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Leguminous and grass fodder combinations for enhancing soil health and system productivity in coconut gardens of the humid tropics

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ABSTRACT

Fodder crops form an inevitable component in coconut based mixed farming systems. However, continuous cultivation of fodder crops in coconut gardens may lead to the gradual depletion of soil fertility particularly that base nutrients such as potassium, calcium and magnesium. Both coconut and fodder grass have greater demand for these nutrients potassium. In the nutrient depleted sandy soils this may lead to declined productivity of both the crops. Hence inclusion of leguminous fodder crops along with grass fodder is a management strategy to prevent the depletion of soil fertility status. A field experiment in Randomized Block Design was conducted at ICAR-Central Plantation Crops Research Institute with six treatments comprising the grass fodder Hybrid Bajra Napier var. Suguna and the leguminous fodder crops cowpea (var. EC 4126) and *stylosanthes hamata* in various combinations. Soil and leaf samples were analyzed for nutrients and the total nutrient uptake was estimated. Inclusion of leguminous fodder crops as intercrops in the grass fodder plot have been found to enhance the soil fertility status particularly organic carbon, available K, Ca and Mg. The differential uptake pattern of nutrients by the grass and leguminous fodders can compensate for the exhaustive removal of nutrient from the soil and thereby could sustain soil health and system productivity. The highest green fodder yield of 132.04 t/ha was recorded when hybrid bajra napier was grown with stylosanthes in the interspaces.

Key words: *Sandy soil, Coconut, Legume fodder, Grass fodder*

Introduction

Coconut is a perennial plantation crop with exhaustive removal of nutrients from the soil. The annual nutrient requirement of an adult bearing coconut palm is 500g N: 320g P:1200g K_2O. Studies conducted by Mathew *et al.* (2021) have found that that the total nutrient uptake of an apparently healthy coconut of average age of twent five years is 889g N, 109.4g P, 1075g K, 389.7g Ca, 71.6 g Mg and 229.7g S. The monocrop of coconut is not remunerative and hence it is advisable for the farmers to adopt for the practice of intercropping and mixed cropping. Inclusion of livestock in the farm enterprise will not only make the cultivation remunerative, but also will enable the farmers to reduce the various risks associated with farming and ensures stable farm income. Apart from that the adoption of cropping system model will enhance the soil biodiversity and enriches the soil health in the plantation system. Inclu-

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sion of fodder grass as an intercrop component will support the farm enterprise, with the enrichment of livestock enterprise by reducing the feed cost and thereby-the cost of production by providing the quality.

Adoption of a cropping system combining grasses and legumes has the possibility to enrich soil fertility by the improvement of soil quality parameters. Inclusion of legumes as a component in the will impart ground cover, tap solar energy, provide biomass, nitrogen fixation and control weed growth. Currently, symbiotic nitrogen fixation by legumes and their associated rhizobia constitutes the only practical means by which significant amounts of noncommercial nitrogen can be added to agricultural soils. Application of required quantities of macro and micronutrients at the appropriate time will enhance coconut-based fodder production systems (Lakshmy *et al.*, 2007).

Perusal of crop productivity in coconut plantations which were intercropped with fodder crops alone without the inclusion of leguminous cover crops over 10 years have shown a gradual reduction in yield of palms. Hence it is better to include legumes also as a component crop in the farming system for replenishing of soil quality parameters. The nutrient supplying capacity of coconut soil may be enhanced by the incorporation of legumes and fodder crops along with better management options in terms of fertilizer application, addition of organic manures and the foliar application of nutrients in the farming system.

