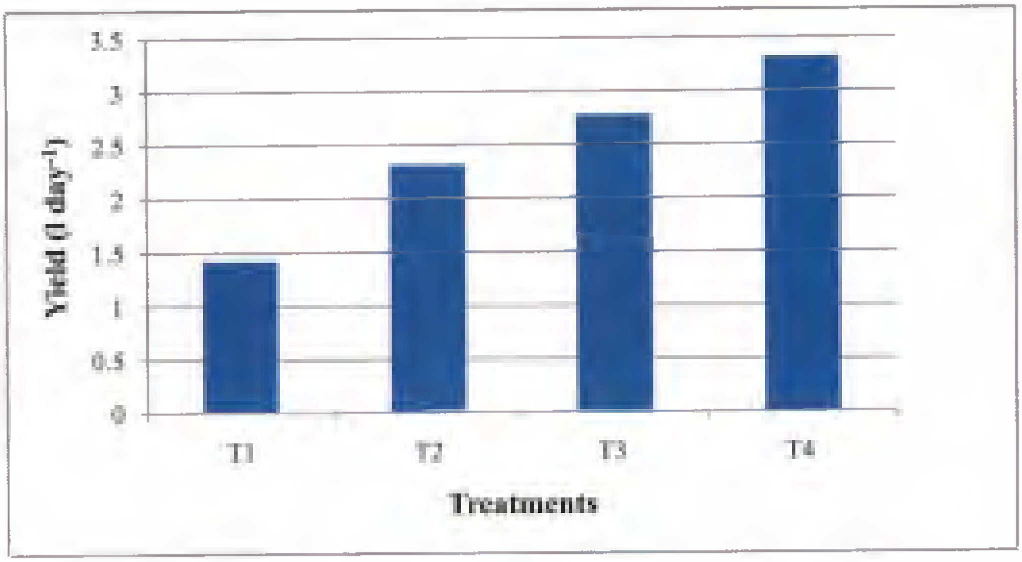

Fig 2. Influence of fertilizer levels on coconut inflorescence sap yield

The results are on accordance with the findings of Konan *et al.* (2013) who reported that the duration of sap production of coconut spathe is related to the length of the spathe and regular flow of sap during their exploitation.

5.1.3.3. pH and electrolyte concentration

The pH of CIS was found to be significantly influenced by treatments. It ranged from 6.70 to 6.40 (Fig. 3). Naik *et al.* (2013) also reported that neera has pH of 6.8. Similar results were reported by Nakumara *et al.* (2004) and Aalbersberg *et al.* (1997) who observed that coconut inflorescence sap has a pH of near neutral. The increasing levels of NPK fertilizers resulted in a decrease in pH of CIS. However the decrease did not show any uniform pattern.

The electrolyte concentration of CIS was observed to be significantly increased with increasing fertilizer levels. It was highest in the treatment receiving 175 % POP recommendation (3.96 dS m^{-1}) which was on par with the 150 % POP recommendation (Fig. 4). The increasing levels of fertilizers application would have resulted in increased production of sugars and phenols which would have increased the electrolyte concentration of CIS. The results on sugars and phenol content of CIS obtained in the experiment also are indicative of these results.

5.1.3.4. Biochemical properties

Increased levels of NPK fertilizers resulted in improved biochemical properties such as reducing sugars, non-reducing sugars, total sugars, alcohol, phenol and vitamin C.

5.1.3.4.1. Reducing sugars, non reducing sugars and total sugars

The content of reducing sugars, non reducing sugars and total sugars were significantly influenced by treatments (Fig. 5). The predominant sugar present in CIS was non-reducing sugars which ranged from 10.27 g/100ml to 9.69 g/100ml. Reducing sugars were in lower concentration (0.42 g $100ml^{-1}$ to 0.57 g/100ml).

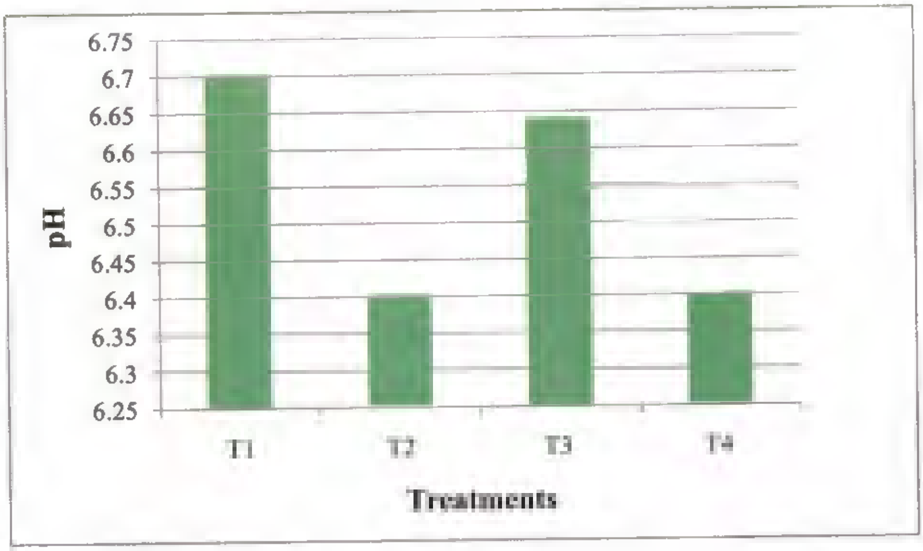

Fig 3. Influence of fertilizer levels on pH of coconut inflorescence sap

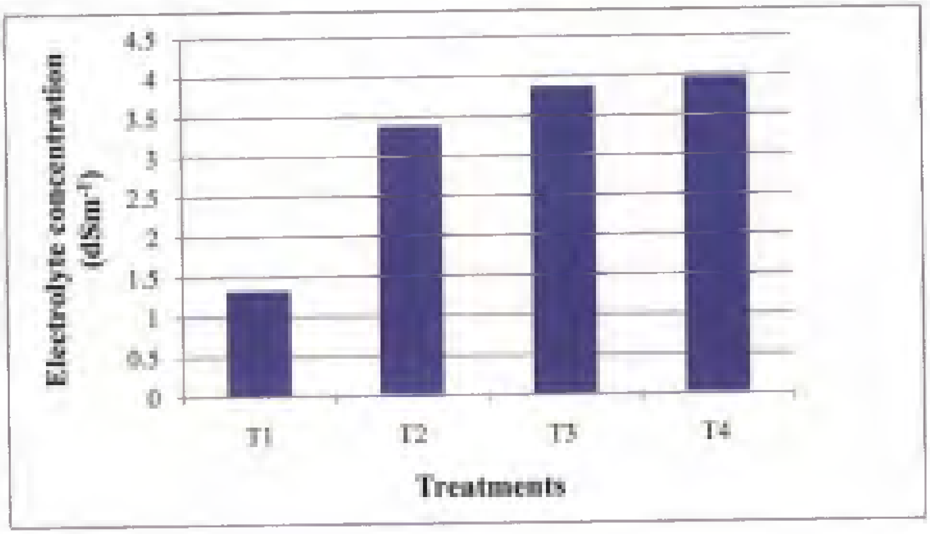

Fig 4. Influence of fertilizer levels on electrolyte concentration of coconut inflorescence sap

The results are in conformity with that reported by Barh and Mazumdar (2008) who found that fresh CIS has 12 to 15 % sucrose and trace amounts of glucose, fructose, maltose and raffinose. Similar results were also obtained by Singavardivel *et al.* (2012) who reported that fresh coconut inflorescence sap contains 12 - 15 % sucrose (non reducing sugar) content. The increasing sugar content with increasing fertilizer levels can be attributed to the extra nutrients supplied in these treatments which would have resulted in improved sugar parameters such as reducing sugars, non reducing sugars and total sugars. The increased available nutrient status of soil obtained in these treatments is also indicative of these results. Konan *et al.* (2014) also reported that soil conditions and mineral nutrition can influence the production of carbohydrates in palms.

5.1.3.4.2. Alcohol

The perusal of results obtained on alcohol content in fresh CIS obtained from different treatments indicates the presence of alcohol in the sap in all the treatments. Increasing levels of fertilizer application has resulted in a significant increase in alcohol content with the highest content of 0.09 % in the treatments receiving 75 % extra NPK fertilizer over POP recommendation (Fig. 6). The sugars present in the fresh CIS would have undergone partial fermentation which would have enhanced the alcohol content of sap. It should be also noted that the highest sugar content (reducing, non reducing and total sugars) was also associated with the treatment receiving 75 % extra NPK fertilizer which may be the reason for the present trend of results obtained with respect to alcohol content. The results are in conformity with those reported by Nur Aimi *et al.* (2013) who attributed the presence of alcohol in fresh coconut inflorescence sap to the presence of naturally present yeast in the sap which would have spontaneously started fermentation of sap even while still in the tapping process.

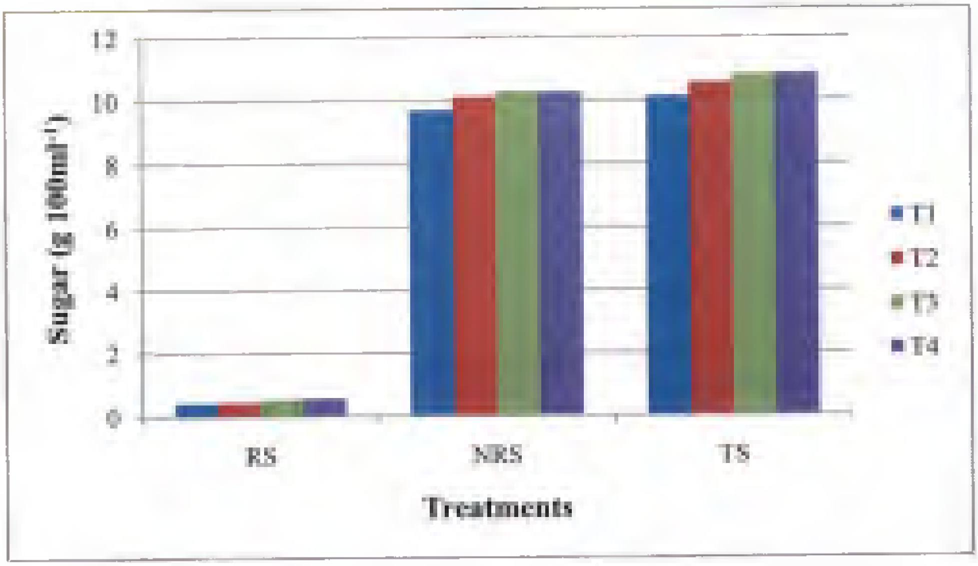

Fig 5. Influence of fertilizer levels on sugar content of coconut inflorescence sap

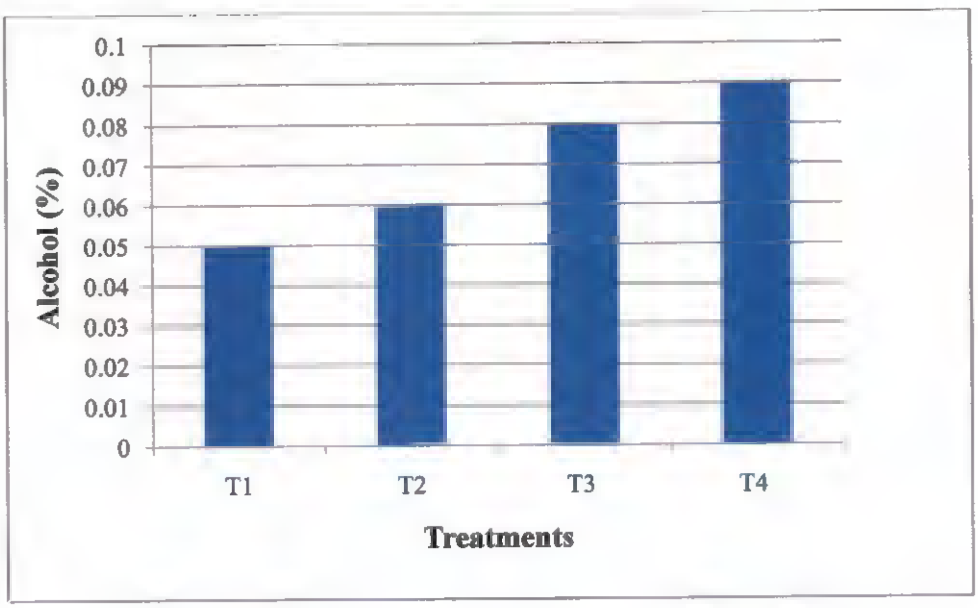

Fig 6. Influence of fertilizer levels on alcohol content of coconut inflorescence sap

5.1.3.4.3. Phenol and vitamin C

The results obtained from the present investigation revealed a significant increase in phenol content in coconut inflorescence sap (Fig. 7). Application of 175 % POP recommendation was superior in terms of phenol content (2.56 mg $100ml^{-1}$). The higher concentration of primary, secondary and micro nutrients in the palms receiving higher levels of NPK fertilizers would have resulted in greater synthesis of phenols which has reflected in higher phenol content in sap. Similar results on total phenolic content of coconut inflorescence sap was reported by Shymala Devi *et al.* (2015) who observed that fresh CIS has a total phenolic content of 0.34 mg l^{-1}.

