The response of Napier-Clone 13 (*Pennisetum purpureum*) to three types of organic manure grown in a simulated sub-canopy environment

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Abstract
The mechanisms which control the biomass yield and quality of Napier-Clone 13 (Pennisetum purpureum*) when grown near and under canopies were investigated in a simulated pot experiment. Napier-Clone 13 was established in galvanized containers (2 plants/ 0.28m^2 container) filled with normal soil (150 kg), treated with poultry litter (PL), goat manure (GM) or spent tea leaves (STL), at the rate of 50kg N/ha/cut. Each manure type i.e. PL, STL and GM was pre analyzed and applied at a rate of 335.7g, 76.38g and 103.5g respectively per container to provide a rate of 50kg N ha^{-1}. Plants were grown either in full sunlight (FL), or two levels of shading, namely, near the canopy with a reduction of 40% full light (NC) and under the canopy with a reduction of 90% full light (UC) imposed by shade cloth. Nine treatments were replicated 3 times, and arranged in a randomized complete block design.*
Plant height, stem diameter, leaf area and root biomass yield (g/plant) were highest 2) when grown NC as compared with plants grown in FL which increased the rate of tillering and the number of leaves. Deep shade UC caused significant decrease in all the above parameters. Poultry manure responded ($P<0.05$) positively in increasing above parameters over STL or GM. The increase in ion biomass yield (BMY) was affected ($P<0.05$) by the level of shading with more than two fold increase in full sunlight as compared to the deepest shade level. The difference in BMY between FL and NC was around 25%. PL responded similarly in increasing BMY over STL or GM. Deep shade UC augmented shoot nitrogen (N) concentration ($P<0.001$) over NC or FL. Poultry manure had a significant ($P<0.05$) effect on shoot N concentration over STL or GM as well.
The results of the simulated shade conditions on the yield and nutritive value of Clone 13 suggested that there would be an increase in N content but the biomass yield was marginal. Vice versa was observed under FL due to the dilution effect of N as a result of increasing biomass yield. Interaction of shade and soil fertility especially by the application of poultry manure near the canopy substantially enhanced the yield and quality of Napier-Clone 13. Therefore, it could be suggested that the grass yield and quality near the canopies could be easily boosted by adding organic manures.
Key words: biomass yield, sub-canopy environment, organic manure

Introduction:

Land is one of the limiting factors for expanding forage cultivation in Sri Lanka. Over 90% of coconut lands are potential grazing lands where forage cultivation and cattle raising are becoming widely accepted. Though numerous methods have been undertaken to achieve high productivity of coconut, very little attention has been given to enhance the productivity of natural pastures. Although cattle are successfully grazed on both native and improved pasture under coconut, various problem areas have been identified. To obtain a higher yield per unit land area, fodder may be suitable for cattle feeding. However land is the limiting factor for the fodder expansion too. Therefore under the trees, near the trees are the common places which can be utilized for the expansion of fodder as well as pasture. The most common effect of trees in tropical grasslands is to reduce the herbaceous yield beneath the canopy (Grossman *et. al.*, 1980). However, this effect is not consistent, and under certain circumstances, herbage yield may increase.

Among the interactions controlling the biomass production of forages, that of soil fertility is important. There is substantial evidence that a critical factor in increasing the herbaceous yield is the augmentation of nutrient levels in the soil beneath the canopy of many tropical areas (Rhoades, 1977). Nevertheless, increases in yield do not necessarily result when there is soil nutrient enrichment; if available light is insufficient for photosynthesis, no positive response can be expected (Mordelet and Menaut, 1995). But in the field, besides the light environment, the interaction between the trees and grasses is affected by a variety of factors. Of the interactions controlling the understory response, one of the simplest is that between canopy shade and soil fertility.

Therefore the objective of this study was to investigate the mechanisms which control the biomass yield and quality of Napier-Clone 13 by adding 3 different kinds of organic fertilizers when growing near and under the canopies in a simulated pot experiment.

Methodology

The experiment was conducted at the Agriculture Faculty Farm, Mapalana (annual rainfall ± 2352mm with fairly constant temperature 28 ^{0}C). Galvanized containers (0.28m^{2}) filled with normal soil (150 kg) were supplemented with poultry litter (PL), goat manure (GM) or spent tea leaves (STL). Each manure type i.e. PL, STL and GM was pre analyzed and applied at a rate of 335.7g, 76.38g and 103.5g respectively per container to provide a rate of 50kg N ha^{-1}. Plants were grown either in full sunlight (FL), or two levels of shading, namely, near the canopy with a reduction of 40% full light (NC) and under the canopy with a reduction of 90% full light (UC) imposed by shade cloths. The experimental design was a randomized complete block design with nine treatments which were replicated 3 times, where each of the 3 shade treatments being the main and the 3 soil treatments being the sub.