Sandy soils are inherently deficient in base nutrient ions such as potassium, calcium and magnesium. Grass fodder crops have exhaustive uptake of nutrients particularly with respect to potassium. But potassium is also the key nutrient in coconut production system. This greater demand for potassium by the grass fodder crops may sometimes result in occurrence of nutrient deficiency and thereby reduction in crop yields. Leguminous fodder crops when intercropped with fodder grass in a coconut-based cropping system can compensate for the exhaustive removal of potassium along with the improvement in soil quality in terms of organic matter content, available nutrient status as well as the population of beneficial soil microbes. Leguminous fodder crops have the potential to fix atmospheric nitrogen in its root nodules and thereby can enrich the soil fertility. Deepthi *et al.* (2021) explained the suitable fodder crop varieties such as Hybrid Napier, stylosanthes, fodder cowpea, congosignal grass and subabul as intercrops in coconut gardens above 25 years of age.

With this background, we planned an experiment with fodder crop Hybrid Bajara Napier with the component crops such as *stylosanthes hamata* and cowpea, planted on the interspaces of coconut garden. The objective of the study was to assess the space effect of grass –legume fodder combinations as intercrops in coconut gardens for enhancing the soil quality and crop productivity in the tropical sandy soils.

Materials and Methods

The experiment was conducted at ICAR-Central Plantation Crops Research Institute, Regional Station, Kayamkulam in Randomized Block Design. The coconut variety chosen for the study was West Cost Tall planted at a spacing of 7.6m × 7.6 m. In the interspaces, Hybrid Bajara Napier (HBN) var. Suguna was planted. The slips were planted at a spacing of 60cmX60cm with a plot size of 5 × 4 meter square. Within the grass plots, in the interspaces, the component crops such as perennial *stylosanthes hamata* and fodder cowpea var. EC 4216 were planted as per the treatments. First harvest was done 60 DAP and subsequent harvests were taken at 45 DAP. There were six treatments as T1: Fodder crop as pure crop with nutrients as per Package of Practices, T2: Fodder crop with stylosanthes as intercrop, T3: Fodder crop with cowpea as intercrop, T4. Cowpea as pure crop, T5: Stylosanthes as pure crop, T6: Fodder crop under organic management with the application of cowdung slurry. The fertiliser requirement of NPK was supplied through urea, mussoriephos and muriate of potash. The recommended dose of fertiliser for fodder grass was 200:50:50 kg ha^{-1} NPK (KAU, 2016). The main crop as well as the component crops were given fertilisers as per the soil test data (84%N, 48% P and 94% K) in treatments T2 to T5.

Biometric Observation

The biometric parameters such as height, no. of tillers, leaf: stem ratio, annual green fodder yield (tha^{-1}) were recorded systematically during the period 2013-2016. From each treatment five plants were selected to record the biometric observations. Plant height was measured from the ground level to the tip of the longest leaf and was expressed in cm. After partitioning of whole tiller into leaf and stem, oven dry weight were recorded and leaf to stem ratio (LSR) was worked out by applying the following formula. LSR = Leaf dry weight (g)/ Stem dry weight (g). The fresh weight of the harvested fodder was recorded during the three year period and were expressed as tonnes ha^{-1}.

Equivalent yield= yield of crop in quintals/ha x space factor

$$\text{Factor} = \frac{\text{Per unit cost of fodder cowpea/stylosanthes}}{\text{Unit cost of fodder grass}}$$

Soil sampling and analysis

Soil samples were collected before and after the conduct of the experiment. The soil samples from each fodder plot were collected from 30 cm depths using soil augur. The soil samples were analysed for organic carbon, available phosphorus, potassium, calcium, magnesium, iron, manganese, copper, zinc and boron. The physical properties such as bulk density, particle density, porosity and water holding capacity were estimated from the treated plots. The soil samples from coconut basins were collected at a distance of 1 meter from the trunk of the palm and the samples were drawn at depths 20 cm and 40 cm.

Plant sampling and analysis

Representative plants from each treatments were uprooted. Fresh weight of the plants were taken, leaves and stems were separated, chopped, and and were later dried in oven at 60 degree Celsius till consistent weight was recorded. Dry weight of the samples were taken and were powdered in willey mill. Wet digestion of the samples with nitric: perchloric acid (9:3) mixture and estimated the concentration of total P, K, Ca, Mg, Fe, Mn, Cu and Zn. The total nutrient uptake was computed as the product of dry weight and nutrient concentration and expressed as kilogram ha^{-1}. The methods of analysis of soil and plant samples are outlined in Table 1. The initial soil fertility parameters at the experiment plot as well as in the coconut basin are represented in Table 2.

