Original Research Article

Physical and Chemical Properties of *Hidimundige* (Crown Choking) Affected and Healthy Arecanut Gardens of Chitradurga District, Karnataka

Abstract: The present investigation was undertaken at College of Agriculture, Shivamogga during 2018-2019 to delineate the causes for hidimundige syndrome in arecanut. Soil samples from two depths 0 to 30 cm and 30 to 60 cm were collected at 60 cm away from the trunk of arecanut from both healthy and affected gardens of Holalkere, Hiriyur, Chitradurga and Hosadurga taluks. The collected soil samples were analyzed for various physical and chemical properties and also for macro and micro nutrients. The results of the investigation indicated that soils coming under affected gardens showed the high mean clay content than healthy gardens. There was a significant increase in bulk density of affected gardens compared to healthy gardens in Holalkere (from 1.63-1.84 Mg m^{-3}) and Hosadurga (from 1.84-1.96 Mg m^{-3}) taluk at lower depth. Whereas, the drainable porosity decreased significantly in affected gardens compared to healthy gardens of Holalkere (from 33.54-25.69 %) and Hosadurga (from 25.79-21.23 %) taluk at lower depth. In all taluks, majority of the soils from both healthy and affected arecanut gardens were neutral to alkaline in reaction. The study showed that availability of N, P, K, S, Fe, Mn, Cu and B and also the content of exchangeable Ca and Mg was quite heterogeneous in both healthy and affected gardens. Whereas, available zinc status in the soil showed significant decrease in affected gardens compared to healthy gardens of Hiriyur, Chitradurga and Holalkere taluks.

Key words: Arecanut; Hidimundige; Bulk density; Drainable porosity; Zinc

1. INTRODUCTION:

Arecanut (*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 arecanut in the world [1]. It is also being grown in Sri Lanka, Bangladesh, Malaysia, Indonesia and Philippines on a limited scale. In India, traditionally arecanut is being grown in Karnataka, Kerala, Assam, West Bengal, Tamilnadu and

Maharashtra. Karnataka is one of the important areca producing states contributing nearly 60 per cent 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 arecanut 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, arecanut 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 arecanut 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 arecanut 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 arecanut are not clear.

Though arecanut 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 arecanut growing areas *viz,* Chitradurga, Holalkere, Hiriyur and Hosadurga taluks in Chitradurga district, Karnataka. The study involves characterisation of soils of healthy and crown choking affected arecanut gardens with the objectives of to assess the soil physical and chemical properties of both affected and healthy arecanut gardens of Chitradurga district.

2. MATERIAL AND METHODS

An experiment was conducted to study the physical and chemical properties in soils of healthy and crown choking (*hidimundige)* affected arecanut gardens in Chitradurga district, Karnataka during August, 2018-19. Chitradurga district is located at 14.18^{0}N and 76.56^{0}E 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 arecanut 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 arecanut gardens. The identified locations for healthy and crown choking affected arecanut 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 arecanut 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 air dried under shade, powdered by using wooden pestle and mortar and passed through 2 mm sieve. The 2 mm sieved air-dried samples were stored in polythene bags for further analytical work. The 0.2 mm sieved soil samples were used for estimation of organic carbon [2].

The collected soil samples were analysed for both physical and chemical properties. The relative proportion of sand, silt, and clay particles present in soil samples was carried out through international pipette method using sodium hexa-metaphosphate as dispersing agent [3]. Bulk density of the soil was determined by core sampler method for undisturbed soil as per the procedure described by [4]. 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 [5]. 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 per cent = (per cent moisture of soil at saturation – per cent moisture of soil at field capacity)

