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Impact of intercropping on root distribution in coconut under coastal sandy soil

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In India coconut is being grown in different soil types. Laterite, sandy and red sandy loam soils are the major soil types occupied by coconut. Coastal sandy soil which occurs all along the west and east coast of peninsular India lie mostly in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. General weather prevailing in coastal region is conducive for growing coconut economically. However, coconut productivity is very low in the coastal sandy soil, mainly due to poor physio-chemical properties of the soil. Coastal sandy soil is characterized by poor water holding capacity, excessive infiltration, easy leaching and low inherent fertility status. These soils have a field capacity in the range of 1-6 per cent and permanent wilting point 0.2-0.6 per cent and bulk density of 1.6-2.0 g cm^{-3}. The mechanical analysis revealed that the sand fraction is very high (94-99%), whereas silt (0.2-2.05%) and clay (0.6-2.8%) fractions are low in all layers of the soil profile.

Adequate quantity of root biomass is essential for better uptake of nutrients and water and also for anchorage of roots of coconut palm. Coconut palm has an adventitious root system, a typical character of monocot. The life span of coconut tree is prolonged more than 60 years during which the palm may undergo several abiotic stresses. The adventitious nature of root is sufficient to serve the basic functions of palm, which is planted at fairly good depth (60 cm) and in a place where soil depth is 1.2 m or more. In middle aged palm 96 per cent of the roots will be present in 0-120 cm depth (Maheshwarappa *et al.*, 2000). It is a fact that root density and proliferation varies with surrounding environment *i.e*., moisture, nutrient availability and use of amendments such as husk, coir pith *etc*. More number of roots will concentrate on the surface of soil when all the soil conditions, especially moisture, is favourable and under stressed condition, roots tends to go deeper and longer in search of water and nutrients. Further application of amendments and inter cultivation of crops also influence the rooting density in the interspace. However, such study on root proliferation in coconut based intercropping system is meager. Keeping this objective in view a study was initiated at CPCRI, Kasaragod to find out the impact of vegetable intercropping on root proliferation and yield of coconut in coastal sandy soil.

The study was carried out during monsoon season of 2011 in 36 year old coconut garden at Central Plantation Crops Research Institute (CPCRI), Kasaragod which is located at a latitude of 12° 30' N and longitude 75° 00' E at an altitude of 10.7 m above MSL in coastal sandy soil where, intercropping of vegetables (interspaces of 60 coconut palms *i.e*., 2880 m^2 area) and monocrop of coconut (60 coconut palms) is maintained since 2007. The palms were irrigated by drip irrigation. Recommended dose of fertilizers was applied as per the CPCRI, package of practice for coconut. The vegetables such as ridge gourd, snake gourd and cowpea were grown in trenches filled with husk on rotation. The study was conducted in the interspace of coconut palm leaving 1.8 m from the trunk. Totally 22 m^2 sector area in between coconut palms was washed with hose pipe to a depth of 90 cm and the washed sand was collected in the trench opened on either side of washing area. The same was repeated in four different places in both monocrop and intercropping system. Observations were recorded on number of roots (old roots and fresh roots- based on colour of the root), number of fine roots, fresh weight and dry weight of roots. Physiological parameters *viz*., photosynthesis rate,

transpiration rate (E) and stomatal conductance (g_s) were measured by using LI-6200 portable photosynthesis system (Li-Cor Inc., Nebraska, USA) in March between 10.00 and 11.30 h by detaching leaflet from the middle portion of the 14th leaf from the spindle. The yield data was recorded every month from all the palms and annual yield palm^{-1} was computed. Coconut yield was also recorded from both systems from 2007-2011.

The study revealed that average number of main roots was found more or less equal in monocrop as well as in the palms intercropped with vegetables. But the number of fresh roots was more in intercropped zone (85) as compared to interspace of monocrop (49). This was mainly due to the long term effect of vegetable cultivation in the interspaces, because in the intercropped area vegetables were managed with irrigation, manuring resulting in continuous availability of water and nutrients which influenced the root growth. This has facilitated the roots to remain alive and active in absorption, whereas, in monocrop (in the interspace area) the roots remained dry and dark coloured. Also the fine roots were less due to non-availability of water and nutrients.

Apart from this, average number of fine roots (43) were more in intercropping sector whereas, it was only 21.5 in monocropped area. Even though roots in the interspace of monocrop had enough fine roots, they were dry, dark coloured and non-active. But the roots of palms with intercropping were found to be fresh and white coloured. This was mainly due to the availability of water and nutrients in the trench filled with coconut husk to facilitate planting of vegetables. The husk enabled to retain water and nutrients in the coastal sandy soil which otherwise would have lost by leaching. This husk enabled adequate supply of water and nutrients for better root growth. It was also found that root proliferation started from shallow depth (15 cm depth from the surface) due to the availability of water in the intercropping system whereas in the palms of monocropping more roots were seen 50 cm deep from the surface of soil. Dhanapal *et al*. (2000) reported that more number of main roots was found in layer of 31-60 cm depth and there was a decreasing trend in the deeper layers (61-90 and 91-120 cm). This indicated that roots of monocrop went deeper and spread wider in search of nutrients and water. Kushwah *et al*. (1973) also reported that 73 per cent of roots were found within 2 m radius and most of them were confined to 31-120 cm depth.