Microbial Analysis

Soil samples for the microbial analysis were processed and stored at 4 °C. Population count of general microbial groups such as heterotrophic bacteria, filamentous fungi, actinomycetes and functional groups such as fluorescent pseudomonads, phos-

Table 1. Method of analysis of soil and plant samples

Sl. No.	Estimation	Method	Reference
Soil Parameters			
		Physico-chemical properties	
1	a. pH	Conductometry	Jackson (1973)
2	Chemical properties		
3	a. Organic Carbon	Chromic acid wet digestion method	Walkley and Black (1934)
4	b. Available P	Bray and Kurtz extraction method using 0.03N Ammoniium flouride and 0.025N HCl	Jackson (1973)
5	c. NN NH_4OAc-K	Neutral Normal NH_4OAc using flame photometer	
6	d. Calcium	Neutral Normal NH_4OAc using AAS	
7	e. Magnesium	Neutral Normal NH_4OAc using AAS	
8	f. Micronutrients Cu, Zn, Fe, Mn	Extraction using 0.1N HCl and estimation using Atomic Absorption Spectrophotometer	
		Plant Parameters	
1	Phosphorus	Vanadomolybdate yellow colour method	Jackson (1973)
2	Potassium	Flame photometry	Stanford and English (1949)
3	Calcium	Atomic Absorption Spectrophotometry	Stanford and English (1949)
4	Magnesium	Atomic Absorption Spectrophotometry	Stanford and English (1949)
5	Micronutrients Cu, Zn, Fe, Mn	Nitric – perchloric acid (9 : 3) digestion and Atomic Absorption spectrophotometry	Lindsay and Norvell (1978)

Table 2. Initial soil fertility status of the treated plots

Sampling site	pH	Organic Carbon %	P	K	Ca	Mg	Fe ppm	Mn	Cu	Zn	B
Coconut Basin	5.88	0.526	57.19	55.03	208.32	34.03	6.13	1.86	0.88	3.08	0.28
Grass-legume fodder plot	5.65	0.612	53.13	12.88	168.52	29.46	7.7	1.73	1.08	2.66	0.25

phate solubilizers and free living nitrogen (N) fixing bacteria was done using the serial dilution and plating technique using appropriate soil dilutions and specific growth media (Pelczar *et al.*, 1957).

Statistical Analysis

ANOVA for one way classified data was used to compare the effect of treatments on the different parameters. For statistical analysis, SPSS version 21.0 was used (IBM, 2016).

Results and Discussion

Biometric characters of Hybrid Bajra Napier var. Suguna and leguminous fodder crops

Data on the biometric characters of grass fodder showed significant difference between the treatments with regard to the number of tillers per plant and the leaf: stem ratio (Table 3). The highest number of tillers per plant (46.46) was observed when HBN was grown as a pure crop with nutrients as per the POP. In the case where it was intercropped along with cowpea or stylosanthes and in the treatment which received organic treatments with the incorporation of cow dung slurry alone, there was no significant difference and the treatments were at par with each other. On analysing the biometric characters of HBN, it was observed that there was no significant difference in the height of the crop with respect to the different treatments. Leaf: stem ratio was highest when HBN was intercropped with stylosanthes hamata (0.940) which was significantly superior to the other treatments. This was followed by the treatment when cowpea was intercropped with HBN. The positive influence of fertiliser levels and plant geometry on enhancing the leaf: stem ratio of HBN was described by Velayudham *et al.* (2011). Inclusion of stylosanthes as intercrops in HBN grass was found to be superior as compared to that of cowpea intercropping and sole crop planting. Intercropping legumes with grass fodders always found to be superior on enhancing the green fodder yield and dry matter yield (Aderinola, 2007). In our study, the results indicated the superiority of perennial legumes such as stylosanthes hamata over the short duration leguminous crops such as cowpea. Though the number of tillers plant^{-1} was highest in