Soil pH was determined in 1:2.5 ratio of Soil: water extract by Potentiometric method using pH meter [2]. The electrical conductivity in soil samples was determined in the supernatant solution of 1:2 ratio of soil: water extract using conductivity meter [2]. EC expressed in terms of dS m^{-1} at 25^0C. Organic carbon in soil samples (0.2 mm sieved) was determined by Walkely and Black's wet oxidation method, where using potassium dichromate with H_2SO_4 and back titrated with ferrous ammonium sulphate as described by [2] and expressed in g kg^{-1}. Available nitrogen in the soil was determined by alkaline potassium permanganate method as described by [6]. Available phosphorus was extracted from soil using Olsen's extractant (0.5M $NaHCO_3$) and the concentration of phosphorus in the extract was determined by chlorostannous reduced molybdophosphric acid blue colour in HCl system by using Spectrophotometer at 660 nm [2]. Available potassium was extracted from the soils using neutral N ammonium acetate in 1:5 soil to extractant ratio and the concentration of potassium present in the extract was determined by flame photometer method [2]. The exchangeable calcium and magnesium were determined by extracting the soil with neutral N ammonium acetate solution at 1:5 soil to extractant ratio and the concentration of calcium and magnesium in the extract were determined by Versenate titration method [2]. Available sulphur was extracted from the soil by 0.15 per cent calcium chloride solution and the concentration of sulphur in solution was determined by turbidometric method at 420 nm [7]. Available iron, manganese, zinc, and copper were extracted by using DTPA extractant at 1:2 soil to extractant ratio as explained by [8]. The concentration of these micronutrients in the extract was estimated using Atomic Absorption Spectrometer by using appropriate hollow cathode lamps under suitable measuring conditions [9]. Available Boron was extracted by boiling the soil with water at 1:2 soil water ratio for 5 minutes using reflex condenser and filtered to get soil extract. Boron concentration in the extract was determined by colorimetric method using Azomethine-H reagent [9].

3. RESULTS AND DISCUSSION

3.1 Soil texture

The data of particle size distribution and textural classes of soils of healthy and *hidimundige* affected arecanut gardens of Chitradurga district is presented in table 1.

The majority of soil samples from both healthy and *hidimundige* affected gardens of Chitradurga district represent sandy clay loam texture. The mean sand content decreased by around 3-4, 3-4, 0.5-1 and 1-7 per cent in case of affected gardens of Holalkere, Hiriyur, Chitradurga and Hosdurga taluk respectively compared to healthy gardens. Whereas the mean clay content increased by around 4-5, 2-3, 1-3 and 0.5-5 per cent in affected gardens of Holalkere, Hiriyur, Chitradurga and Hosdurga taluk respectively compared to healthy gardens. The increase in clay content of the affected gardens may be due to the excess application of tank silt. Tank silt contains high clay content (60 to 80%) followed by silt (14 to 22%) and sand (less than 10%), [10].

The sand content in soils of all taluks decreased from the surface to downwards, whereas silt and clay content gradually increased down the depth. Similar results have been reported by [11]. Higher content of finer fraction (silt+clay) in lower depths might be due to the translocation of finer particles from the surface horizons and subsequent illuviation in sub surface horizons [12].

3.2 Bulk density

There was a significant difference between healthy and affected gardens of Holalkere and Hosdurga wrt. bulk density values at lower depth (table 2 and figure 1). The highest mean bulk density (1.95 Mg m^{-3}) was observed in affected gardens of Hosdurga in subsurface layer and lower mean bulk density (1.52 Mg m^{-3}) was noticed in surface layer of healthy gardens of Holalkere. BD indicates the compactness of the soil and in the present study there is an increase in BD of the affected gardens which may be due to excess application of tank silt.

The bulk density increased with increase in depth of soils in both healthy and affected gardens of all the taluks. This was due to the low organic matter content of lower layer and compaction from the pressure of the upper layers. Similar results were also reported by [13].

Table 1: Average particle size distribution of soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Sand (%)				Silt(%)				Clay(%)			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	61.83	58.05	58.32	54.30	17.90	15.79	17.74	17.57	20.12	25.97	23.85	28.03
	t value	0.43		0.45		0.54		0.04		0.95		0.65	
Hiriyur	Mean	66.53	62.78	62.51	59.30	13.16	14.34	14.98	15.34	20.23	22.65	22.24	25.15
	t value	0.54		0.45		0.22		0.07		0.57		0.57	
Chitradurga	Mean	53.08	53.85	48.37	48.89	20.83	18.95	23.22	20.01	26.09	27.19	28.41	30.98
	t value	0.15		0.08		0.65		1.30		0.29		0.58	
Hosdurga	Mean	54.99	55.97	53.36	46.71	17.70	16.45	18.67	19.85	27.26	27.45	27.93	33.37
	t value	0.18		1.12		0.55		0.40		0.03		0.97	