Approximately 4 months after planting, an initial harvest was done at 10cm height above ground level. Subsequent 3 harvests were done at 6 week intervals. Same amounts of organic manure as at the beginning were applied after each harvest. At each harvest, plant height, stem diameter, leaf area, number of tillers and root biomass yield (g/plant) were recorded. Harvested materials were separated into shoots, leaves, stems and then chopped and dried at 65 ^{0}C for 2-3 days in a forced-draught oven. The plant materials were ground to pass a 1 mm sieve. The samples were analyzed for dry matter (DM), crude protein (CP), organic matter (OM) and ash. The nitrogen content of the samples were determined by the Kjeldahl procedure.

Results and discussion

Biomass yield (BMY) was affected ($P<0.05$) by the level of shading with more than two fold increase in full sunlight (FL) as compared to the deepest shade level (Table1). The difference in BMY between FL and near the canopy (NC) was around 25%. The response to PL in increasing BMY was similarly more than the response to STL or GM. Bacha and Pathirana (1987) also have reported a similar response in dry matter yield (DMY) of Guinea grass to two levels of paddock manure. Durr and Rangel (2000) further proved that the highest level of shading produced a highly significant decrease in biomass production.

Table 1. Effect of shade and type of manure on plant biomass yield

Parameter	Type of Manure	Type of Shade			Trt. Mean
		Full Light (FL)	Near Canopy (NC)	Under Canopy (UC)	
Fresh Yield/Plant (g) (Mean Cumulative)	GM	865.83	830.00	197.67	631.17[a]±375.8
	PL	1509.17	1087.78	720.98	1105.98[a]±394.4
	STL	1184.17	869.83	617.24	890.41[a]±284.0
Treatment Mean		1186.39[a]±321.6	929.2[ab]±138.7	511.96[b]±277.0	
DM Yield/Plant (g) (Mean Cumulative)	GM	182.26	159.34	48.46	130.02[a]±71.5
	PL	315.41	228.42	122.10	221.98[a]±96.8
	STL	237.44	177.93	116.00	177.12[a]±60.7
Treatment Mean		245.04[a]±66.9	188.56[ab]±35.7	95.52[b]±40.8	
Fresh Yield/Plant (g)	GM	216.4583	207.5	56.26389	160.07[a]±90.0
	PL	377.2917	268.3333	180.2458	275.29[a]±98.7
	STL	296.0417	217.4583	161.8319	225.11[a]±67.4
Treatment Mean		296.60[a]±80.4	231.10[ab]±32.6	132.78[b]±66.9	
DM Yield/Plant (g)	GM	45.56493	39.83458	13.0516	32.82[a]±17.3
	PL	78.85284	50.8702	30.52538	53.42[a]±24.2
	STL	59.3599	44.48228	30.0473	44.63[a]±14.6
Treatment Mean		404.55[a]±16.7	301.25[ab]±5.5	24.54[b]±9.9	

[a-b] Means within the last column for manure effects and those within rows for shade effects followed by different letters differ ($P<0.05$)

Plant height, stem diameter, leaf area and root biomass yield (g/plant) non-significantly ($P>0.05$) tended to be higher (Table 2) when grown near the canopy as compared with the plants grown in FL which non-significantly increased the rate of tillering and the number of leaves. Poultry manure responded ($UC<0.05$) positively in increasing above parameters over STL or GM under all three light conditions. It was visually observed that leaves were much thinner and comparatively long under deep shade. Durr and Rangel (2000) also found similar results for leaf area and tillering habit in *Panicum maximum*.

Treatment effects on plant nutritive value are shown in Table 3. Deep shade under the canopy augmented shoot nitrogen (N) concentration ($P<0.05$) over NC or FL. Poultry manure had a significant ($P<0.05$) effect on shoot N concentration over STL or GM as well. Durr and Rangel (2000) also proved that soil from under the trees had a greatly enhanced N level. The results of the simulated shade conditions on the yield and nutritive value of Clone 13 suggested that there would be an increase in N content but the biomass yield was marginal. Vice versa was observed under FL due to the dilution effect of N as a result of increasing biomass yield.