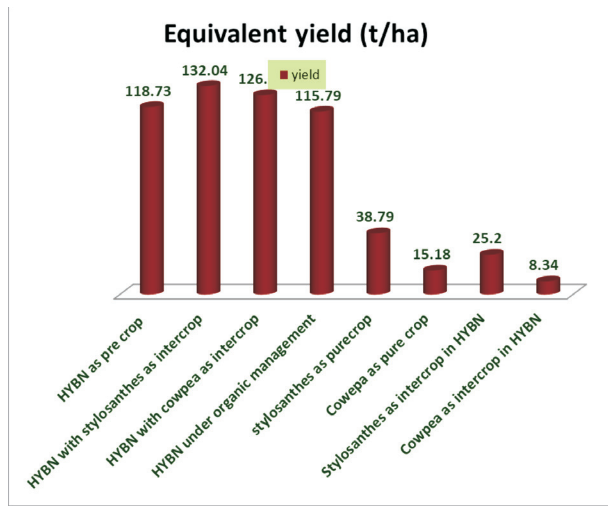

Fig. 1. Equivalent yield of fodder grass and legume fodder combinations

Table 3. Biometric characters of fodder grass

Treatments	Height (cm)	No. of tillers (per plant)	Leaf/ stem ratio
Hybrid Bajra Napier(HYBN) as pure crop with nutrients as per POP	185.125	46.46	0.843
Hybrid Bajra Napier(HYBN) with stylosanthes with nutrients as per soil test data	186.91	36.09	0.940
Hybrid Bajra Napier(HYBN) with cowpea as intercrop with nutrients as per soil test data	194.94	32.79	0.885
Hybrid Bajra Napier(HYBN) under organic management	177.22	36.67	0.760
CD(0.05)	NS	8.07	0.07

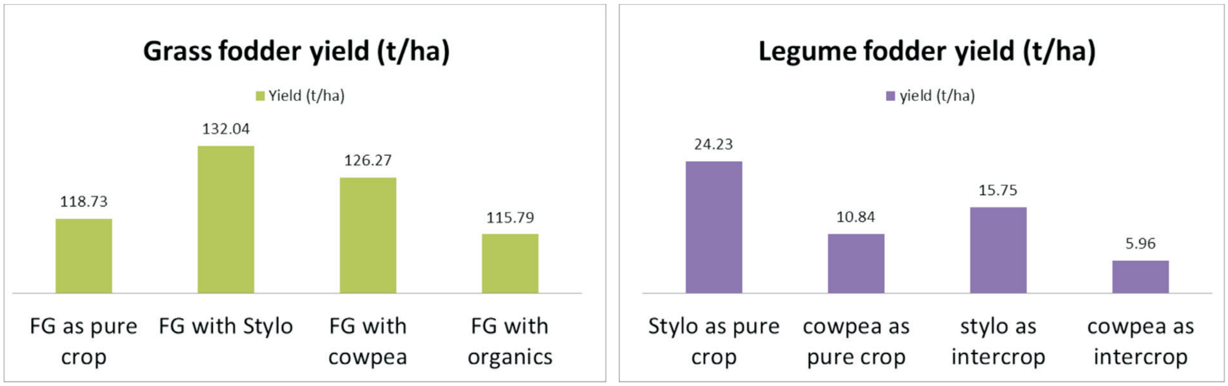

Fig. 2. Actual yield of grass and fodder legumes

when HBN was grown as a sole crop, the highest leaf: stem ratio was recorded when intercropped with *stylosanthes hamata* followed by that of cowpea.

