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Relation between drainable porosity and leaf tissue concentration of healthy and hidimundige affected areca nut gardens of Chitradurga district, Karnataka

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Abstract
An investigation on the relation between drainable porosity and leaf tissue concentration of healthy and hidimundige affected gardens of Chitradurga district, Karnataka was made during 2018-19 to delineate the causes for hidimundige syndrome in areca nut. Soil samples were collected at 60 cm away from the trunk of areca nut from both healthy and affected gardens. Similarly, leaf tissues from corresponding healthy and affected garden were also collected from 4th and 6th leaf of the areca nut trees. Soil samples were analysed for drainable porosity. In present investigation it was observed that there was decrease in drainable porosity in the hidimundige affected gardens. Drainable porosity had a significant and positive correlation with leaf tissue concentration of Zn in both surface (r = 0.53*) and subsurface layers (r = 0.47*) of affected gardens of Chitradurga district. It was observed that lower drainable porosity of the hidimundige affected gardens could be the cause for decreased uptake of nutrients and hence, lower tissue concentration. This may be responsible for poor shoot growth and modifications in the internodal regions, resulting in abnormal growth and development of areca nut trees.

Keywords: Areca nut, hidimundige, drainable porosity, leaf composition

Introduction
Areca nut (*Areca catechu* L.) belonging to the family palmae, is one of the economically important plantation crops grown in humid tropics of India. It is a native of Malayan Archipelago, Philippines and other East Indian Islands. India ranks first in area (0.45 mha) and production (0.74 mt) of areca nut in the world (Anon, 2016) [1]. It is also being grown in Sri Lanka, Bangladesh, Malaysia, Indonesia and Philippines on a limited scale. In India, traditionally areca nut is being grown in Karnataka, Kerala, Assam, West Bengal, Tamilnadu and Maharashtra. Karnataka is one of the important areca producing states contributing nearly 60 percent to the countries total production followed by Assam and Kerala. In Karnataka, which leads the country in its production by producing 4, 57, 560 tonnes from an area of 2, 18, 010 hectares (5, 38, 700 acres).

For optimum areca nut production soil properties play a dominant role in addition to climatic conditions and water resource facilities. Soil is a basic non- renewable resource and a dynamic medium for plant growth. Though, areca nut palm is grown on a variety of soil types, *viz.* clayey, sandy, loamy, etc, laterite soils with an admixture of pebbles are ideal. The soil should be sufficiently porous to permit drainage of excess water to facilitate proper root growth.

Huge yield gap, shallow root system, large nutrient removal, low nutrient use efficiency and disorders are serious concerns in areca nut cultivation. Continuous cropping for enhanced yield removes substantial amounts of nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, improper irrigation and various cultural practices also deplete the soil quality rapidly. Efficient nutrient use is critical for correcting nutrient imbalance and imparting resistance to abiotic and biotic stresses in perennial systems. Constraints of nutrient or sick soils may cause some of the serious problems like yellow leaf disease and crown choking.

Crown choking is a disorder of the areca nut and is a major problem in Karnataka and Konkan Coast of Maharashtra. It is known as hidimundige disease in Karnataka, pencil point disease in Sri Lanka and rosette disease in Australia. The first visible symptoms are reduction in leaf size which turns brittle and crinkled with wavy margins. As the disorder advances, there is a reduction in inter-nodal length, formation of small bunches and tapering of stem. The crown shows a rosette shape due to failure of natural opening of leaves. And also the bunches become small and malformed.

Poor drainage, low soil fertility, sub soil pan or hard clayey pan is possible causes of this crown choking disorder. However, the exact causes for development of disorders in areca nut are not clear.

Though areca nut is an important commercial crop of Karnataka, not much research work has been done on this crown choking disorder. The present investigations were carried out in selected healthy and crown choking affected gardens of areca nut growing areas *viz,* Chitradurga, Holalkere, Hiriyur and Hosadurga taluks in Chitradurga district, Karnataka. The study conducted with the objectives of to assess the relation between drainable porosity and leaf tissue concentration of healthy and hidimundige affected areca nut gardens of Chitradurga district, Karnataka.