Table 2: Effect of shade and type of manure on some plant characters

Parameter	Type of Manure	Type of Shade			Trt. Mean
		Full Light (FL)	Near Canopy (NC)	Under Canopy (UC)	
Height	GM	148.96	153.41	115.53	139.30 [b]±20.7
	PL	167.50	170.50	175.44	171.15 [a]±4.0
	STL	164.63	165.30	163.11	164.35 [a]±1.1
Treatment Mean		160.36 [a]±9.9	163.07 [a]±8.7	151.36 [a]±31.6	
No. of tillers/Plant	GM	11	11	1	7.50 [a]±6.0
	PL	10	9	2	7.00 [a]±4.3
	STL	13	8	1	7.17 [a]±5.8
Treatment Mean		11 [a]±1.4	9 [a]±1.4	1 [b]±0.7	
No. of Leaves	GM	10.25	9.83	8.67	9.58 [a]±0.8
	PL	10.58	9.67	12.08	10.78 [a]±1.2
	STL	10.58	11.00	11.00	10.86 [a]±0.2
Treatment Mean		10.47 [a]±0.19	10.17 [ab]±0.72	10.58 [b]±1.74	
Stem Diameter	GM	1.70	1.87	0.27	1.28 [a]±0.8
	PL	1.37	1.77	1.33	1.49 [a]±0.2
	STL	1.83	1.83	1.03	1.57 [a]±0.4
Treatment Mean		1.63 [a]±0.2	1.82 [a]±0.1	0.88 [b]±0.5	
Leaf Area (cm^2)	GM	126.79	128.38	87.28	114.15 [b]±23.2
	PL	163.16	167.17	167.97	166.10 [a]±2.5
	STL	165.07	174.22	159.45	166.25 [a]±7.4
Treatment Mean		151.67 [a]±21.5	156.59 [a]±24.6	138.23 [a]±44.3	
Root DM%	GM	95.11	93.39	91.72	93.41 [a]±14.3
	PL	91.5	95.62	93.81	93.64 [b]±16.2
	STL	95	95.59	95.05	95.21 [ab]±18.6
Treatment Mean		93.87 [a]±16.5	94.86 [a]±17.2	93.53 [a]±15.4	

[a-b] Means within the last column for manure effects and those within rows for shade effects followed by different letters differ ($P<0.05$)

Conclusions:

Interaction of shade and soil fertility especially by the application of poultry manure near the canopy substantially enhanced the yield and quality of Napier-Clone 13. Therefore, it could be suggested that the grass yield and quality near the canopies could be easily boosted by adding organic manures.

Table 3: Effect of shade and manure on plant nutritive value

Parameter	Type of Manure	Type of Shade			Trt. Mean
		Full Light	Near Canopy	Under Canopy	
CP%	GM	5.934787	6.211334	8.860441	7.00 [a]±1.6
	PL	6.915991	7.602725	8.373046	7.63 [a]±0.7
	STL	6.702817	6.060386	8.615721	7.13 [a]±1.3
Treatment Mean		6.52 [b]±0.5	6.62 [b]±0.8	8.62 [a]±0.2	
CP Yield/Plant (g)	GM	270.4181	247.4259	115.6429	211.16 [a]±83.5
	PL	545.3455	386.7522	255.5904	295.90 [a]±145.0
	STL	397.8785	269.5798	258.8792	308.78 [a]±77.3
Treatment Mean		404.55 [a]±137.5	301.25 [ab]±74.8	210.04 [b]±81.7	
CF %	GM	26.35473	30.99074	28.63642	28.66 [c]±2.3
	PL	28.98561	31.14219	29.09132	29.74 [a]±1.2
	STL	28.00649	30.03896	28.28084	28.78 [b]±1.1
Treatment Mean		27.78 [c]±1.3	30.72 [a]±0.5	28.67 [b]±0.4	
CF Yield/Plant (g)	GM	1200.851	1234.503	373.7511	936.37 [a]±487.5
	PL	2285.598	1584.209	888.0234	1585.94 [a]±698.7
	STL	1662.462	1336.202	849.7628	1282.81 [a]±408.9
Treatment Mean		1716.30 [a]±544.3	1384.97 [ab]±179.8	703.85 [b]±286.5	

[a-b] Means within the last column for manure effects and those within rows for shade effects followed by different letters differ ($P<0.05$)

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