The root characteristics of cowpea and stylosanthes are presented in Figure 3 and 4. It could be observed that the characteristics such as root length, number of active nodules and the root dry weight are significantly higher for the crops when grown as pure crop than as intercrop. This could be due to greater availability of resources and the limited competition from the grass fodder crops. Anyhow, the inclusion of leguminous fodder as intercrop within the fodder grass plot could enrich the soil health characters due to the presence of significant number of root nodules.

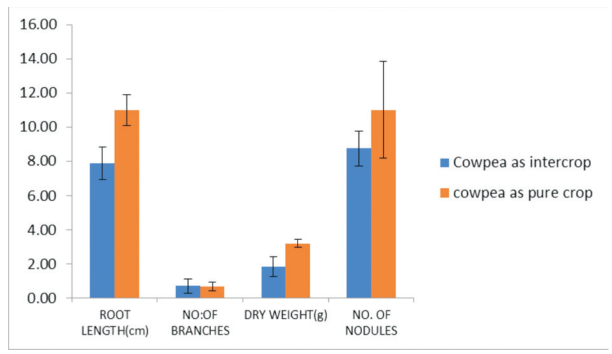

Fig. 4. Root characterstics of cowpea when grown as a pure crop and as intercrop

Effect of treatments on green fodder yield

The initial harvest of HBN was done 60 DAP. Subsequest harvests were made at 45 days interval. The highest green fodder yield of 132.04 t ha^{-1} was recorded when HBN was intercropped with stylosanthes giving the nutrients based on the soil test data. This was followed by cowpea intercropping with HBN recording the green fodder yield of 126.27 tha^{-1}. When grown as a pure crop with nutrients based on the POP recommendations, the yield was comparatively less (118.73t ha^{-1}). Under organic management the recorded yield was 115.79 tha^{-1}. On comparing the yield of leguminous fodder crops when grown as pure crop as well as intercrop, it was observed that stylosanthes as a pure crop recorded a yield of 24.23 t ha^{-1} and as an intercrop crop, the yield was 15.75 t ha. In the case of cowpea as a pure crop, the recorded yield was 10.84 t ha^{-1} and as intercrop the yield was 5.96 t ha^{-1}. The advantage of the leguminous fodder intercropping is reflected in the green fodder yield (Figure 1). The positive influence of grass fodder and leguminous fodder mixtures on the crop stand, reduction in weed intensity and forage distribution was emphasised by Akinlade *et al.*, 2003; Baylor (1994).

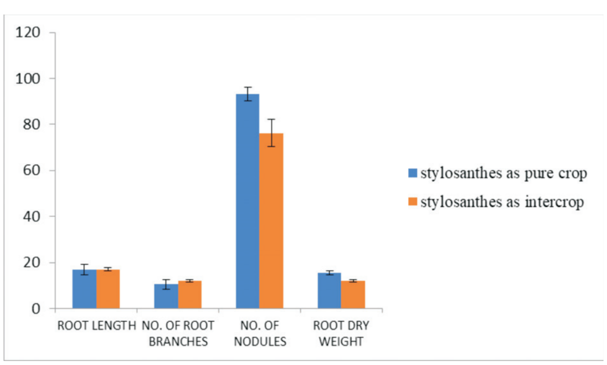

Fig. 3. Root characterstics of stylosanthes when grown as pure crop and as intercrop

Effect of grass-legume fodder combinations on soil fertility

Fodder grass such as HBN have exhaustive removal of nutrients from the soil. On the other hand, leguminous fodder crops may boost up the soil fertility. The combination of monocotyledonous (fodder grass and coconut) and leguminous crops may facilitate for the complementary effect of the two plant groups on enhancing the soil fertility.

Soil fertility parameters at the coconut basin indicated that the soil is deficient in available K, Ca and Mg along with extreme soil acidity. In the experiment plot where the fodder grass was cultivated, it could be observed that the soil is deficit in organic matter content, available potassium, calcium and magnesium. After the experiment, the soil from the coconut basin indicated that there was improvement in organic carbon content and available potassium content. Skipping of phosphatic fertiliser resulted in the reduction in available phosphorus from 57.19 ppm to 49.70 ppm. The available potassium content increased from 55.03 ppm to 63.91 ppm.

