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EFFECTS OF UREA-ENRICHED ORGANIC MANURES ON SOIL FERTILITY, TEA SEEDLING GROWTH AND PRUNED YIELD NUTRIENT UPTAKE IN IBADAN, NIGERIA

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Abstract

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Readily available farm wastes of plant and animal origins were enriched with urea at ratio 3:1 of nitrogen need of tea plant (150 kg N ha^{-1}) and NPK (25:5:5) were used to fertilize tea (*Camellia sinensis* L.) seedlings at Ibadan, Nigeria. The enriched manures (cocoa husk, cow dung, poultry droppings, tea fluff and siam weed - *Chromolaena odorata*) resulted to higher soil fertility enhancement in N, P, K, Ca, Mg and organic carbon buildup than NPK and control (no fertilizer). Tea growth parameters and pruned dry matter yields were higher and similar for enriched manures and NPK but lower for control treatment plants. Nutrient contents of the enriched manure treated tea plants were higher compared to those for NPK and control treated plants. About 3.0 – 4.6, 0.08 – 0.21, 0.69 – 1.79, 0.36 – 0.76, 0.17 – 0.24 and 31.5 – 5.45 kg N, P, K, Ca, Mg and C ha^{-1} respectively could be recycled to the soil through pruned materials from tea seedlings treated with enriched manures compared to 1.17, 0.05, 0.25, 0.69, 0.18 and 40.84 kg $ha^{-1}$for similar elements for NPK treated plants. About 67.3 % of the possible recycled nutrients are contained in the leaves. The C/N ratio of the pruned materials ranged from 9.81 – 10.5. Poultry droppings and tea fluff were more efficient manures than others on the overall parameters and were hence recommended as alternative nutrient sources for tea plants.

Key words: Enriched manures, nutrient uptake, soil fertility, tea seedlings

Introduction

Tea (*Camellia sinensis* L.) is a beverage crop cultivated for its fresh leaves (2 leaves + bud) in plantations as monocrop and requires high soil nutrients, particularly N, P, K, Ca and Mg (Bore, 1996). These nutrients are critical and their deficiency and or inadequate supply would eventually lead to poor tea seedling establishment and performance on the field. Tea cannot therefore be produced optimally without fertilizer application. Soils of the tropics, Nigerian soils inclusive, are inherently low in native fertility (Ogunwale et al., 2002) and lack the capacity to support plant growth without external nutrient addition (Adeoye et

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al., 2005)

Tea production is commercially by nutrient supply through inorganic fertilizers at rates between 150 – 300 kg N ha^{-1} for black tea (fermented tea) (Tsuji and Kinshita, 2001; Wanyoko et al., 1997) and up to 1000 kg N ha^{-1} for green tea (unfermented tea) (Toyomasa, 2001). These rates are high and require about 50 % of the total annual farm variable inputs (Owuor, 1996). Presently there is a global short supply and high procurement cost of inorganic fertilizers and the poor resource farmers cannot afford this. There is need to lock for alternative nutrient sources, that are cheap, readily available and affordable to the farmers. Heavy application of inorganic fertilizers leads to deterioration of soil cation exchange capacity (CEC) and clay contents of the soil, high concentration of Al and silicate in drainage water in addition to air pollution through nitrous gas emission, excessive leaching leads to underground water pollution (Jarvis, 1996; Prasad and Power, 1995). Most tropical soils are low in organic matter content and they need proper organic matter management by way of organic fertilizer application for sustainable long term land use. This work was carried out to know the possibility of using some readily available organic wastes, complemented with inorganic fertilizer for tea plant nutrition in Ibadan southwestern Nigeria.

Materials and Methods

Five organic nutrients: cocoa husk, siam weed (*Chromolaena odorata*), tea fluff, cow dung and poultry droppings were pulverized, analyzed and mixed with urea (45% N) at ratio 3:1 of N contents, while NPK (5:1:1) compounded by mixing urea (45% N) for N, Sokoto rock phosphate (33% P_2O_5) for P and muriate of potash (60% K_2O) for K, were applied to supply 150 kg N ha^{-1} for tea seedling nutrition at Ibadan, Nigeria. The tea seedlings were planted in 10 kg soils in plastic pots and watered twice weekly to 70 % field capacity and monitored for 12 months. Monthly data on growth parameters and growth components were taken. These includes: plant height from soil base to plant tip, girth at soil base with vernier caliper, number of leaves by visual counting and leaf area with leaf area meter. After 12 months, tea seedlings were pruned at 30 cm height from the plant base, oven dried to constant weight at 65^0 C. Samples were separated into leaf and stem, weighed, milled and analyzed for the N, P, K, Ca, Mg and organic carbon contents. Soil samples were collected from the pots and processed in the laboratory for routine chemical analyses.