There was a significant influence of nutrition to coconut in terms of higher levels of NPK fertilization on vitamin C content of coconut inflorescence sap. It increased from 1.74 mg $100ml^{-1}$ in the treatments receiving POP recommendation of fertilizers to 2.19 mg $100ml^{-1}$ in the highest fertilizer level viz., 175 % POP recommendation (Fig. 7). The status of available nutrients in soil and the content of primary, secondary and micro nutrients were also high in the above treatment. This would have facilitated synthesis of vitamin C at higher levels in the plant which has reflected in the higher concentration of vitamin C in the sap. The results are in agreement with the views of Hebbar *et al.* (2015) who reported that the essential elements N, P, K, Mg and micronutrients Zn, Fe and Cu give the biochemical constituents in freshly collected coconut inflorescence sap.

5.1.3.5. Nutritional qualities

The nutritional qualities *viz.*, N (protein and non-protein nitrogen), P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and total mineral content of coconut inflorescence sap increased with increasing fertilizer levels.

5.1.3.5.1. Primary nutrients (N, P and K)

As expected the content of primary nutrients N, P and K in fresh coconut inflorescence sap was significantly increased by increasing levels NPK fertilizers added. In the case of all the 3 nutrients, the highest level viz., 175 % POP recommendation resulted in highest content of N, P and K in sap (Fig. 8). The alkaline $KMnO_4$ N, Bray P and exchangeable K in soil was also high in the above treatment owing to the greater amounts of these nutrients applied to soil as NPK fertilizers. This would have resulted in better absorption of these nutrients which has reflected in higher content of these nutrients in coconut inflorescence sap. Similar results with respect to concentration of primary nutrients in leaf tissue were reported by Mohandas (2012).

Non protein nitrogen could not be detected in sap from any of the treatments. This is in spite of a significant increase in available N content in soil and content of N (protein N) in plant due to high level of fertilizer application (175 % POP recommendation). This indicates that application of NPK fertilizers in this very high level is not resulting in the accumulation of non protein nitrogen in sap which could have had possible health concerns.

5.1.3.5.2. Secondary and micronutrients

The content of secondary nutrients Ca, Mg and S in sap showed an upward trend with increasing levels of NPK fertilizer application (Fig. 9). However there was no clear trend with respect to content of micronutrients in sap except for iron which showed a significant increase with increasing levels of NPK fertilizers (Fig. 10). It should also be noted that there was no significant influence of treatments on status of secondary and micronutrients in soil. Hence it is presumed that the better nutrition of the crop in terms of the primary nutrients N, P and K would have produced a better root system for the crop which would have resulted in enhanced absorption of all nutrients including the secondary and micro nutrients.

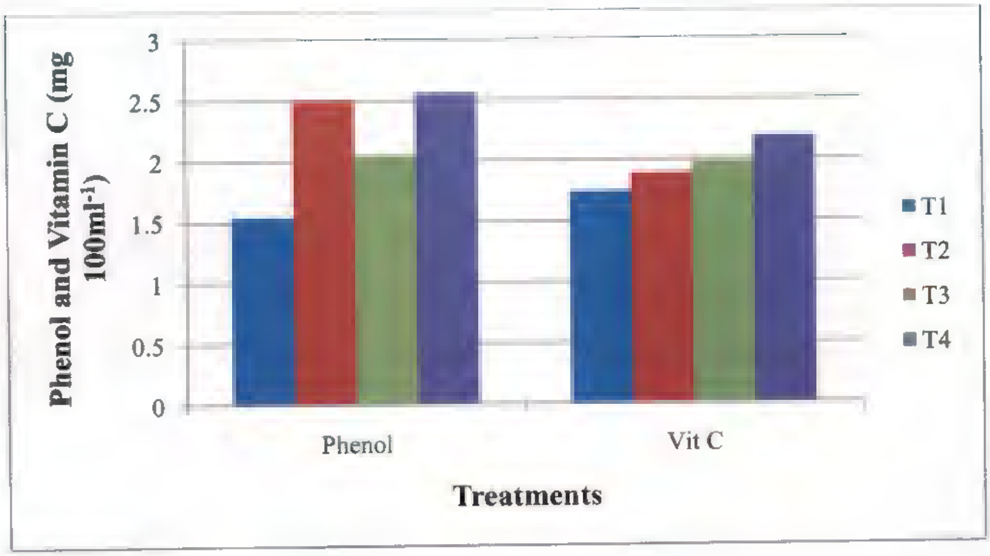

Fig 7. Influence of fertilizer levels on phenols and vitamin-C content of coconut inflorescence sap

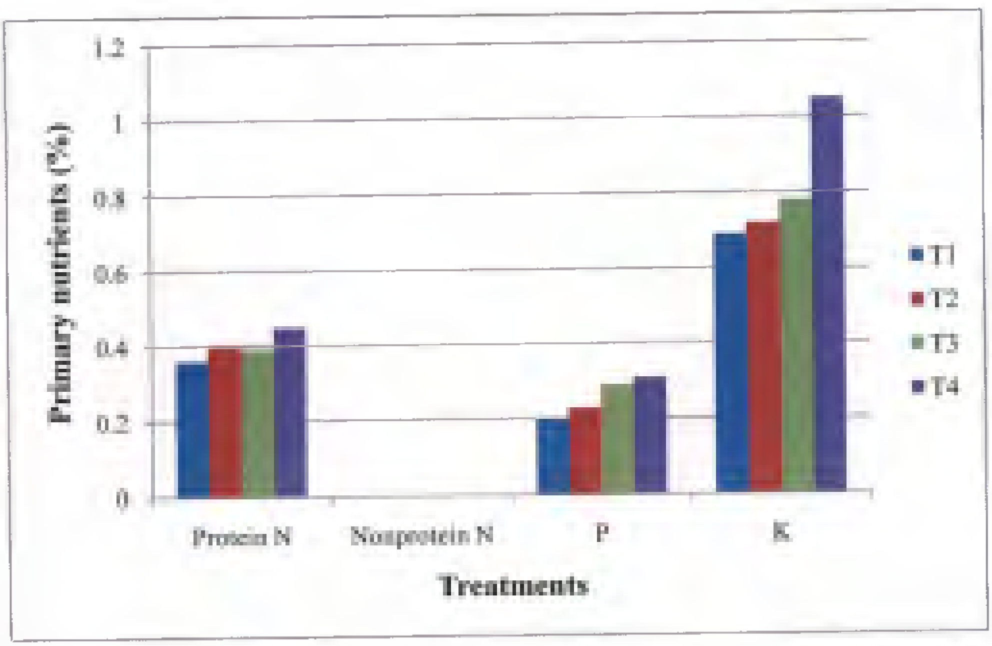

Fig 8. Influence of fertilizer levels on primary nutrients of coconut inflorescence sap

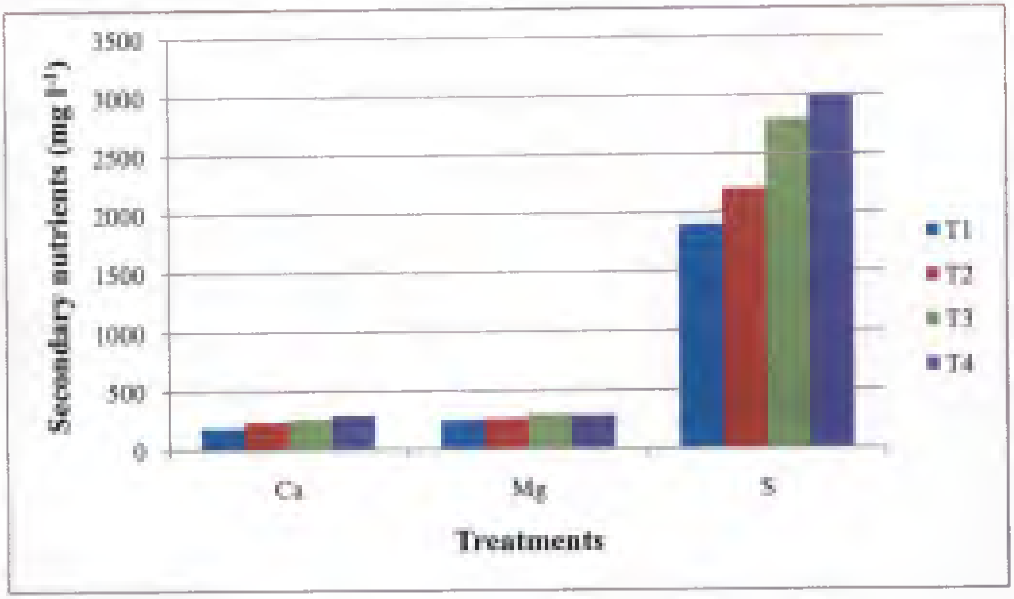

Fig 9. Influence of fertilizer levels on status of secondary nutrients of coconut inflorescence sap

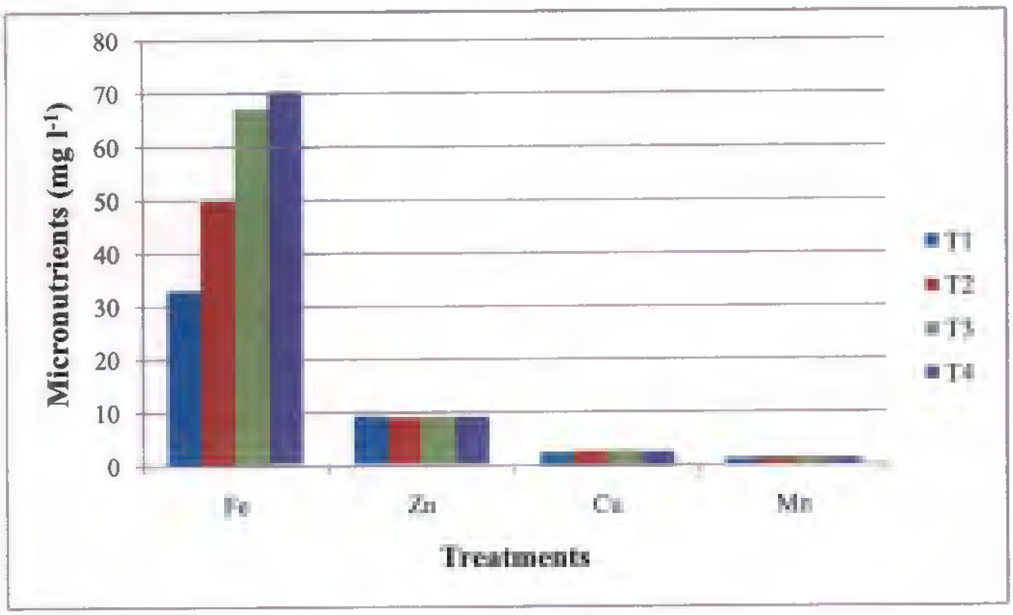

Fig 10. Influence of fertilizer levels on status of micro nutrients of coconut inflorescence sap

5.1.3.5.3. Total mineral content

The total mineral content of coconut inflorescence sap was conspicuously higher in the treatments receiving higher levels of NPK fertilizer. Among the treatments, application of 175 % POP recommendation was superior to all other treatments (Fig. 11). This is the reflection of the increased concentration of primary, secondary and micro nutrients in sap resulting from the increased absorption of these elements from the soil.