The influence of different treatment combinations on the soil fertility status of the fodder plots is depicted in Table 4. It could be observed that there was significant difference in pH between the different treatment combinations. The highest pH 5.85 was recorded when cowpea was grown as a pure crop, which was just followed with stylosanthes as a pure crop. Both were on par with each other. The highest value of organic carbon was recorded by the pure crop of *stylosanthes hamata* followed by the combination treatment of HBN with cowpea. Significant number of root nodules in the leguminous fodders might have contributed to the enhancement of soil organic carbon. All the treatments except those with the sole crop of HBN were at par with each other. There was no significant difference between the treatments with regard to available P and K. Significantly highest value of exchangeable Ca was recorded by the combination treatment of HBN with *stylosanthes hamata*, followed by the individual treatment with cowpea as the sole crop. This difference can be attributed to the complementary effect of monocot dicot combination on the uptake of nutrients and enriching the soil fertility status.

The difference in root cation exchange capacity between monocot crops (HBN) and the dicot crops (*stylosanthes hamata)* and led to the differential uptake of nutrients by them from the soil. Dicots with higher root CEC takes up polyvalent ions such as Ca and Mg from the soil whereas the monocot crops prefer monovalent nutrients such as potassium and sodium (Woodward *et al.,* 1984). Root CEC of dicots are larger than that of monocot plants. The relation between the root cation exchange capacity and the differential uptake of nutrients by the monocots and dicots were elaborated earlier by Mattson *et al.* (1948). Huffaker and Wallace (1958) explained the relationship between root CEC and concentration of potassium, calcium and magnesium of several plants on the basis of Donnan distribution. *Stylosanthes hamata*, being the perennial leguminous fodder had greater influence on enhancing the soil fertility parameters such as organic carbon, exchangeable calcium and magnesium. Hence the values were comparatively higher in the treatments with it either as a sole crop or as an intercrop in HBN.

Effect of treatments on the nutrient uptake

The total nutrient uptake is presented in the Table 5 and Table 6. The nutrient uptake by the grass fodders are significantly higher than the leguminous fodder crops. This is due to the higher dry matter production. It could be observed that the uptake of potassium and calcium by HBN was significantly higher when cowpea was intercropped with HBN followed by the intercropping of stylosanthes with HBN. Pure crop of HBN showed less nutrient uptake. The pure crop of *Stylosanthes hamata* showed greater uptake of all the nutrients compared to that of cowpea as pure crop due to the greater biomass

Table 4. Effect of treatments on enhancing soil fertility status

Treatments	pH	OC%	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
T1	5.46^{a}	0.642^{b}	72.08	23.75	211.68^{b}	22.33^{c}
T2	5.62^{a}	0.731^{a}	52.19	27.5	303.05^{a}	55.09^{a}
T3	5.55^{b}	0.840^{a}	53.63	24.38	250.75^{b}	35.54^{b}
T4	5.90^{a}	0.720^{a}	73.78	24.63	257.13^{ab}	46.04^{a}
T5	5.85^{a}	0.865^{a}	59.69	25.13	223.91^{b}	47.3^{a}
T6	5.32^{b}	0.830^{a}	53.44	19.73	137.11^{c}	31.64^{b}
CD (0.05)	0.35	0.21	NS	NS	47.33	11.02

Table 5. Effect of treatments on the total uptake of major nutrients by fodder grass, stylosanthes and cowpea

Treatments	Total dry matter production tons ha^{-1}	Total P Uptake	Total K uptake	Total Ca Uptake	Total Mg Uptake
		kgha^{-1}			
HYBN as pure crop with nutrients as per POP	12.76	39.24	150.04	39.24	67.12
HYBN with stylosanthes with nutrients as per soil test data	15.11	40.19	166.79	40.29	53.38
HYBN with cowpea as intercrop with nutrients as per soil test data	11.03	37.62	205.78	42.05	51.05
Stylosanthes as pure crop	4.60	5.51	28.49	39.09	20.09
Cowpea as pure crop	1.08	2.33	9.01	14.19	5.12
HYBN with organic management	12.82	34.27	265.12	34.37	53.81
CD (0.05)	3.52	13.33	90.06	13.41	21.49

production by stylosanthes as compared to that of cowpea.