Table 2: Average drainable porosity and average bulk density of soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Drainable porosity (%)				Bulk density (Mg m^{-3})			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	37.47	32.24	33.54	25.69	1.53	1.66	1.63	1.84
	t value	1.23		2.34*		1.21		2.38*	
Hiriyur	Mean	37.43	35.77	35.92	32.71	1.52	1.57	1.56	1.65
	t value	0.44		0.90		0.45		0.92	
Chitradurga	Mean	31.05	28.93	25.44	24.43	1.70	1.75	1.84	1.87
	t value	0.70		0.31		0.68		0.33	
Hosdurga	Mean	27.42	26.64	25.79	21.23	1.79	1.81	1.84	1.96
	t value	0.34		2.37*		0.32		2.41*	

*Significant at 5% level, ** Significant at 1% level , HG: Healthy garden, AG: Affected garden

3.3 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 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.

It was observed that there was a significant difference in the drainable porosity of healthy and affected gardens of Holalkere and Hosdurga taluk at lower depth. In all the taluks, average drainable porosity was high in healthy gardens compared to *hidimundige* affected gardens (table 2 and figure 2). Among the taluks, the highest average drainable porosity was observed in healthy gardens of Holalkere taluk in surface layer (37.47 %) and lowest average drainable porosity was noticed in subsurface layer (21.23 %) of affected gardens of Hosdurga taluk. Because of application of tank silt in the arecanut gardens there is decrease in the size of macropores which decrease the ability of the soil to drain water. Thus drainable porosity of the affected gardens is lower compared to healthy gardens indicating lower aeration in the affected garden soils. This might be due to the indiscriminate application of tank silt to the arecanut gardens which creates compaction and decrease the pore volume.

The drainable porosity tended to decrease with increase in depth of soils in both healthy and affected gardens of all the taluks. This is due to decrease in pore volume down the depth.

Thus drainable porosity indicates the percentage of aeration pores or macropores which play a major role in root penetration, nutrient movement through root interception and mass flow. When drainable porosity is decreased it also affects the nutrient mobility in soil. This is very much evident from the results that calcium, magnesium and zinc uptake is reduced in affected gardens of Holalkere, Hiriyur and Hosdurga taluk which could be related to decreased pore space as indicated by lower drainable porosity.

(a) (b)

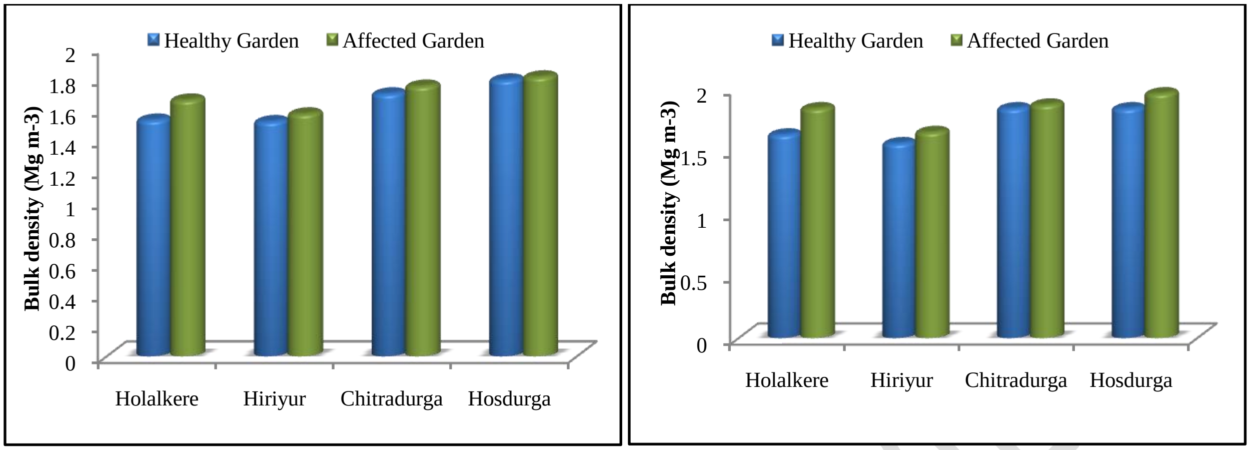


Fig.1: Average bulk density of soils under healthy and *hidimundige* affected arecanut gardens of Chitradurga district (a) in surface layers (b) in subsurface layers