5.2. EXPERIMENT 2

5.2.1. Influence of varieties on yield, biochemical properties and nutritional qualities of coconut inflorescence sap

5.2.1.1. CIS yield

The varieties varied significantly with respect to yield of coconut inflorescence sap. The tall variety west coast tall had the highest CIS yield of 3.14 l day^{-1} which was significantly higher than the hybrids and dwarf varieties. The two hybrids Keraganga and Kerasree performed on par.

However the dwarf variety Malayan yellow dwarf was poor performer with a CIS yield of 0.84 l day^{-1} (Fig. 12). These differences can be attributed to the genetic potentials of the palms. These findings are in agreement with those reported by Samsudeen *et al.*, (2013) who reported that CIS production was maximum in tall variety WCT followed by D × T hybrid and lowest in the dwarf variety COD. Hebbar *et al.* (2015) and Konan *et al.* (2013) also reported same results.

5.2.1.2. pH and electrolyte concentration

pH of CIS did not vary significantly among the different varieties. It remained near neutral in all the varieties (Fig. 13).

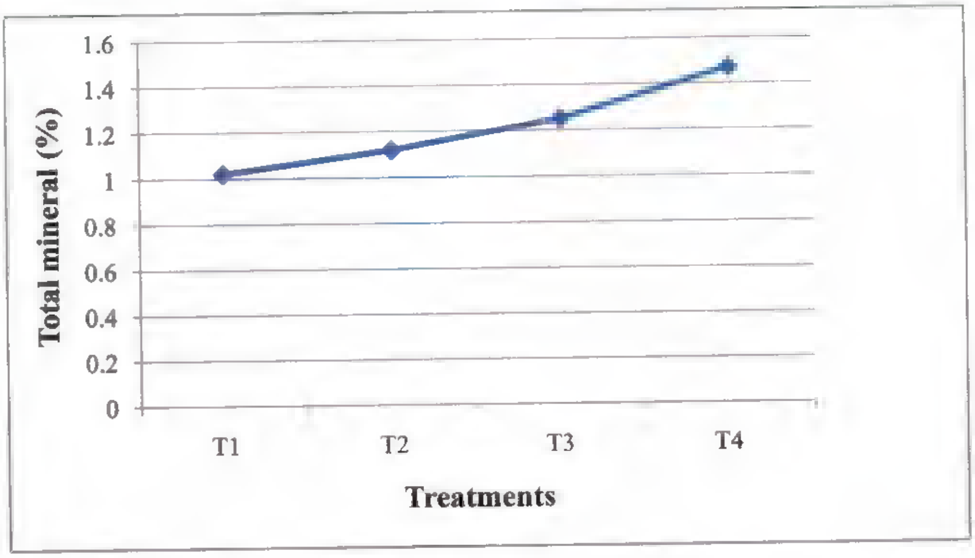

Fig 11. Influence of fertilizer levels on total mineral content of coconut inflorescence sap

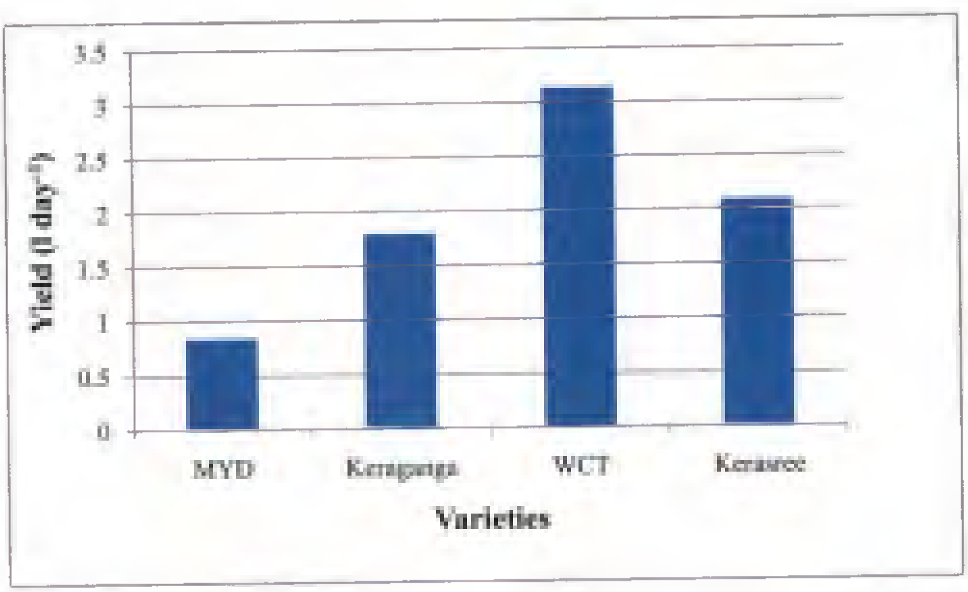

Fig 12. Influence of varieties on yield of coconut inflorescence sap

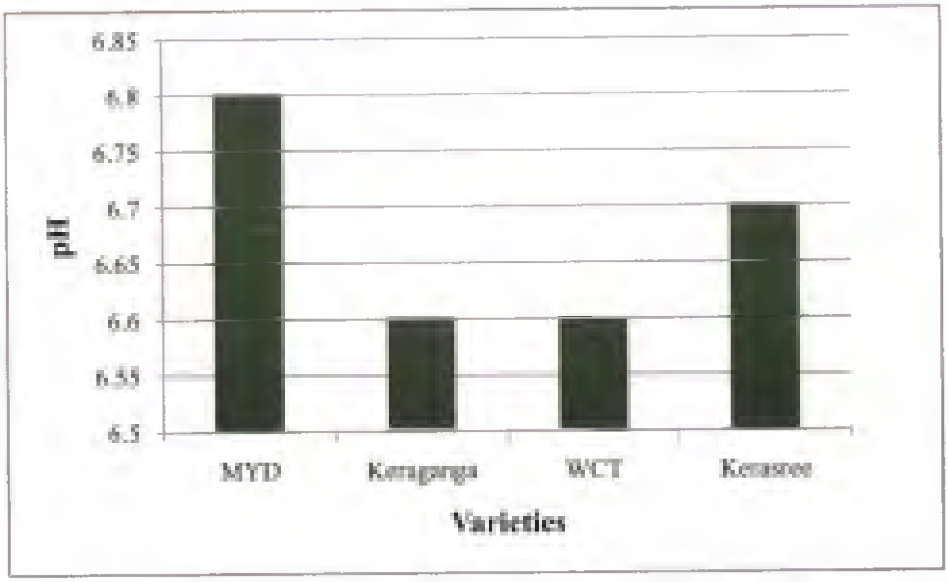

Fig 13. Influence of varieties on pH of coconut inflorescence sap

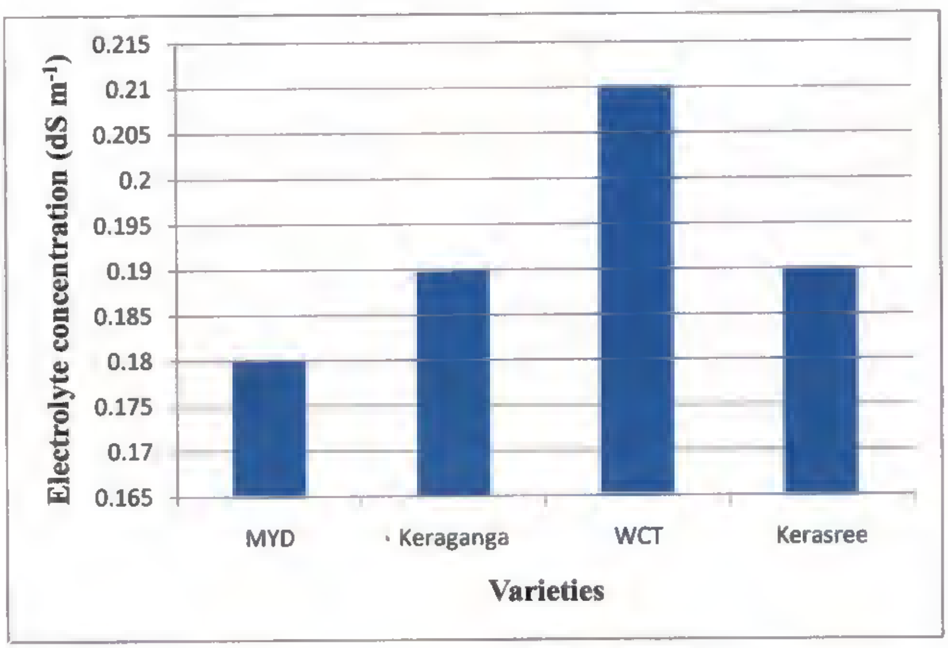

Fig 14. Influence of varieties on electrolyte concentration of coconut inflorescence sap

Similar results were reported by Nakamura *et al.* (2004). Further Hebbar *et al.* (2015) also reported that fresh coconut inflorescence sap has a nearly neutral pH.

The electrolyte concentration of CIS was observed to be significantly varying among the varieties (Fig. 14). It was highest in WCT (0.21 dS m^{l}), which was on par with Keraganga (0.19 dS m^{-1}) and Kerasree (0.19 dS m^{-1}) and significantly higher than MYD (0.18 dS m^{-1}).

This can be interpreted to the higher concentration of reducing sugars, non reducing sugars, total sugars and phenols associated with this treatment.

5.2.1.3. Biochemical properties

5.2.1.3.1. Reducing sugars, non reducing sugars and total sugars

The varieties differ significantly with respect to reducing sugars, non reducing sugars and total sugars (Fig. 15). This was in line with the findings of Konan *et al.* (2014) who reported that the sugar content of CIS depends on coconut ecotypes. Non reducing sugar dominated over reducing sugar in the case of all the varieties. More than 95 % of the total sugars in all the varieties were contributed by non reducing sugars. This is harmony with the findings of Michael *et al.* (1988) and Konan *et al.* (2014) who observed that carbohydrates of unfermented CIS had a greater proportion of sucrose. Similar results were also reported by Barh and Mazundar (2008).

Reducing sugar was highest in tall variety WCT which was on par with the hybrid Kerasree and significantly superior to the hybrid Keraganga and the dwarf variety Malayan yellow dwarf. The presence of small quantity of reducing sugars in the sap from all the varieties can be attributed to two biochemical processes.

The first source might be the enzymatic hydrolysis of sucrose during fermentation of sap which starts spontaneously by microorganisms in the sap, while the second source could be physiological synthesis of reducing sugars by the coconut palms during photosynthesis. Similar results were also reported by Konan *et al.* (2014).

The non reducing sugar content of sap was significantly higher in the dwarf variety MYD which was on par with WCT and significantly superior to the hybrids Kerasree and Keraganga. Similar results have been reported by Singaravardiel *et al.* (2012) and Nakumara *et al.* (2004) who found that dwarf varieties have more non reducing sugars than tall varieties and hybrids.

The highest total sugar content was associated with the variety WCT which was on par with Malayan yellow dwarf and Keraganga. It should be noted that even though the dwarf variety had poor sap production potential, it was superior with respect to concentration of non reducing sugars and total sugars.

This indicates more intensive sugar synthesis in dwarf coconut palms. The dwarf palms have weak root system that might not enable good mineral uptake. Consequently for their survival the dwarf coconut palms could achieve an intensive photosynthesis leading to higher production of carbohydrates which has reflected as higher non reducing sugar and total sugar in sap. Similar results were also reported by Konan *et al.* (2014).