Effect of treatments on the soil physical properties

Soil physical properties are crucial soil health indicators for enhancing soil fertility and sustaining plant health and productivity. The data presented in Table 7 shows the effect of treatments on enhancing the soil physical properties. Soil physical properties like bulk density and particle density are influenced by long term management practices. In our experiment there is no significant difference between the treatments with regard to these two properties. However, porosity and water holding capacity were influenced by the treatments. The highest per cent of porosity (42.69%) was recorded when organic management was practiced for growing the pure crop of HBN and was followed by cowpea as a sole crop (T4). The maximum water holding capacity (23.06%) was recorded when cowpea was grown as a sole crop. As compared to *Stylosanthes hamata*, cowpea recorded greater number of root nodules and might have facilitated better aeration and soil aggregation.

The positive influence of fodder grass on soil

Table 6. Effect of treatments on the total uptake of micro nutrients by fodder grass, stylosanthes and cowpea

Treatments	Total Fe Uptake mg/plant	Total Mn uptake	Total Cu Uptake	Total Zn Uptake
HYBN as pure crop with nutrients as per POP	62.49	18.08	3.18	11.09
HYBN with stylosanthes with nutrients as per soil test data	78.66	14.86	3.93	10.77
HYBN with cowpea as intercrop with nutrients as per soil test data	66.19	18.11	2.95	8.14
Stylosanthes as pure crop	1.19	0.103	0.040	0.088
Cowpea as pure crop	2.07	0.080	0.045	0.143
HYBN with organic management	69.72	10.29	3.25	8.87
CD (0.05)	18.78	7.65	0.729	3.645

Table 7. Effect of treatments on the soil physical properties

Treatments	Bulk density g/cc	Particle Density g/cc	Porosity%	Maximum Water Holding Capacity%
HYBN as pure crop with nutrients as per POP	1.69	2.64	35.95^{c}	19.84^{b}
HYBN with stylosanthes with nutrients as per soil test data	1.59	2.47	35.88^{c}	22.58^{a}
HYBN with cowpea as intercrop with nutrients as per soil test data	1.62	2.67	37.93^{b}	22.57^{a}
Stylosanthes as pure crop	1.53	2.57	42.69^{a}	23.06^{a}
Cowpea as pure crop	1.55	2.52	38.49^{b}	21.16^{b}
HYBN with organic management	1.59	2.60	38.84^{b}	20.52^{b}
CD (0.05)	NS	NS	1.22	1.35

physical properties were studied and elaborated by Pushpanjali *et al.* 2022. Halli *et al.* (2022) found that incorporation of the fodder grass biomass improved the physical and biological properties of the soil.

Effect of treatments on the equivalent yield of fodder crops

The equivalent yield of hybrid bajra napier grass and the leguminous fodder crops such as *Stylosanthes hamata* and cowpea were computed using the actual yield as well as the per unit cost of stylosanthes hamata and cowpea (Figure 1). The data presented in Figure 2 regarding the actual yield of fodder stylosanthes and cowpea when grown as a pure crop and as an intercrop showed that the per ha yield of stylosanthes when grown as pure crop as intercrop are 24.23 tons and 15.75 tons respectively. As for fodder cowpea, the per ha yield under pure crop and as intercrop are 10.84 and 5.96 tons respectively. The equivalent yield factor for fodder cowpea and for stylosanthes is 1.2 and 1.6 respectively. The equivalent yield of fodder stylosanthes when grown as pure crop and as intercrop is 38.79 and 25.2 tons whereas that for cowpea as pure crop and as intercrop are 15.18 and 8.34 tons respectively.