(a) (b)

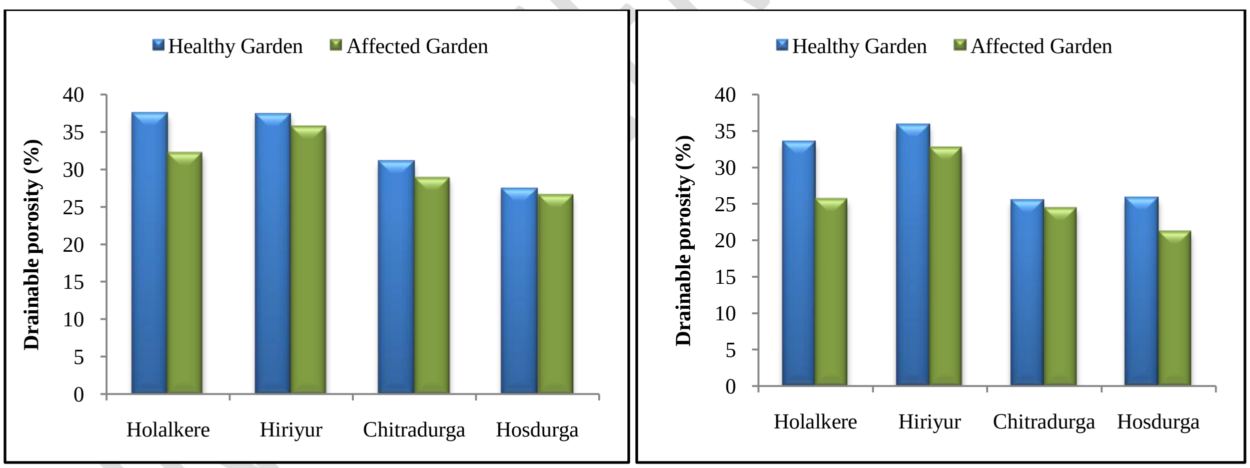


Fig.2: Drainable porosity in surface layers of soils under healthy and *hidimundige* affected arecanut gardens of Chitradurga district (a) in surface layers (b) in subsurface layers

Soil reactions, electrical conductivity and organic carbon content of both healthy and affected garden soil samples were studied and the data is presented in table 3.

3.4 Soil reaction (pH)

In all taluks, majority of the soils from both healthy and affected arecanut gardens were neutral to alkaline in reaction. The pH of the soils under healthy and affected gardens did not vary significantly in Holalkere, Hiriyur, Chitradurga and Hosdurga taluks of Chitradurga district.

In both healthy and affected gardens of all the taluks, the pH values of surface soils were lower than the subsurface soils. This pattern of variability in soil pH suggested the increase in bases with increase in depth that could be attributed to the downward movement of solutes by leaching within a profile [14]. Some scientists also reported that the increase in pH with soil depth could be associated with enhanced carbonate levels and less weathering rates [15].

3.5 Electrical conductivity

It was observed that there was no significant difference between the electrical conductivity of healthy and affected gardens of Chitradurga district.

The EC was increased with increase in depth in both healthy and affected gardens of all the taluks which may be due to leaching off salts.

3.6 Soil organic carbon

The results indicates that the organic carbon content was medium to high in all soils samples from both healthy and affected gardens of Chitradurga district. It was observed that there was no significant variation in organic carbon content between healthy and affected arecanut of Holalkere, Hiriyur and Chitradurga taluk.

The data on organic carbon content indicates that the organic carbon content tended to decrease with increasing soil depth in both healthy and affected gardens of all the taluks. The high organic carbon content in surface layers of the soil was due to the accumulation of organic matter in surface horizon and recycling of organic matter, addition of organic manure and also because of crop residues remaining in soil surface [16].

The data pertaining to available nitrogen, phosphorus and potassium content of both healthy and affected gardens of Chitradurga district is presented in table 4.

3.7 Available nitrogen

In all the taluks of Chitradurga district, the available nitrogen content of healthy gardens were low to medium, while it was low in case of affected gardens. The healthy and affected gardens of Holalkere and Chitradurga taluk showed significant variation wrt. availability of nitrogen in surface layer whereas, in case of Hosdurga taluk there was significant variation between healthy and affected gardens in terms of availability of nitrogen in both depths. It was observed that compared to healthy gardens, affected gardens showed lower values of available nitrogen content. But in case of Hiriyur taluk there was no significant variation between healthy and affected gardens wrt. availabilty of nitrogen at both depths and also in subsurface layers of healthy and affected gardens of Holalkere and Chitradurga there was no significant difference was observed. So the studies reveal that the availability of nitrogen was quite heterogeneous in both healthy and affected gardens.