Dry weight of fresh roots (3.38 kg per 22 m^2) and fine roots (2.87 kg per 22 m^2) were found more in the palms with intercropping, whereas dry weight of old roots were more in monocropped area (17.7 kg per 22 m^2). But no difference was found in dry weight of total root biomass in both system of cropping. The study area being high rainfall zone, during monsoon season (June to September) due to availability of enough moisture in the root zone, the roots have developed well in the interspace of the monocrop palms but later when there were no rains, the roots have seen dried and became inactive. Thus in the total root biomass there was not much difference between the two categories of palms. It was also found that moisture percentage of total root biomass in the monocrop palm roots was only 42.3 per cent, whereas in the palms with intercropping it was 59.9 per cent. One more interesting point is, though for the monocrop palms drip irrigation was provided in the basin but due to non-availability of space for fresh root development more roots could not have been developed (in the basin area new, old and dead roots got packed). Dhanapal *et al*. (2000) also noticed that the dry weight of total root biomass was not different with basin and drip irrigation method.

Table 1. Main root number and weight of roots influenced by inter cropping and monocropping in coastal sandy soil

Parameters	Intercropping	Monocropping
Ave. root length away from 1.8 m basin area (m)	2.25	2.47
No. of old roots	111.00	161.00
No. of fresh roots	85.00	49.00
Ave. number of fine roots	43.00	21.50
Dry weight of old roots (kg)	15.00	17.70
Dry weight of fresh roots (kg)	3.38	1.74
Dry weight of fine roots (kg)	2.87	1.78
Total fresh weight of roots (kg)	53.10	36.80
Total dry weight of roots (kg)	21.30	21.20
Moisture content of roots (%)	59.90	42.30
Depth of start of more roots from the surface (cm)	15.00	50.00

It is already established that under good management conditions coconut will perform better to give higher yield. Despite coastal sandy soil is poor in organic matter and nutrients, timely manuring and

irrigation may results in higher yield. Intercropping in coconut garden using husk as amendment for growing vegetables produced higher nut yield over the monocropping treatment (Table 2). Increase in coconut yield might be due to the more proliferation of fresh roots in the interspaces of the palm and also due to more number of fine roots in the trench filled with husk where vegetable planting was taken up resulting in better uptake of water and nutrients. Also the nutrient mining area was large *i.e*., both in the basin as well as in the interspace. This is in line with the findings of Subramanian *et al*. (2006), who reported that pumpkin and ash gourd responded well to the husk and coir pith application in the pits. Yield increment was observed when soil was incorporated with coconut husk/coir pith as compared to control where no soil amendments were used and the coconut yield also increased over the years.

Table 2. Influence of intercropping on coconut yield in coastal sandy soil (nuts palm^{-1}year^{-1})

	Pre-treatment yield	Post-treatment yield				Mean
		yr 1	yr 2	yr 3	yr 4	
Intercropping	23.7	44.7	84.3	73.3	78.0	70.1
Monocropping	21.7	45.7	51.7	51.3	52.0	51.1

Physiological parameters such as photosynthetic rate, stomatal conductance and transpiration rate were higher in intercropped palms (Fig. 1). Continuous availability of water and nutrients influenced the higher photosynthetic rate which attributed to higher yield in the intercropped palms.

Though there was no difference in total number of main roots (fresh and old roots), difference in dry weight, number of fresh roots and fine roots was observed between intercropped and moncropped coconut palms. Because of availability of space, nutrients and water in the interspace between the palms, there was a better root development and proliferation especially the fine roots. Higher the number of fine roots, higher will be the uptake of water and nutrients. By applying

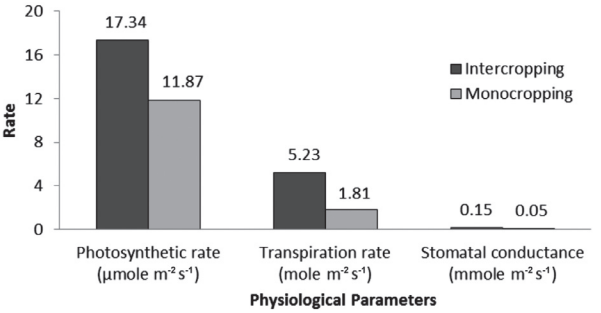

Fig. 1. Effect of intercropping practices on physiology of coconut under coastal sandy soil condition

the husk in the interspaces and cultivating vegetables facilitate better availability of water and nutrients which enhance fine root growth and its multiplication. In the initial years there was enough space for the root development in the basin area. But when the palms attain an age between 10 to 15 years, the basin area is packed with old and dead roots and thus there is space constraint for the growth and proliferation of the fresh roots. Thus, providing favourable environment in the interspace away from the basin area helps in better root development. This may change the present concept of management practices such as manuring in the basin area of the palm. However, this needs further studies to confirm.

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