Effect of treatments on soil biological properties of soil

The influence of different fodder crop combinations on soil microbial population was evaluated and is presented in Figure 5. The population of general and function specific microbes in the coconut basin is presented in Table 8. It could be seen that significant difference between the treatments were observed for the population of heterotrophic bacteria, filamentous fungi and florescent pseudomonads. Population of filamentous fungi was greater in the treatment where stylosanthes was grown as a pure crop. Heterotrophic bacterial population was greater when HBN was intercropped with stylosanthes.

Table 8. Soil Microbial population in the coconut basin

Microbial group	Average Population (CFU/g dry wt. of soil)
General Population	
Heterotrophic Bacteria	5.27×10^6
Filamentous fungi	10.77×10^3
Actinomycetes	3.41×10^5
Function specific microbial population	
Fluorescent pseudomonads	1.95×10^2
Free-living Nitrogen fixers	4.92×10^5
Phosphate Solubilizing Bacteria)	0.32×10^3

Conclusion

In the tropical land use systems, coconut is a predominant plantation crop and forms the backbone of agrarian economy. Under coconut based mixed farming systems, fodder crops form an inevitable ingredient in the cropping cafeteria to sustain the small and marginal farmers in particular. Legumi-

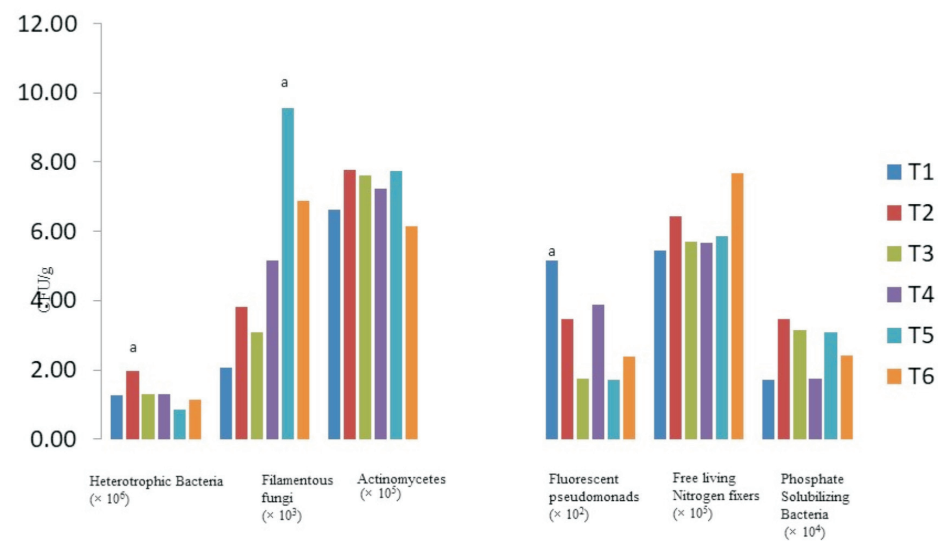

Fig. 5. General and function specific microbial population

nous fodder when intercropped with grass fodder have shown to be resulting in enhancement of soil fertility particularly with respect to organic carbon, microbial activity, exchangeable calcium. The soil physical properties were also found to be improved in the combination of grass fodders and legume fodder crops. Hence sustainable fodder production in coconut based mixed farming systems of tropical regions can be attained through HBN intercropped with *Stylosanthes hamata* or cowpea. As the leguminous fodder crops are planted in the border rows of the grass fodder, the nutrient explorative competition between the roots of coconut and that of the fodder grass, both being monocotyledonous crops can be reduced to a certain extent. The differential nutrient uptake pattern between a monocot (grass fodder) and a dicotylenous crop (legumes) could reduce the nutrient exhaustive effect of grass fodder crops on the coconut growth and productivity.

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