5.2.1.3.2. Alcohol

The CIS from the different varieties had alcohol content ranging from 0.09 % (MYD) to 0.04 % (WCT) (Fig. 16). Singaravadivel *et al.* (2012) also reported that fresh CIS contains 0.2 % alcohol. There was a significant variation in alcohol content of CIS with varieties. The presence of alcohol in the sap of all varieties can be attributed to the fact that fermentation of sap starts right from the secretion of the first drop of sap as the CIS has a high load of yeast. Similar results were reported by Nur Aimi *et al.* (2013) who attributed the presence of alcohol in fresh coconut inflorescence sap to the presence of naturally present yeast in the sap

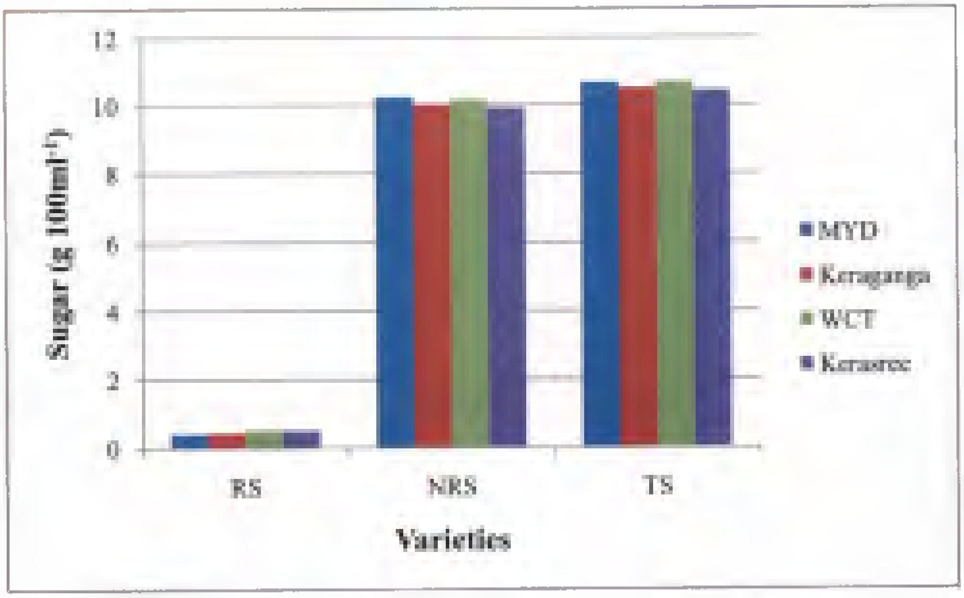

Fig 15. Influence of varieties on sugar content of coconut inflorescence sap

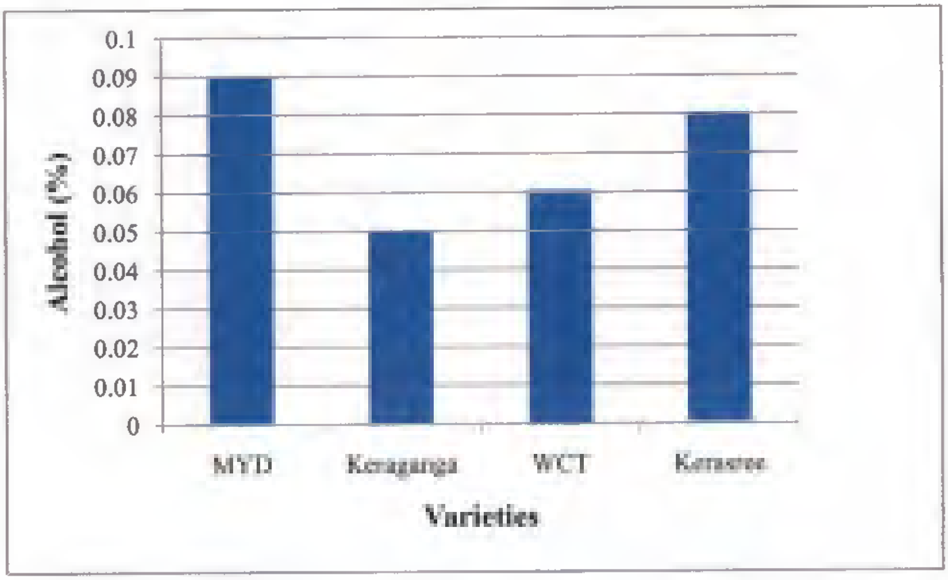

Fig 16. Influence of varieties on alcohol content of coconut inflorescence sap

which would have spontaneously started fermentation of sap even while still in the tapping process.

This highest alcohol content was associated with the dwarf variety Malayan yellow dwarf which was on par with Kerasree. Rather than the inherent genetic characters of the palm, the higher alcohol content can be attributed to the higher concentration of non reducing sugars which would have provided more substrate for yeast fermentation.

5.2.1.3.3. Phenol and vitamin C

The results obtained from the present investigation indicate that, phenol content in CIS ranged from 4.02 mg 100 ml^{-1} (MYD) to 5.71 mg 100ml^{-1} (WCT) (Fig. 17). Similar results were reported by Naik *et al.* (2013) who reported that Keramritham (Neera) contains 8.0 mg 100ml^{-1} of phenols and Syamala Devi *et al.* (2015) who observed a total phenolic content of 0.34 g l^{-1} in fresh coconut inflorescence sap. There was no significant variation among the varieties with respect to phenol content of sap.

There was a significant influence of varieties on vitamin C content of CIS (Fig. 17). The highest value was in the variety WCT which was on par with MYD and Kerasree. The source of vitamin C in the sap is from the yeast fermentation of sugar present in the sap. The highest vitamin C content in the variety WCT and MYD may be attributed to the higher non reducing sugar and total sugar seen in these varieties which would have facilitated faster fermentation and higher production of vitamin C. In similar studies Hebbar *et al.* (2015) observed 17.5 mg 100ml^{-1} of vitamin C and Syamala Devi *et al.* (2015) reported 20.6 mg l^{-1} of vitamin C in fresh coconut inflorescence sap.

5.2.1.4. Nutritional qualities of coconut inflorescence sap

5.2.1.4.1. Primary nutrients (N, P and K)

There was no varietal difference with respect to protein nitrogen content of coconut inflorescence sap. Also non protein nitrogen could not be detected in the sap from any of the varieties studied (Fig. 18).

The phosphorous and potassium content of sap were significantly influenced by the varieties (Fig. 18).

Phosphorus content ranged from 0.43 % in MYD to 0.26 % in Kerasree while the potassium content was highest in WCT (1.40 %) and lowest in MYD (1.18 %). These differences can be attributed to the genetic variation between varieties with respect to requirement and uptake of specific nutrients and intern their concentration in plant. Hebbar *et al.* (2015) have also reported that coconut inflorescence sap is rich in minerals with 168.4 mg $100ml^{-1}$ potassium and 3.9 mg $100ml^{-1}$ of phosphorous.

5.2.1.4.2. Secondary nutrients (Ca, Mg and S)

The calcium content of sap exhibited significantly variation among the varieties. Highest calcium content of 579.20 mg l^{-1} was observed in the variety MYD. The magnesium content of CIS did not show any significant variation among the varieties. The highest sulphur content was observed in variety WCT (0.30 %) (Fig. 19).

5.2.1.4.3. Micro nutrients (Fe, Mn, Zn and Cu)

The highest copper was observed in variety MYD (2.31 mg l^{-1}) which was significantly higher than other varieties. Zinc, Iron and Manganese content of CIS did not show any significant variation among the different varieties (Fig. 20). Similar findings were observed by Hebbar *et al.* (2015).

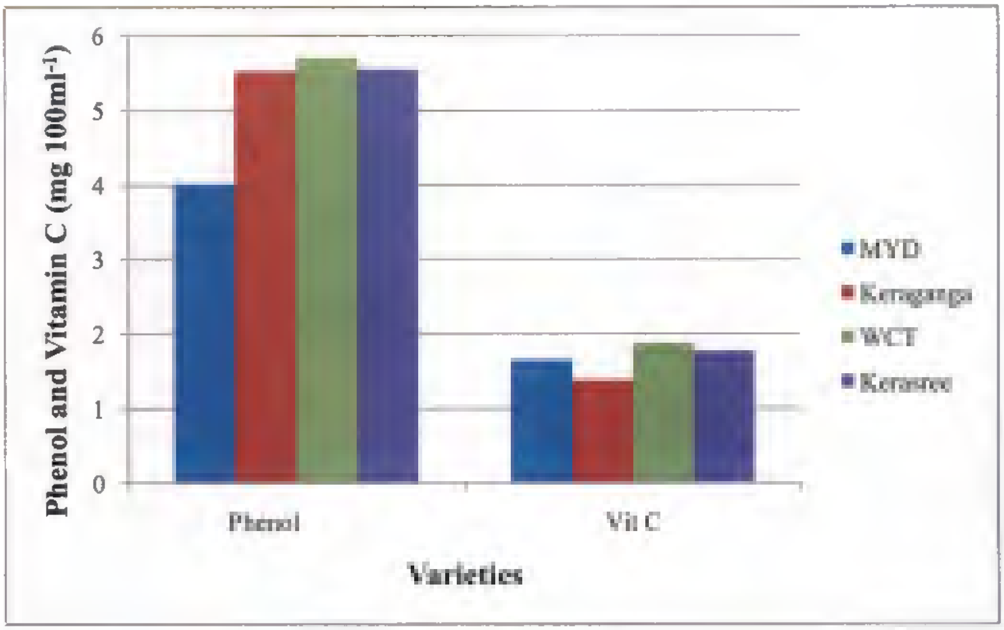

Fig 17. Influence of varieties on phenols and vitamin C content of coconut inflorescence sap

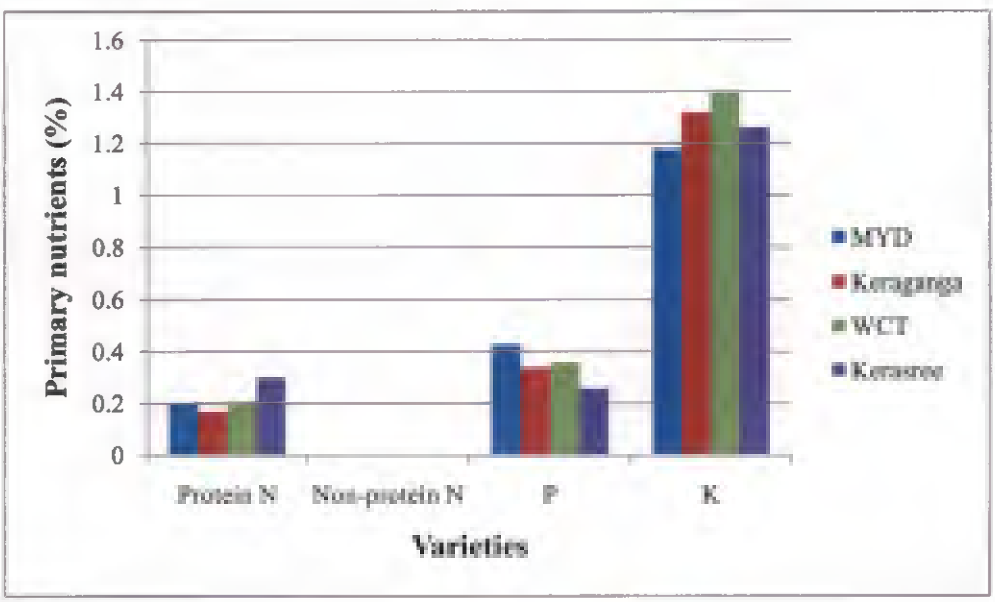

Fig 18. Influence of varieties on primary nutrients of coconut inflorescence sap

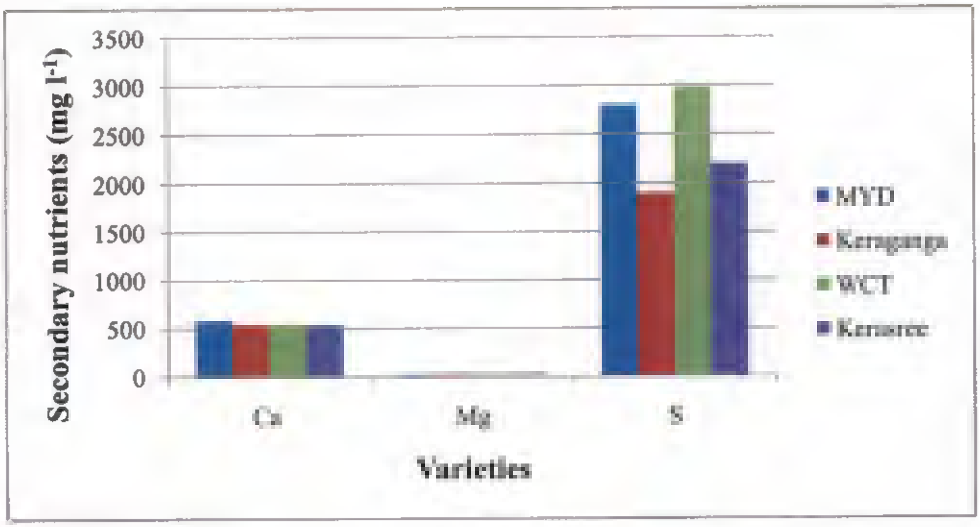

Fig 19. Influence of varieties on secondary nutrients of coconut inflorescence sap