The data indicates that the availability of nitrogen content tended to decrease with increasing soil depth. This could be due to decrease in organic carbon content and microbial population in lower depth. Similar findings were reported [17], [18] and [16].

3.8 Available phosphorus

In case of Holalkere taluk, the soil samples of healthy gardens were medium in available phosphorus status while it was low to medium in affected gardens. Whereas in case of Hiriyur taluk, the status of available phosphorus content of healthy gardens were medium to high while it was low to medium in case of affected gardens. The majority of the soil samples from both healthy and affected gardens of Chitradurga district showed medium in available phosphorus status. While in case of Hosadurga, the majority of soil samples of healthy gardens showed medium in available phosphorus content while it was low to medium in affected gardens. However, it was observed that there was no significant variation between available phosphorus content of healthy and hidimundige affected arecanut in all taluks except Holalkere. It indicates that there was no marked difference between healthy and *hidimundige* affected gardens wrt. availability of phosphorus.

The availability of phosphorus tended to decrease with increasing soil depth in both healthy and arecanut gardens of all the taluks. This could be due to the increased clay and reduced organic matter content with increasing depth of the soil. Organic compounds in soil increase phosphorus availability by the formation of organophosphate complexes that are more easily assimilated by plants, anion replacement of H_2PO_4 from adsorption sites, the coating of Fe/Al oxides by humus to form a protective cover and reduced phosphorus fixation. Moreover, decomposition of organic matter releases acids that increase the solubility of calcium phosphates [19].

3.9 Available potassium

The available potassium content was low to medium in all soil samples from affected gardens of Chitradurga district while in case of healthy gardens, majority of the soil samples represents medium in content. It was observed that compared to healthy garden, affected garden showed lower values of available potassium content in all taluks. But significant decrease was observed only between healthy and affected gardens of Chitradurga taluk in surface layer.

The availability of potassium was high in surface soils as compared to subsurface soils in both healthy and affected gardens of all the taluks. The decreasing trend with depth may be due to higher organic carbon content in surface soils than the subsurface soils and presence of of higher potassium bearing minerals in surface [20] and [21].

3.10 Exchangeable calcium and magnesium

The data pertaining to exchangeable calcium and magnesium content of both healthy and affected gardens of Chitradurga district is presented in table 5.

In all the taluks of Chitradurga district, the content of exchangeable calcium and magnesium are in the sufficiency range in both healthy and affected gardens. However, it was observed that compared to healthy calcium and magnesium content was less in affected gardens of all taluks. it was observed that there was significant decrease in content of calcium and

Table 3: values of soil pH, EC and organic carbon content in soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		pH				EC (dSm^{-1})				Organic Carbon ($g\ kg^{-1}$)			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	8.05	8.00	8.91	8.53	0.17	0.16	0.26	0.24	9.96	9.30	7.94	7.43
	t value	0.12		1.43		0.45		0.45		0.40		0.37	
Hiriyur	Mean	8.25	7.96	8.54	8.69	0.23	0.22	0.26	0.34	11.61	9.96	8.15	5.66
	t value	0.83		0.37		0.03		1.25		1.35		1.40	
Chitradurga	Mean	7.31	7.76	8.24	8.52	0.22	0.20	0.30	0.28	10.07	8.37	8.26	6.01
	t value	0.93		0.62		0.52		0.24		0.95		1.39	
Hosdurga	Mean	7.82	6.96	8.24	8.05	0.21	0.19	0.32	0.25	8.63	10.78	6.01	6.38
	t value	1.90		0.42		0.46		1.22		2.63*		0.21	