Plate 1: Hidimundige affected areca nut gardens in different taluks of Chitradurga district

Material and Methods

An experiment was conducted to study the soil physical properties (drainable porosity) and leaf composition of healthy and crown choking (hidimundige) affected areca nut gardens in Chitradurga district, Karnataka during August, 2018-19. Chitradurga district is located at 14.18^0N and 76.56^0E and it has an altitude of 732 meters above mean sea level. It is located in the midst of Central Dry Zone, IV of Karnataka. Soil samples for the present investigation were collected at 0 to 30 cm and 30 to 60 cm depths in the root zone at 60 cm distance away from tree trunk from both healthy and crown choking affected areca nut gardens of Chitradurga district. In all, soil samples from 21 locations of Holalkere, Hiriyur, Chitradurga and Hosadurga taluks were identified during the survey and soil samples were collected from the healthy and affected areca nut gardens. The identified locations for healthy and crown choking affected areca nut gardens were such that, they were either adjacent or opposite in the same area. In all, 84 soil samples (42 from crown choking affected and 42 from healthy areca nut gardens) were collected. At each location, the soil samples were collected from 4 to 5 spots and pooled to get one composite sample for each depth.

The collected soil samples were analysed for drainable porosity. Drainable porosity is the pore volume of water that is removed when the water table is lowered in response to gravity and in the absence of evaporation. When a saturated soil is allowed to drain under gravity some of the water will drain out. The drainable porosity varied from soil to soil (Smedema and Rycroft, 1983) [13]. The amount of water drained depends on the size of the pores present in the soil. The larger size pores will drain rapidly followed by medium sized pores and small pore size will drain very slowly. Drainable porosity was calculated with the formula, Drainable porosity in percent = (percent moisture of soil at saturation – percent moisture of soil at field capacity)

The leaf tissues of healthy and affected areca nut trees were collected by following the sampling technologies given by CPCRI (Central Plantation Crop Research Institute, Kasargod). Leaf samples were collected from middle portion of 4^{th} and 6^{th} leaves separately and subjected to analysis for major, secondary and micronutrients respectively (Bhat and Sujatha, 2013) [2]. A total of 42 leaf samples (21 from healthy and 21 from affected areca nut gardens) were collected and analyzed separately. The leaf samples were washed with tap water and then with distilled water. The samples were first air dried and then oven dried at 60 °C. The dried leaves were powdered and preserved in polythene bags for further analysis of different nutrient content (Jackson, 1973) [5].

Total nitrogen in leaf samples was determined by Kjeldhal's method as described by Jackson (1973) [5]. The powdered sample of 0.5 g was digested with concentrated H_2SO_4 in presence of digestion mixture (K_2SO_4:$CuSO_4.5H_2O$:Se in the proportion of 100:20:1) and distilled under alkaline medium. The liberated NH_3 was trapped in four percent boric acid containing mixed indicator and titrated against standard H_2SO_4.

Digestion of plant sample with di-acid mixture

One gram of powdered leaf sample was pre-digested with HNO_3 and then digested with di-acid mixture containing HNO_3 and $HClO_4$ in the proportion of 10:4 as described by Jackson (1973) [5]. The volume of the digest was made up to 50 ml with distilled water and filtered through Whatman No. 41 filter paper and collected the filtrate in 50 ml volumetric flask and used it for total elemental analysis.

Total phosphorus was determined by vanadomolybdophosphoric yellow colour method in nitric acid system as described by Jackson (1973) [5]. Total potassium content in plant sample was determined by flame photometric method after diluting di-acid digested plant extract with distilled water. The flame photometer readings of the sample were compared with the calibration curve of potassium and percent potassium in the plant sample was calculated (Jackson, 1973) [5]. In an aliquot of the diacid digested plant extract, calcium and magnesium was estimated by titrating against standard Versenate solution (Jackson, 1973) [5]. A known volume of the di-acid digested sample (10 ml) was taken for total sulphur determination by using turbidometric method and turbidity developed due to barium sulphate formation was measured at 420 nm using spectrophotometer (Page *et al*., 1982) [9]. The diacid digested plant extract with proper dilution was fed to the Atomic Absorption Spectrophotometer with appropriate hallow cathode lamps to determine the total Fe, Mn, Zn and Cu in the materials (Page *et al*., 1982) [9]. Boron content of leaf was determined by taking digest obtained by dry combustion following Azomethine-H colorimetric method (Page *et al*., 1982) [9].

The data obtained were subjected to statistical analysis and correlation analysis was carried out to assess the relationship of drainable porosity with leaf tissue concentration of both healthy and affected areca nut gardens.