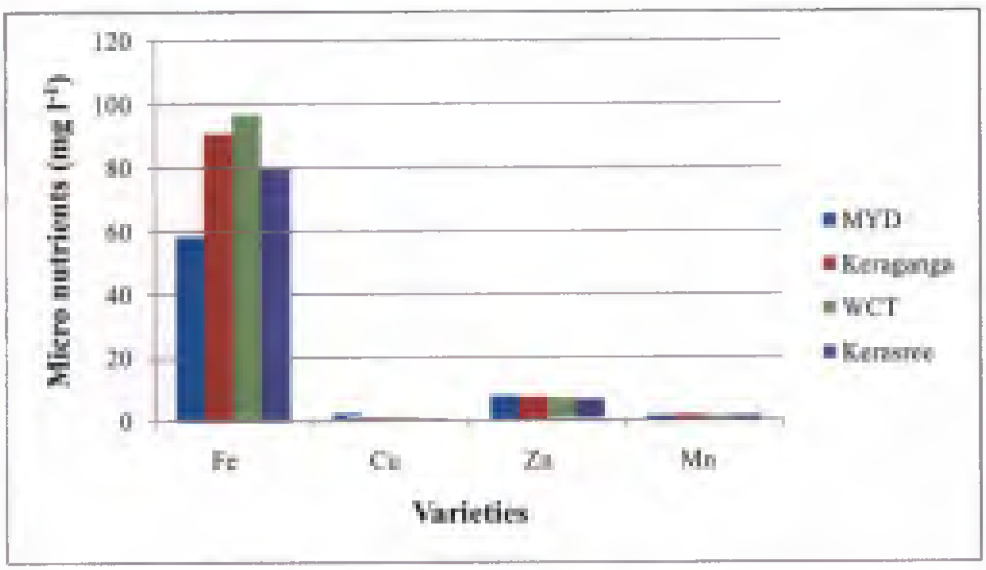

Fig 20. Influence of varieties on micro nutrients of coconut inflorescence sap

5.2.1.4.4. Total mineral content

As a reflection of the content of individual mineral elements in the sap, the total mineral content of sap was highest in the variety WCT which was significantly more than other varieties. This was followed by the variety MYD (Fig. 21). This can be accounted for the genetic characters of the variety with respect to uptake of these elements and accumulation in sap.

5.2.2. Biochemical properties of coconut inflorescence sap one week after collection

The present study showed that during storage of CIS, changes were observed in biochemical properties and nutritional qualities. These changes would have probably been induced by the fermentation of sugars. Natural fermentation of CIS consists of three stages viz., initial lactic acid fermentation, a middle alcoholic fermentation and a final acetic fermentation. At each stage, the microbial activity helps the activity of the micro-organisms in the next stage (Atputharajah *et al.*, 1986).

5.2.2.1. pH

The storage of CIS sample resulted in a significant decrease in pH. The lowest pH was obtained in variety Kerasree one week after storage (Fig. 22). This may be due to an acidification from lactic acid bacteria as reported by Xia *et al.*, (2011). Similar results have been reported by Singaravadivel *et al.* (2012). Further Hebbar *et al.* (2015) confirmed that fresh sap has slightly alkaline pH (7.5 - 8) and on fermentation a reduction in pH occurs and the pH attains values of 5.5 to 4.21 on 24 hours storage. Similar results were also reported by Stringini *et al.* (2009) and Hebbar *et al.* (2015).

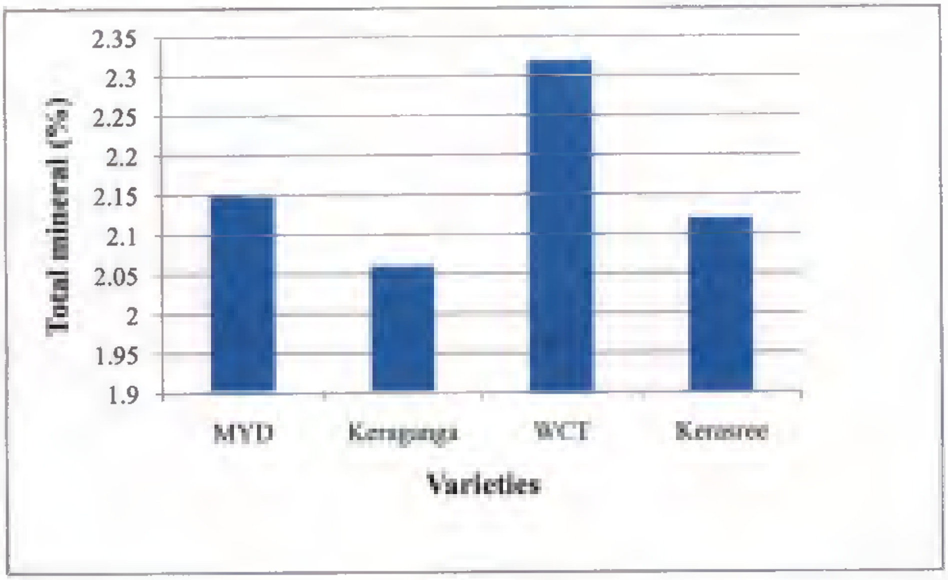

Fig 21. Influence of varieties on total mineral content of coconut inflorescence sap

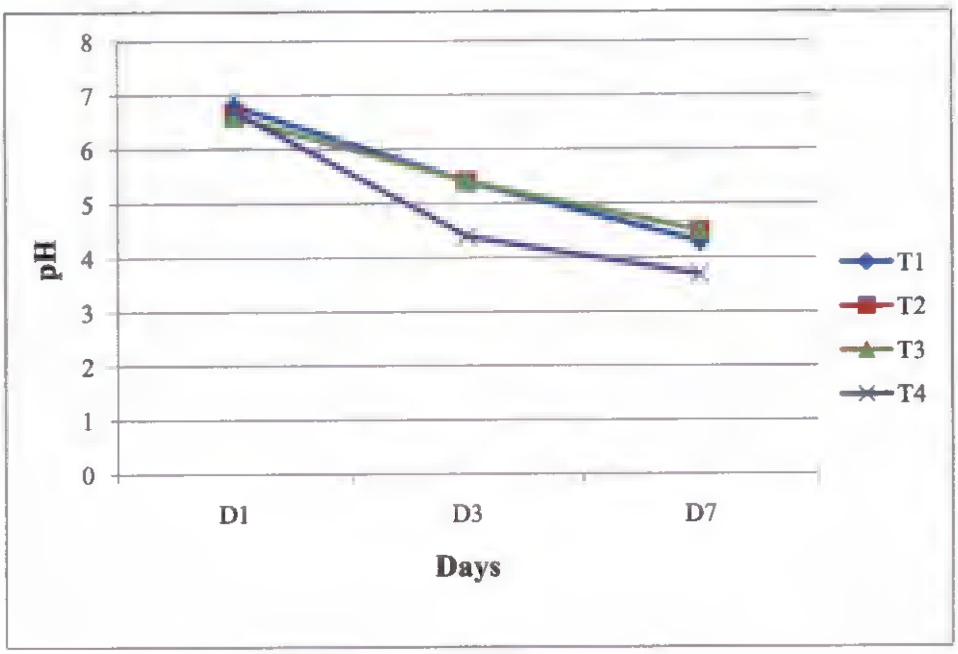

Fig 22. Changes in pH of coconut inflorescence sap on storage

5.2.2.2. Electrolyte concentration

The electrolyte concentration of coconut inflorescence sap increased significantly on storage. The highest electrolyte concentration was observed in the variety Kerasree (Fig. 23). This might be due to the production of higher quantities of alcohols, phenols and vitamins during the fermentation of sugars.

5.2.2.3. Reducing sugars

Irrespective of the variety, the reducing sugar content of sap showed a significant reduction on storage. Sap of each variety showed a significant reduction in reducing sugar content and finally it reached zero on day 7 (Fig. 24). These findings are on line with the reports of Atputharajah *et al.* (1988), who reported that initially sucrose will be converted into glucose and fructose and the amount of these reducing sugars will get reduced with time as the microbes that involve in fermentation will use the reducing sugars for their energy needs. Konan *et al.* (2014) also stated that the initial decrease of the reducing sugars could be as a result of the direct use of the residual glucose by microorganisms.

5.2.2.4. Non reducing sugars

The non-reducing sugar content was also reduced significantly on storage in the case of all the varieties (Fig. 25). This may be due to the conversion of sucrose to glucose and fructose during initial fermentation.

Similar results were reported by Xia *et al.* (2011). However in the present study it could be observed that unlike reducing sugar, non reducing sugar was not completely exhausted indicating that the fermentation process doesnot end with 7 days of storage of coconut inflorescence sap.

5.2.2.5. Total sugars

Falling in line with the trend of results obtained for reducing and non reducing sugars, the total sugar content was also significantly reduced during

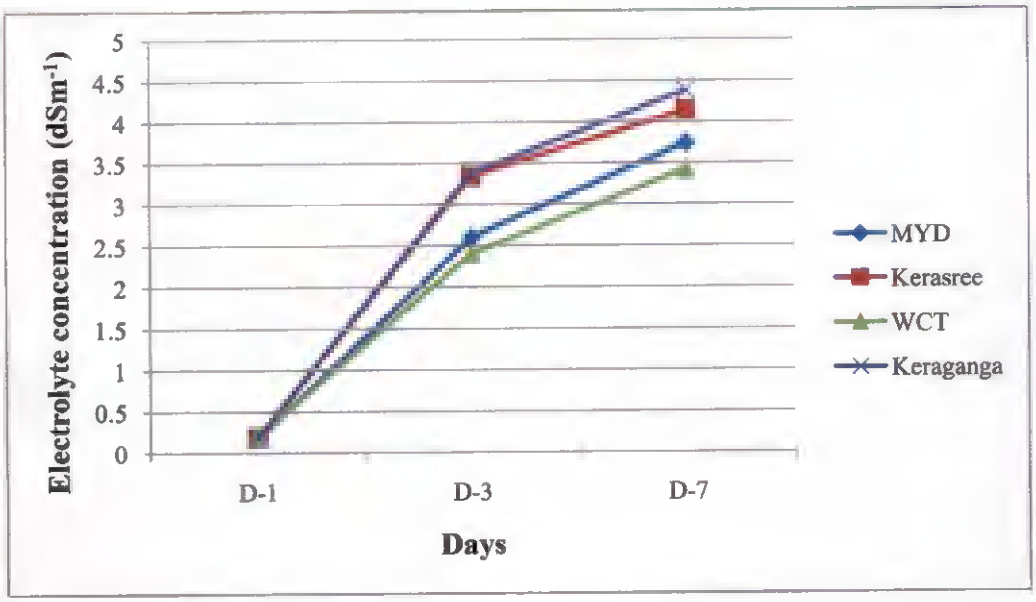

Fig 23. Changes in electrolyte concentration of coconut inflorescence sap on storage