Table 4: Available nitrogen, phosphorus and potassium content in soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Avail. N ($kg\ ha^{-1}$)				Avail. P_2O_5 ($kg\ ha^{-1}$)				Avail. K_2O ($kg\ ha^{-1}$)			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	281.01	233.21	238.88	199.57	34.91	24.25	31.99	21.14	207.77	153.40	147.63	129.94
	t value	1.24		1.19		3.08*		2.75*		1.90		0.60	
Hiriyur	Mean	260.92	208.23	213.41	178.67	44.08	31.58	34.84	27.44	303.54	217.54	238.11	180.90
	t value	2.98*		1.71		1.29		0.84		0.94		0.69	
Chitradurga	Mean	275.19	215.76	215.76	180.22	42.27	34.34	33.87	28.16	202.26	144.96	164.49	121.85
	t value	2.52*		2.07		0.81		0.60		2.99*		1.36	
Hosdurga	Mean	292.69	217.43	253.98	206.98	31.74	25.06	27.06	20.38	312.15	224.83	275.49	205.82
	t value	2.81*		2.69*		1.73		1.91		1.02		0.84	

*Significant at 5% level, ** Significant at 1% level , HG: Healthy garden, AG: Affected garden magnesium in affected gardens compared to healthy gardens of Hosdurga taluk and Holalkere taluk respectively.

The exchangeable calcium and magnesium content of subsurface soils of both healthy and affected gardens of all the taluks recorded higher values than the surface layer soils which may be due to movement of calcium to the lower depths during irrigation. And also his can be attributed to leaching of cations by higher content of clay in the subsurface. Similar results were observed by [16] and [22].

3.11 Available sulphur

The data on available sulphur content of both healthy and affected gardens of Chitradurga district presented in table 5.

The available sulphur contents are in sufficiency range in both healthy and affected gardens of all taluks. In all taluks of Chitradurga district, there was a decrease in content of available sulphur in affected gardens compared to healthy gardens, but it did not vary significantly.

The availability of sulphur tended to decrease with increasing depth in both healthy and affected gardens of all the taluks. Decreased in available sulphur was due to low organic carbon content [23] and reducing microbial population are the possible reasons for such decreasing trend.

3.12 Micronutrients

The data on available micronutrient content of both healthy and affected gardens of Chitradurga district presented in table 6 and 7.

The content of Fe, Mn, Cu, Zn and B are in sufficiency range in both healthy and affected gardens of all taluks. However, in Hiriyur taluk, there was significant variation between zinc content of healthy and affected gardens, it was observed that zinc content was lower in affected gardens compared to healthy gardens at both depth. Whereas, the content of manganese and zinc decreased significantly in affected gardens compared to healthy gardens in Chitradurga taluk. While in case of Hosdurga taluk, the availability of micronutrients like Fe, Mn, Cu, Zn and B

Table 5: Exchangeable calcium, magnesium and available sulphur content in soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Exch. Ca (cmol (p+) kg^{-1})				Exch. Mg (cmol (p+) kg^{-1})				Avail. S (mg kg^{-1})			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	21.22	17.24	23.47	21.80	8.44	5.82	8.60	6.73	59.35	51.85	53.85	44.90
	t value	0.85		0.29		2.46*		1.27		1.30		1.29	
Hiriyur	Mean	13.72	13.00	15.02	14.16	7.94	7.00	11.32	9.16	70.85	48.51	58.40	38.72
	t value	0.17		0.21		0.45		1.14		1.77		1.95	
Chitradurga	Mean	18.02	14.76	20.32	16.84	9.80	7.16	10.90	8.72	60.00	48.95	48.70	40.26
	t value	0.96		0.95		1.76		1.51		1.11		1.04	
Hosdurga	Mean	15.97	12.67	18.12	13.95	8.48	6.37	10.83	7.85	48.50	39.50	45.68	33.83
	t value	2.03		2.73*		1.86		2.15		1.59		2.06	