Relation between drainable porosity and leaf composition of healthy and crown choking affected areca nut gardens

Drainable porosity is the pore volume of water that is removed when the water table is lowered in response to gravity and in the absence of evaporation. When a saturated soil is allowed to drain under gravity some of the water will drain out. The amount of water drained depends on the size of the pores present in the soil. The larger size pores will drain rapidly followed by medium sized pores and small pore size will drain very slowly. The volume of water drained under gravity by the coarse textured soils is more than that by the fine textured soils, since they have more of macro pores. This physical property indicates the percentage of drainable pores responsible for draining the water and providing aeration in the soil and also for nutrient movement. Thus this parameter was estimated to know the extent of variation in the drainable porosity which helps in relating to the nutrient movement from soil to the plant system.

The relation between drainable porosity and leaf tissue concentration were studied for healthy and affected areca gardens of Chitradurga district are presented in Table 1 and 2. Simple correlations were worked out between drainable porosity of soil and leaf tissue concentrations of both healthy and affected areca gardens of Chitradurga district.

Drainable porosity had a significant and positive correlation with leaf tissue concentration of Zn in both surface (r = 0.53*) and subsurface layers (r = 0.47*) of affected gardens of Chitradurga district.

Drainable porosity had showed a positive correlation with tissue phosphorus (r = 0.31 and 0.30 in surface and subsurface layer respectively), potassium (r = 0.22 and 0.19 at 0-30 cm depth and 30-60 cm depth respectively), calcium (r = 0.34 and 0.31 in surface and subsurface layer respectively), magnesium (r = 0.24 in the surface layer), sulphur (r = 0.19 and 0.21 at 0-30 cm depth and 30-60 cm depth, respectively), iron (r = 0.24 at 0 - 30 cm depth), manganese (r = 0.23 in the surface layer), copper (r = 0.31 in the surface layer) and boron (r = 0.22 and 0.30 in surface and subsurface layer, respectively) in crown choking affected areca gardens. This indicates that nutrient uptake lowered with decreasing drainable porosity in affected gardens. This might be due to the indiscriminate application of tank soil to the areca nut gardens. Because of application of tank silt in the areca nut gardens there is decrease in the size of macropores which decrease the ability of the soil to drain water. Due to lower drainable porosity in affected gardens compared to healthy gardens resulted in lower aeration in the soils of affected gardens. It also affects the diffusion of nutrients and nutrient uptake by plants.

Farmers have the tendency to apply tank silt or any soil as a method of soil fertility improvement, and hardly any chemical fertilizers are applied. During the survey, it was observed that nutrient management was not properly adopted by the farmers. Although tank soil has the ability to alter the soil physical properties, it’s quantity of application need to be estimated and applied based on the soil tests. So that there will not be any adverse effects. Hence, in order to ensure proper growth of areca nut trees, it is required to maintain optimum drainable porosity for better aeration, root penetration and effective movement of nutrients in the rhizosphere. Thus management of physical condition of the soil or rhizosphere is equally important along with balanced nutrition for better growth and development of areca trees. There is a need to test soil physical and chemical properties before application of tank silt in order to ensure that there will not be any adverse effects on the soil physical and chemical properties of areca nut gardens.

Table 1: Correlation co-efficient (r) observed between drainable porosity and leaf tissue concentration in healthy gardens of Chitradurga district

Properties	N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Drainable porosity (0-30 cm depth)	0.06	0.10	0.08	0.13	0.11	0.08	-0.01	0.06	0.03	0.01	0.09
Drainable porosity (30-60 cm depth)	0.00	-0.07	0.11	0.01	0.11	0.09	0.07	-0.02	-0.05	0.10	0.01

*Significant at 5% level, ** Significant at 1% level

Table 2: Correlation co-efficient (r) observed between drainable porosity and leaf tissue concentration in Hidimundige affected gardens of Chitradurga district

Properties	N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Drainable porosity (0-30 cm depth)	0.16	0.31	0.22	0.34	0.24	0.19	0.24	0.23	0.31	0.53*	0.22
Drainable porosity (30-60 cm depth)	0.17	0.30	0.19	0.31	0.16	0.21	0.13	0.13	0.14	0.47*	0.30

*Significant at 5% level, ** Significant at 1% level

Conclusion

Drainable porosity had a significant and positive correlation with leaf tissue concentration of Zn in both surface and subsurface layers of affected gardens of Chitradurga district. Drainable porosity showed a positive correlation with tissue phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper and boron in crown choking affected areca gardens.

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Statements and Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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