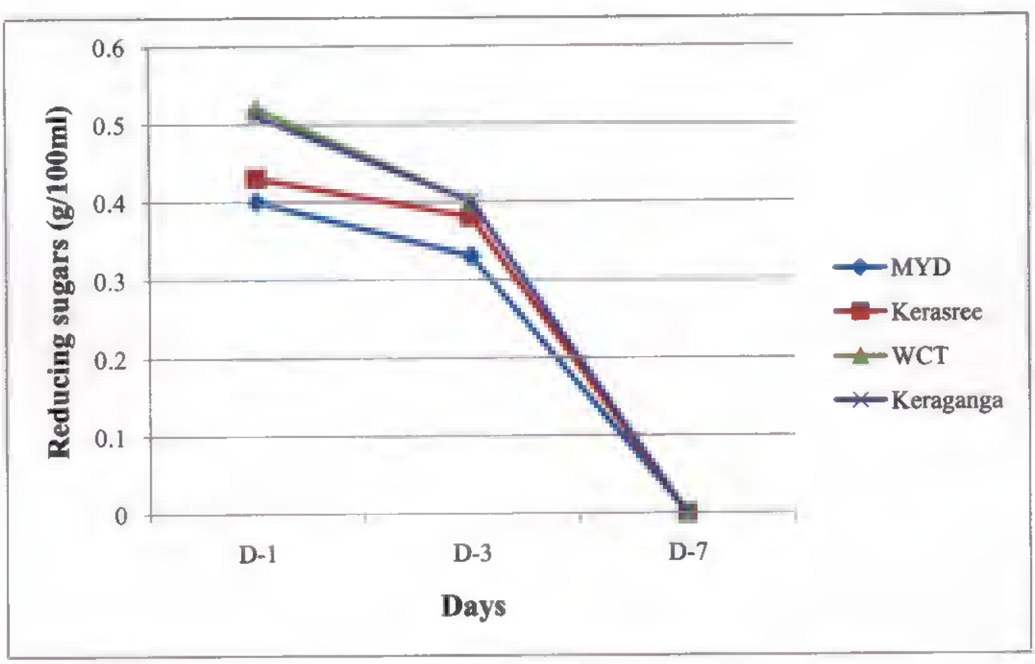

Fig 24. Changes in reducing sugars of coconut inflorescence sap on storage

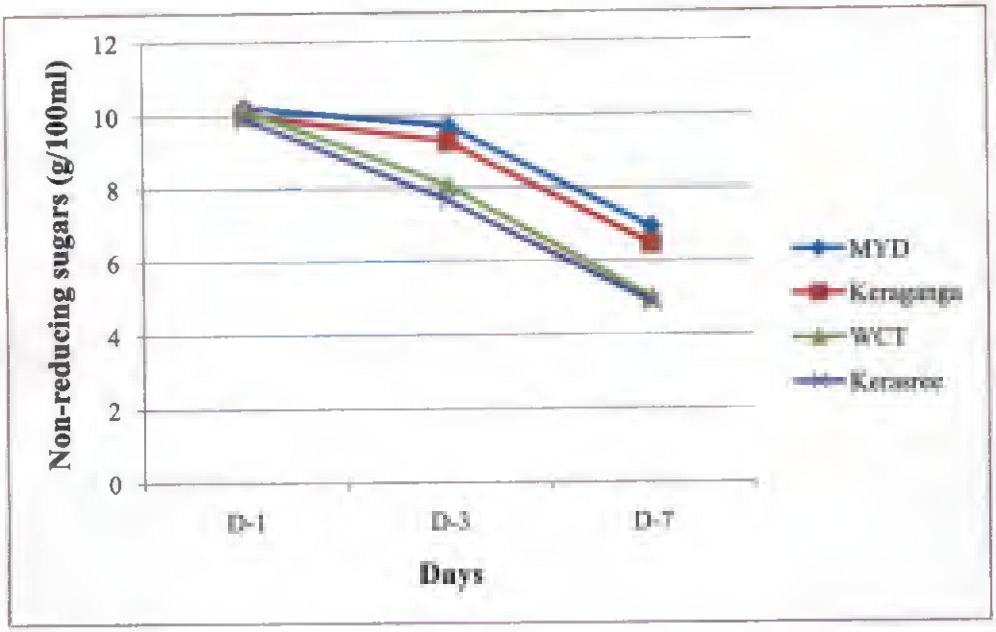

Fig 25. Changes in non-reducing sugars of coconut inflorescence sap on storage

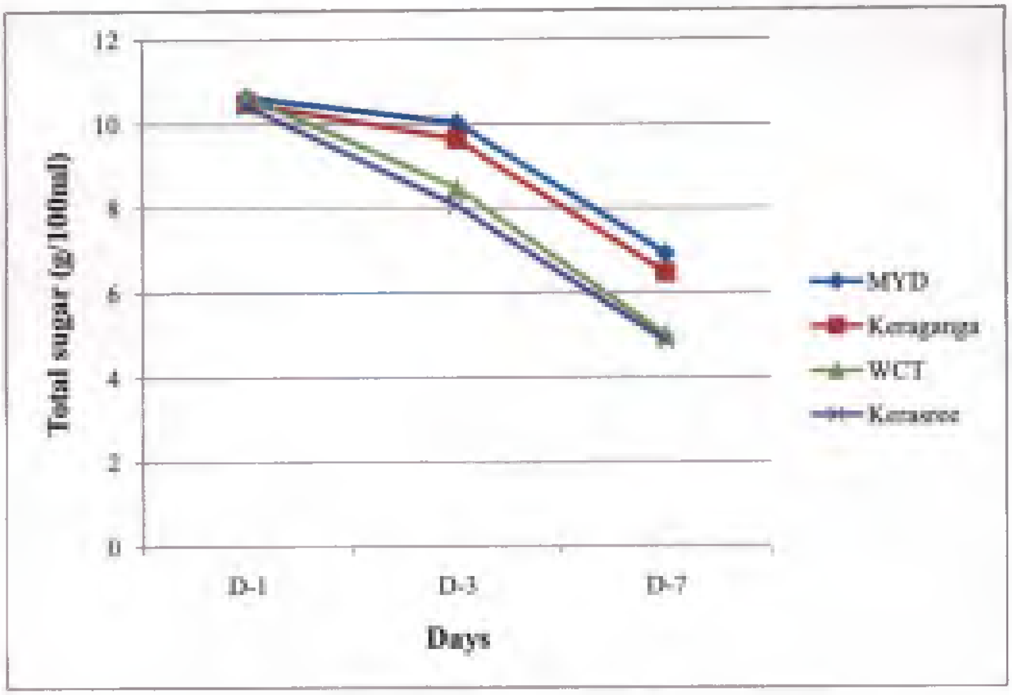

Fig 26. Changes in total sugar of coconut inflorescence sap on storage

storage. All the varieties behaved in the similar manner (Fig. 26). Similar results were also reported by Eze and Ogan (1988). This fluctuation in sugar content in coconut inflorescence sap might be due to the utilization of sugar for energy and the conversion of sugars into other substances by microbial activity. Similar findings were also observed by Opara *et al.* (2014).

5.2.2.6. Alcohol

As expected the alcohol content of coconut inflorescence sap was significantly increased on storage. The variety WCT gave the highest alcohol content of 3.38% on day 7 (Fig. 27). This was in harmony with the findings of Singaravadivel *et al.* (2012) who found that alcohol content of coconut inflorescence sap increases on storage. It increased to 4.5 % after 24 hours against the initial value of 0.2 %.

5.2.2.7. Phenol

Irrespective of the variety studied, the total phenol content of sap increased on storage. Highest value was obtained on day 7 for all the treatments (Fig. 28). The increase in the phenol content may be attributed to the degradation of glucoside bonds by the acids produced during natural fermentation which would have yielded polyphenolic compounds. The metabolism of certain microorganisms could have also contributed to the addition of polyphenols to the system. These results are in accordance with those reported by Landbo and Meyer (2004) and Xia *et al.* (2011).

5.2.3.8. Vitamin C

The perusal of results on changes in vitamin C content of CIS on storage revealed that the vitamin C content increased significantly on storage in the case of all the varieties wherein there was a sharp increase in vitamin C content from day 1 to day 3 and thereafter it appeared start stabilizing on day 7 (Fig. 29).