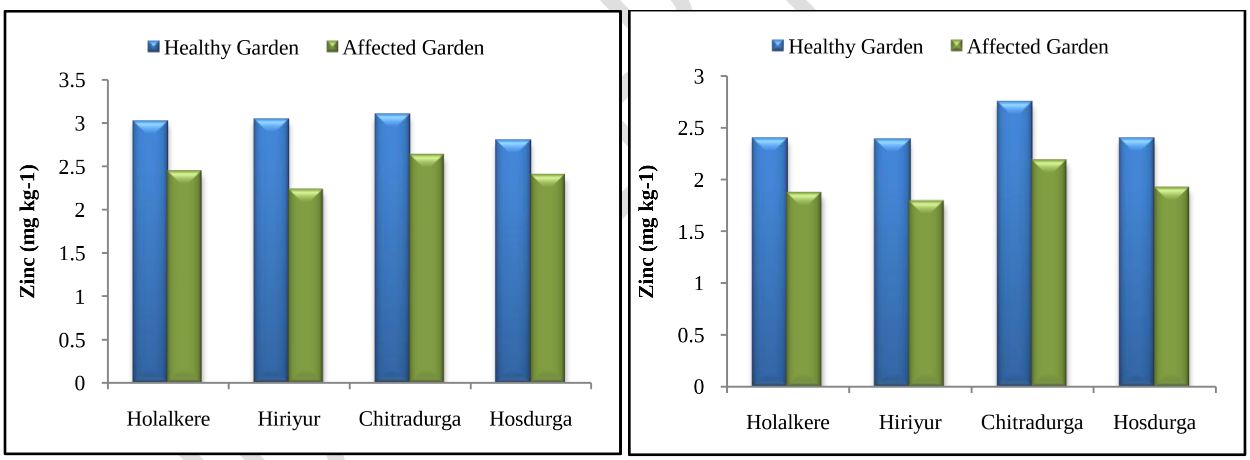
Table 6: Available Fe, Mn and Cu content in soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Fe (mg kg^{-1})				Mn (mg kg^{-1})				Cu (mg kg^{-1})			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	Mean	15.40	13.65	13.99	12.66	11.82	10.65	10.31	9.71	3.24	2.30	2.60	1.86
	t value	0.68		0.50		1.34		0.77		1.01		1.04	
Hiriyur	Mean	16.50	11.64	14.49	10.87	10.32	8.68	8.90	7.20	3.15	2.01	2.18	1.50
	t value	1.89		1.84		1.75		1.63		1.47		1.34	
Chitradurga	Mean	14.88	12.52	13.47	11.42	11.57	8.72	10.34	7.46	2.88	2.37	1.98	1.69
	t value	1.64		2.02		3.44**		2.99*		1.49		1.47	
Hosdurga	Mean	15.76	13.15	14.53	11.58	12.72	10.03	11.77	9.19	2.55	1.86	2.19	1.56
	t value	2.67*		2.96*		3.51**		3.12*		3.02*		3.19*	

*Significant at 5% level, ** Significant at 1% level, HG: Healthy garden, AG: Affected garden

Table 7: Available zinc and boron content in soils of healthy and *hidimundige* affected arecanut gardens in Chitradurga district

Taluk		Zn (mg kg^{-1})				Boron (mg kg^{-1})			
		0-30 cm		30-60 cm		0-30 cm		30-60 cm	
		HG	AG	HG	AG	HG	AG	HG	AG
Holalkere	**Mean**	3.02	2.44	2.40	1.87	1.05	0.80	0.81	0.53
	t value	1.26		1.85		2.11		1.85	
Hiriyur	**Mean**	3.04	2.23	2.39	1.79	1.17	0.84	0.80	0.55
	t value	2.87*		2.80*		1.52		1.17	
Chitradurga	**Mean**	3.094	2.628	2.748	2.182	1.25	1.036	0.94	0.634
	t value	2.05		3.34*		0.88		1.29	
Hosdurga	**Mean**	2.80	2.40	2.40	1.92	1.18	0.79	0.87	0.47
	t value	1.90		2.32*		1.97		3.33**	



(a) (b)

Fig.3: Average zinc content in soils under healthy and *hidimundige* affected arecanut gardens of Chitradurga district (a) surface layers (b) subsurface layers

decreased significantly in affected gardens compared to healthy gardens. The results indicates that although, the difference between healthy and affected gardens wrt. micronutrient varied, zinc content showed a marked difference between healthy and affected gardens of Hiriyur, Chitradurga and Hosdurga taluk (fig. 3).

4. CONCLUSION

from the results of the experiment, it can be concluded that the bulk density increased significantly in affected gardens compared to healthy gardens in Holalkere and Hosadurga taluk at lower depth. Whereas, drainable porosity decreased significantly in affected gardens compared to healthy gardens of Holalkere and Hosadurga taluk. And also available zinc status in soil showed significant decrease in affected gardens compared to healthy gardens of Hiriyur, Chitradurga and Holalkere taluks.

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