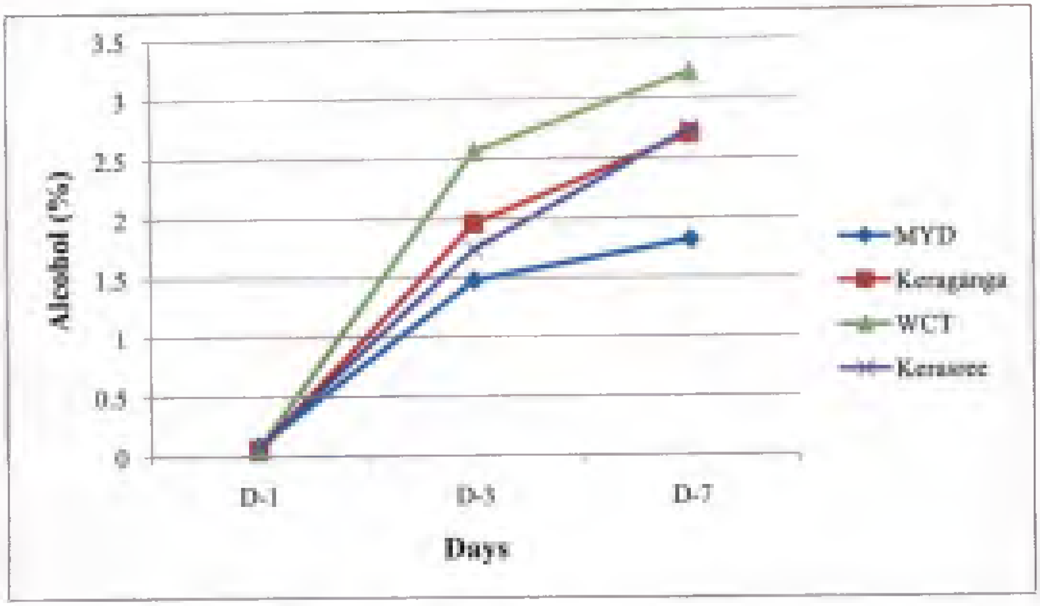

Fig 27. Changes in alcohol of coconut inflorescence sap on storage

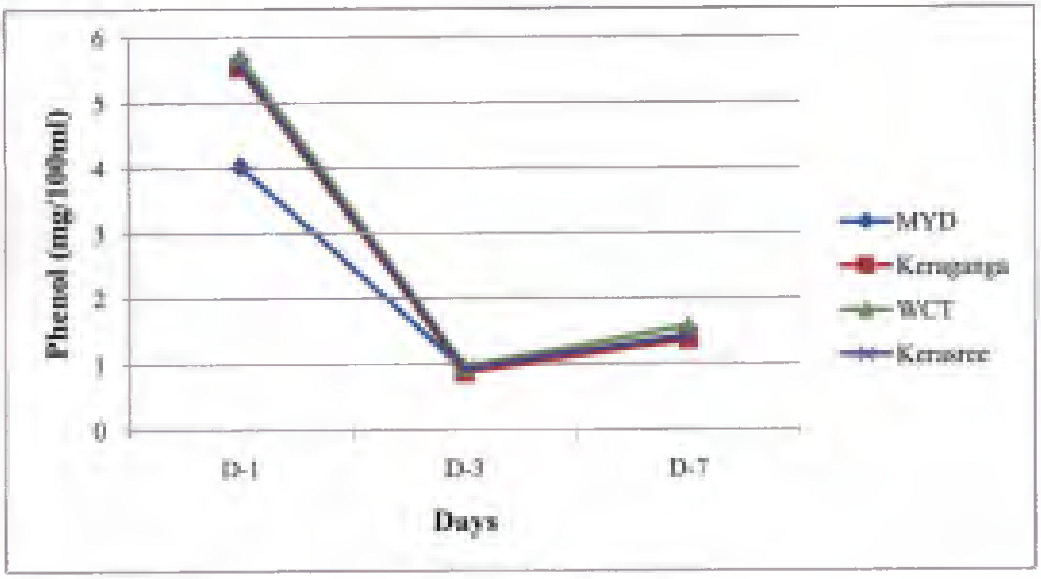

Fig 28. Changes in phenol of coconut inflorescence sap on storage

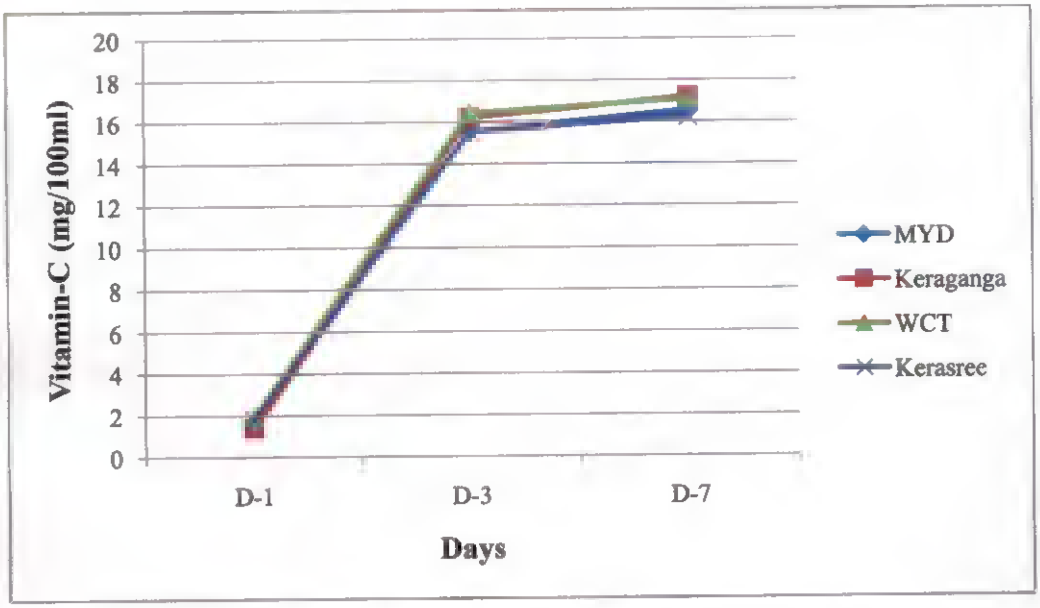

Fig 29. Changes in vitamin-C of coconut inflorescence sap on storage

The increased vitamin C content may be attributed to the increased activity of yeast which would have synthesized vitamin C during fermentation.

Similar results were also reported by Bremus *et al*., (2006), Singavardiel *et al*. (2012) and Syamala Devi *et al*. (2015).

SUMMARY

6. SUMMARY

The investigation entitled "Influence of nutrition and varieties on yield and qualities of coconut inflorescence sap" was undertaken at Instructional farm, College of Agriculture, Vellayani and Nileswaram farm, RARS Pilicode during 2014-2016 with an objective to assess the influence of nutrition to coconut (different levels of NPK fertilizers) and varieties on yield, nutritional qualities and biochemical properties of coconut inflorescence sap. The salient findings emanated from the study are summerised in this chapter.

The first experiment was to study the influence of nutrition as different levels of NPK fertilizers namely POP recommendation, 125 % POP recommendation, 150 % POP recommendation and 175 % POP recommendation which was carried out on west coast tall variety at Instructional Farm Vellayani.

From the results the following conclusions were derived.

- The treatment 175 % POP recommendation resulted in significantly higher available primary nutrients in the soil compared to other treatments.
- There was no significant influence of treatments on available secondary and micro nutrients status of soil.
- The concentration of primary, secondary and micro nutrients in index leaf tissue of coconut was not influenced by treatments except for Zn.
- Application of 175 % POP recommendation was superior to other treatments with respect to CIS yield (3.32 l day^{-1}).
- There was no significant influence of treatments on sap production duration.
- There was a significant influence of treatments on biochemical properties and nutritional qualities of CIS. The biochemical properties like reducing sugar (0.57 g $100ml^{-1}$), non reducing sugars (10.27 g $100ml^{-1}$), total sugars (10.84 g $100ml^{-1}$), alcohol (0.09 %), phenols (2.56 mg $100ml^{-1}$) and

vitamin C (2.19 mg $100ml^{-1}$) were significantly higher in the treatment receiving 175 % POP recommendation.

- The content of nitrogen, phosphorous and potassium in sap was significantly higher in the treatment receiving 175 % POP recommendation.
- Higher levels of fertilizer application did not result in the buildup of non protein nitrogen in the sap.
- The content of secondary nutrients Ca, Mg and S in the sap showed an upward trend with increasing levels of NPK fertilizers.
- There was no clear trend with respect to content of micronutrients in sap except for iron which was significantly higher in the treatment 175 % POP recommendation.
- Application of 175 % POP recommendation resulted in significantly higher total mineral content in sap.

The second experiment was to study the variability among coconut varieties namely Malayan Yellow Dwarf, Kerasree, West Coast Tall and Keraganga with respect to yield and quality of CIS which was conducted at Nileswaram farm RARS Pilicode. From the results of the study it can be concluded that

- The tall variety WCT was superior to dwarf variety and hybrids with respect to CIS yield. The dwarf variety MYD produced the lowest CIS yield.
- The pH of CIS did not vary significantly with varieties.
- The electrolyte concentration of sap was highest with the variety WCT.
- The varieties differed significantly with respect to reducing sugars, non reducing sugars and total sugar content of sap.
- Non reducing sugar dominated over reducing sugar in all the varieties. More than 95 % of the total sugars in all varieties were contributed by non

reducing sugars. Non reducing sugar content of sap was significantly higher in the dwarf variety MYD and tall variety WCT.

- Reducing sugar was highest in the tall variety WCT which was on par with hybrid Kerasree and significantly superior to the hybrid Keraganga and dwarf variety MYD.
- The increased non reducing sugar content associated with the variety MYD has also reflected in the higher alcohol % in this variety.
- There was no significant influence of varieties on phenol content of CIS.
- The varieties WCT and MYD were superior with respect to vitamin C content of coconut inflorescence sap.
- There was no varietal difference with respect to protein nitrogen content of CIS.
- Non protein nitrogen couldnot be detected in the sap from any of the varieties.
- The phosphorous and potassium content of sap were significantly influenced by the varieties. The variety MYD registered the highest phosphorous content while WCT records the highest potassium content in sap.
- The variety MYD was superior with respect to calcium content of sap while sap from the tall variety WCT had superior sulphur content.
- The micronutrient content of sap was not influenced by the varieties except for copper wherein MYD was superior to other varieties.
- The variety WCT was superior in terms of total mineral content of sap which was followed by the variety MYD.
- Studies on storage of CIS for one week revealed that without any differentiation between the varieties there was a significant reduction in the pH, total sugar, reducing sugars and non reducing sugar while there was an increase in alcohol, vitamin C and phenol content.

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INFLUENCE OF NUTRITION AND VARIETIES ON YIELD AND QUALITIES OF COCONUT INFLORESCENCE SAP

by

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Abstract of the thesis

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ABSTRACT

The present investigation entitled "Influence of nutrition and varieties on yield and qualities of coconut inflorescence sap" was conducted at Instructional farm, College of Agriculture, Vellayani and Nileswaram farm, RARS, Pilicode during 2014-2016. The objective of the study was to assess the influence of nutrition to coconut as different levels of fertilizers and varieties on yield, nutritional qualities and biochemical properties of coconut inflorescence sap.

The study consisted of two field experiments, both laid out in randomised block design. The first experiment was to study the influence of different levels of NPK fertilizers namely POP recommendation (T_1), 125 % POP recommendation (T_2), 150 % POP recommendation (T_3) and 175 % POP recommendation (T_4) which was carried out on west coast tall variety at Instructional Farm Vellayani under rainfed condition.

The analysis of soil samples collected at the end of the experiment revealed that the status of available primary nutrients (N, P and K) was significantly influenced by the treatments. T_4 recorded the highest value for all the 3 nutrients but it was on par with T_2 and T_3 in the case of N and was significantly superior to T_2 and T_3 in the case P and K. There was no significant difference between the treatments with respect to secondary and micro nutrients.

The analysis of index leaf tissue of coconut revealed that there was no significant influence of the fertilizer levels on the content of primary, secondary and micro nutrients except for zinc where T_4 (193.76 mg kg^{-1}) recorded the highest value which was on par with T_3 (189.84 mg kg^{-1}).

The yield of coconut inflorescence sap (CIS) was significantly influenced by fertilizer levels. T_4 (3.32 l day^{-1}) recorded the highest yield, which was 134% more over POP recommendation (T_1). However, there was no significant influence of treatments on sap production duration.

Analysis of CIS revealed that the pH of sap was significantly decreased by increasing fertilizer levels while the total electrolyte concentration increased till T_4 (3.96 dS m^{-1}) but was on par with T_3 (3.85 dS m^1).

The quality parameters namely reducing sugar, non reducing sugar and total sugar were significantly influenced by the treatments with T_4 recording the highest value. The alcohol content was highest in T_4 (0.09 %) which was on par with T_3 (0.08 %). The content of phenols, vitamin C and protein nitrogen were significantly increased by fertilizer levels. The treatments significantly increased the content of primary, secondary and micro nutrients in sap except for zinc, copper and manganese.

The second experiment was to study the variability among coconut varieties namely Malayan Yellow Dwarf (T_1), Kerasree (T_2), West Coast Tall (T_3) and Keraganga (T_4) with respect to yield and quality of CIS. This was carried out at Nileswaram farm, RARS, Pilicode under irrigated condition.

The varieties varied significantly with respect to CIS yield. It was maximum in the tall variety WCT (3.14 l day^{-1}) followed by the hybrid varieties Kerasree (2.09 l day^{-1}) and Keraganga (1.80 l day^{-1}). The dwarf variety MYD gave the lowest CIS yield of 0.84 l day^{-1}.

The analysis of CIS revealed that the variety WCT was superior with respect to reducing sugar (0.52 g $100ml^{-1}$), total sugar (10.66 g $100ml^{-1}$), phenols (5.71 mg $100ml^{-1}$), vitamin C (1.87 mg $100ml^{-1}$) and total mineral content (2.32 %) while the dwarf variety MYD gave higher non-reducing sugar (10.23 g $100ml^{-1}$) and alcohol (0.09 %).

The study on changes in CIS during storage for 1 week indicated that without any differentiation between varieties there was a decrease in pH, total sugar, reducing sugar and non-reducing sugar while there was an increase in alcohol and vitamin C content.

From the results of the study it can be concluded that, the yield, nutritional qualities and biochemical properties of CIS can be significantly improved by applying 75 % extra NPK fertilizers over and above the current POP recommendation for palms maintained for nut production. The tall variety WCT exhibited better sap yield and sap quality parameters and is more suitable for sap production compared to dwarf varieties and hybrids.

സംഗ്രഹം

"തെങ്ങിൻ പൂങ്കുലസത്തിന്റെ വിളവിലും ഗുണമേന്മയിലും പോഷണത്തിന്റെയും ഇനങ്ങളുടെയും സ്വാധീനം" എന്നതിനെ കുറിച്ച് ഇൻസ്ട്രക്ഷണൽ ഫാം, കാർഷിക കോളേജ്, വെള്ളായണി, നീലേശ്വരം ഫാം, പ്രാദേശിക കാർഷിക ഗവേഷണ കേന്ദ്രം, പീലിക്കോട് എന്നിവിടങ്ങളിൽ 2015-2016 കാലയളവിൽ ഒരു പരീക്ഷണം നടത്തുകയുണ്ടായി. ഈ പരീക്ഷണത്തിന്റെ പ്രധാന ലക്ഷ്യങ്ങൾ തെങ്ങിൻ പൂങ്കുലസത്തിന്റെ വിളവിലും പോഷക ഗുണത്തിലും വിവിധ വളങ്ങളുടെ അളവുകളും ഇനങ്ങളും എങ്ങനെ ബാധിക്കുന്നു എന്നതായിരുന്നു.

പരീക്ഷണം രണ്ട് ഭാഗങ്ങളായാണ് നടത്തിയത്. രണ്ട് പരീക്ഷണത്തിലും റാൻഡമൈസ്ഡ് ബ്ളോക്ക് ഡിസൈൻ എന്ന പരീക്ഷണ രീതിയാണ് അവലംബിച്ചത്. ഒന്നാമത്തെ പരീക്ഷണത്തിൽ കേരള കാർഷിക സർവ്വകലാശാലയുടെ തെങ്ങിന്റെ സാധാരണ കൃഷിക്കുള്ള ശുപാർശയുടെ അടിസ്ഥാനത്തിൽ പാക്യജനകം, ഭാവകം, ക്ഷാരം വളങ്ങളുടെ വിവിധ അളവുകളുടെ സ്വാധീനം പഠന വിഷയമാക്കി. അളവുകൾ ഇപ്രാകാരം - കേരള കാർഷിക സർവ്വകലാശാലയുടെ തെങ്ങിന്റെ സാധാരണ കൃഷിക്കുള്ള ശുപാർശ (T_1) T_1 ന്റെ 125 % (T_2), T_1 ന്റെ 150 % (T_3), T_1 ന്റെ 175 % (T_4). ഇവ വെസ്റ്റ് കോസ്റ്റ് ടാൾ എന്ന തെങ്ങിനത്തിൽ, വെള്ളായണി, ഇൻസ്ട്രക്ഷണൽ ഫാമിൽ മഴയെ അടിസ്ഥാനമാക്കിയുള്ള കൃഷിരീതിയിൽ അവലംബിച്ചു.

പരീക്ഷണത്തിന്റെ അവസാനത്തിൽ മണ്ണുപരിശോധനയിൽ നിന്നും പ്രാധമിക മൂലകങ്ങളുടെ (പാക്യജനകം, ഭാവകം, ക്ഷാരം) ലഭ്യതയെ വിവിധ പരിചരണമുറകൾ സ്വാധീനിച്ചതായി കണ്ടു. പ്രാധമിക മൂലകങ്ങളുടെ അളവ് കൂടുതലായി രേഖപ്പെടുത്തിയത് T_4 എന്ന പരിചരണ മുറയിലാണ്. എന്നിരുന്നാലും പാക്യജനകത്തിന്റെ കാര്യത്തിൽ T_2 വും T_3 യും T_4 നോട് ആനുപാതികമാണ്. ഭാവകത്തിന്റെയും, ക്ഷാരത്തിന്റെയും കാര്യത്തിൽ T_4, T_2 വിനേക്കാളും T_3 യേക്കാളും മുൻപന്തിയിലാണ്. ദ്വിതീയ മൂലകങ്ങളുടെയും സൂക്ഷ്മ മൂലകങ്ങളുടെയും കാര്യത്തിൽ പരിചരണ മുറകൾ തമ്മിൽ പറയത്തക്ക വ്യത്യാസങ്ങളൊന്നും കണ്ടില്ല.

തെങ്ങിന്റെ സൂചിക ഇല പരിശേധിച്ചപ്പോൾ പ്രാധമികം, ദ്വിതീയം സൂക്ഷ്മ മൂലകങ്ങൾ എന്നിവയിൽ വളങ്ങളുടെ വിവിധ അളവുകൾക്ക്

സ്വാധീനത ഇല്ല എന്ന് മനസിലാക്കാൻ സാധിച്ചെങ്കിലും നാക മൂലകത്തിന്റെ അളവ് ഏറ്റവും കൂടുതൽ കാണപ്പെട്ടത് T_4 (193.76 മില്ലി. ഗ്രാം) പരിചരണമുറയിലാണ്, അത് T_3 (189.84 മില്ലി. ഗ്രാം) യുമായി ആനുപാതികത്തിലാണ്.

വളങ്ങളുടെ വിവിധ അളവുകൾ തെങ്ങിൻ പൂങ്കുലസത്തിന്റെ ഉല്പാദനത്തെ കാര്യമായി സ്വാധീനിച്ചു. ഏറ്റവും കൂടുതൽ ഉല്പാദനം ലഭിച്ചത് T_4 (3.32 ലിറ്റർ / ദിവസം) ൽ നിന്നാണ്. അത് കേരള കാർഷിക സർവ്വകലാശാലയുടെ തെങ്ങിന്റെ സാധാരണ ശുപാർശയേക്കാൾ (T_1) 134 ശതമാനം കൂടുതൽ വിളവ് കാണിച്ചു. എന്നിരുന്നാലും തെങ്ങിൻ പൂങ്കുലസത്തിന്റെ ഉല്പാദന കാലാവധിയെ വിവിധ പരിചരണമുറകൾ സ്വാധീനിച്ചതായി കാണപ്പെട്ടില്ല.

പൂങ്കുലസത്ത് പരിശോധിച്ചപ്പോൾ വളത്തിന്റെ അളവ് കൂട്ടുന്നതനുസരിച്ച് സത്തിന്റെ പി.എച്ച് കുറയുന്നതായി കാണപ്പെട്ടു. എന്നാൽ വളത്തിന്റെ അളവ് കൂട്ടുന്നതനുസരിച്ച് ഇലക്ട്രോലൈറ്റിന്റെ അളവ് കൂടി. കൂടുതൽ അളവ് T_4 ആണ് കാണിച്ചതെങ്കിലും അത് T_3 യുമായി ആനുപാതികത്തിലാണ്.

ഗുണനിലവാര ഘടകങ്ങളായ റെഡ്യൂസിംഗ് ഷുഗറും, നോൺ റെഡ്യൂസിംഗ് ഷുഗറും, ടോട്ടൽ ഷുഗറും, കൂടുതൽ കാണപ്പെടുന്നത് T_4 ലാണ്. ആൽക്കഹോൾ അളവ് ഏറ്റവും കൂടുതൽ T_4 ലും അത് T_3 യുമായി ആനുപാതികത്തിലുമാണ്. ഫീനോളിന്റെയും, വിറ്റാമിൻ സിയുടേയും, മാംസ്യ പാക്യജനകത്തിന്റെയും, അളവ് വളങ്ങളുടെ അളവ് കൂട്ടുന്നതനുസരിച്ച് കൂടുന്നതായി കാണപ്പെട്ടു. പരിചരണ മുറകൾ സത്തിലുള്ള നാകം, കോപ്പർ, മാൻഗനീസ് ഒഴികെയുള്ള പ്രാധമികം, ദ്വിതീയം സൂക്ഷ്മ മൂലകങ്ങളുടെ അളവുകളെ സാരവത്തായി കൂട്ടിയതായി കാണപ്പെട്ടു.

രണ്ടാമത്തെ പരീക്ഷണം, വിവിധ തെങ്ങിനങ്ങളായ മലയൻ യെല്ലോ ഡ്വാർഫ് (T_1) കേരശ്രീ, (T_2) വെസ്റ്റ് കോസ്റ്റ് ടാൾ (T_3) കേരഗംഗ (T_4) എന്നിവ സാപ്പിന്റെ ഉലാപാദനത്തിലും ഗുണനിലവാരത്തിലും എങ്ങനെ വ്യത്യാസപ്പെട്ടിരിക്കുന്നു എന്ന് മനസില്ക്കാൻ വേണ്ടിയുള്ളതായിരുന്നു. ഈ പരീക്ഷണം നീലേശ്വരം ഫാം, പ്രാദേശിക കാർഷിക ഗവേഷണ കേന്ദ്രം, പീലിക്കോടിൽ ജലസേചന സഹായത്തോടെയാണ് അവലംബിച്ചത്.

സത്തിന്റെ ഉല്പാദനം തെങ്ങിന്റെ ഇനങ്ങൾക്കനുസരിച്ച് സാരവത്തായി വ്യത്യാസപ്പെട്ടതായി കണ്ടെത്തി. സത്തിന്റെ ഉല്പാദനം വെസ്റ്റ് കോസ്റ്റ് ടാൾ എന്ന ഇനത്തിലായിരുന്നു ഏറ്റവും കൂടുതൽ (3.14 ലിറ്റർ / ദിവസം). സത്തിന്റെ ഉല്പാദനം ഹൈബ്രഡ് ഇനങ്ങളായ കേരശ്രീയിലും (2.09 ലിറ്റർ / ദിവസം) കേരഗംഗയിലും (1.80 ലിറ്റർ / ദിവസം) കൂടുതലായി കാണപ്പെട്ടു. സത്തിന്റെ ഉല്പാദനം ഏറ്റവും കുറവായി (0.84 ലിറ്റർ / ദിവസം) കാണപ്പെട്ടത് കുറുകിയ ഇനമായ മലയൻ യെല്ലോ ഡ്വാർഫിലാണ്.

പൂങ്കുലസത്ത് പരിശോധിച്ചപ്പോൾ തെങ്ങിനമായ വെസ്റ്റ് കോസ്റ്റ് ടാൾ റെഡ്യൂസിംഗ് ഷുഗർ (0.52 ഗ്രാം / 100 മില്ലി ലിറ്റർ) ന്റെയും, ടോട്ടൽ ഷുഗറിന്റെയും (10.66 ഗ്രാം / 100 മില്ലി ലിറ്റർ), ഫീനോളിന്റെയും (5.71 മില്ലി ഗ്രാം / 100 മില്ലി ലിറ്റർ), വിറ്റാമിൻ സിയുടെയും (1.87 മില്ലി ഗ്രാം / 100 മില്ലി ലിറ്റർ), ടോട്ടൽ മിനറൽ കണ്ടന്റി ന്റെയും (2.32 %) അളവിൽ മുൻപന്തിയിൽ നിൽകുന്നതായും കുറുകിയ ഇനമായ മലയൻ യെല്ലോ ഡ്വാർഫ് നോൺ റെഡ്യൂസിംഗ് ഷുഗറിന്റെയും (10.23 ഗ്രാം / 100 മില്ലി ലിറ്റർ), ആൽക്കഹോളി ന്റെയും (0.09 %) അളവിൽ മുൻപന്തിയിൽ നിൽക്കുന്നതായും കണ്ടെത്തി.

പൂങ്കുലസത്ത് ഒരാഴ്ച സൂക്ഷിച്ച് വച്ചപ്പോൾ എല്ലാ ഇനങ്ങളിലും പി.എച്ചും ടോട്ടൽ ഷുഗറും റെഡ്യൂസിംഗ് ഷുഗറും നോൺ റെഡ്യൂസിംഗ് ഷുഗറും കുറഞ്ഞു. എന്നാൽ ആൽക്കഹോളിന്റെയും വിറ്റാമിൻ സിയുടെയും അളവ് കൂടുന്നതായി കാണപ്പെട്ടു.

തേങ്ങ ഉല്പാദനത്തിനായി വളർത്തുന്ന തെങ്ങിന് കേരള കാർഷിക സർവ്വകലാശാലയുടെ തെങ്ങിന്റെ സാധാരണ ശുപാർശയേക്കാൾ 75 ശതമാനം കൂടുതൽ പാക്യജനകം, ഭാവകം, ക്ഷാരം വളങ്ങൾ കൊടുക്കുന്നതു വഴി സത്തിന്റെ വിളവും ഗുണമേന്മയും ബയോകെമിക്കൽ ഗുണങ്ങളും മെച്ചപ്പെടുന്നതായി ഈ പരീക്ഷണത്തിൽ നിന്ന് മനസിലാക്കാൻ സാധിച്ചു. നല്ല സത്ത് ഉല്പാദനം ഗുണമേന്മ എന്നിവ ഉള്ളത് കൊണ്ട് കുറികിയ ഇനങ്ങളേക്കാളും ഹൈബ്രിഡിനേക്കാളും പൊക്കം കൂടിയ ഇനമായ വെസ്റ്റ് കോസ്റ്റ് ടാൾ സത്തുല്പാദനത്തിന് അനിയോജ്യമാണ്.

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