Analytical procedures

Soil

Soil samples collected before and after 12 months commencement of the experiment were analyzed for their N contents according to Kjeldahl, P by Bray 1 method, while K, Ca and Mg were by leaching the soils with 1M NH_4OAC and read out from atomic absorption spectrophotometer (AAS) using the appropriate lamps. The organic carbon (OC) content was according to IITA (1979).

Manures and plant materials

The organic materials used as manures and the pruned tea plant parts were analyzed for their N content according to Kjeldahl method. Total P, K, Ca and Mg contents were read after ashing in a muffle furnace at 500^0 C for 5 hours. The ash was dissolved in 5 ml 4 % HCL, leached with distil water to 100 ml level and P content determined by Molybdophosphoric acid blue colour method. The organic carbon (OC) content was according to IITA (1979). Total K, Ca and Mg were determined using an atomic absorption spectrophotometer (AAS). The % N, P, K, Ca, Mg and organic carbon contents were used to multiply the weight of the dry matter to obtain the uptake. The total nutrient contents were by addition of the resultant component part values. Each value of the total nutrient contents was multiplied by 16,667 to obtain the expected nutrient content per ha for each nutrient. All values were subjected to analyses of variance and significant mean differences were separated using LSD at 5 %

Results and Discussion

The soil N (0.2 g/kg), available P (4.6 mg/kg) and organic C (4.2 g/kg) are considered low, while the exchangeable K (0.63 cmol/kg) and Mg (0.37 cmol/kg) values are moderate compared to the critical values of 1.2 g/kg N, 6.0 mg/kg P and 30g/kg OC calculated for ideal soils for tea in Nigeria. The N and P are critical nutrients for good tea nutrition. The low level of these in the soil suggests that the soil need to be supplemented with these nutrients for sustainable tea cropping on the soil. The organic materials contain substantial amount of N, P, K, Ca and Mg (Table 1) with C/N ratio of 8 – 25 which are within the limit for quick decomposition and nutrient release (Dogo, 2001). The rate of nutrient release however, is expected to be faster for poultry droppings, followed by tea fluff, cow dung, siam weed (*Chromolaena odorata*) and least in cocoa husk.

The plant height, girth, number of leaves and leaf area values showed that the tea plants responded favorably to the applied fertilizers compared to control (Table 2). This was positively reflected in the higher pruned dry matter yield (PDMY) for the fertilizer treated tea plants than for control. However the enriched organic fertilizer materials resulted to higher PDMY than NPK. The general superiority of the fertilizer treated tea plants over the control on the growth parameters and PDMY suggests the need for fertilizer addition to the soil, while the usage of the enriched organic fertilizers were better than NPK.

Analytical results of the pruned materials showed that fertilizer treatments gave significantly higher N, P, K, Ca and Mg uptakes over the control (Table 3). The enriched organic fertilizers were generally superior to the use of NPK on the uptake. The NPK and control treated tea plants were high in organic carbon contents. This coupled with the low macronutrient contents, indicated that their PDMY contains mostly roughage and was of lower quality compared to the enriched organic fertilizer treated plants. Quality of tea has been ascribed to be based on the level of N, P, K Ca and Mg contents, in addition to other chemical properties (Obanda et. al., 1996). The expected nutrient recycle to the field through the pruned materials ranged between 3.0 – 4.67 kg N, 0.08 – 0.2 kg P, 0.69 – 1.79 kg K, 0.36 – 0.76 kg Ca, 0.17 – 0.24 kg Mg and 31.5 – 45.8 kg organic carbon, compared to 1.17 kg N, 0.05 kg P, 0.25 kg K, 0.69 kg Ca, 0.18 kg Mg and 40.8 kg organic carbon by NPK. The values were least in the control compared to NPK. This result was in trend with reports by Wanyoko and Mwakha (1991). About 67.32 % of the nutrient uptakes in the pruned materials were contained in the leaf portion, with C/N ratio range of 9.81 – 10.5, showing that the materials could easily decompose and become beneficial to the soil, especially in improving P uptake (Dogo, 2001).

The urea-enriched treatments were significantly ($P<0.05$) higher than NPK and control in the reserved N, P, K, Ca, Mg and organic carbon build up in the soil compared to NPK and control (Table 4). The

Table 1
Some nutrient contents of the organic fertilizer materials used

Properties	Cocoa husk	Cow dung	Poultry droppings	Siam weed	Tea fluff
Total N, g/kg	9.5	23	30	25	29
Organic C, g/kg	243	384	262	436	362
C/N	25.6	12.8	8.7	17.4	12.5
P, mg/kg	0.2	0.9	3.7	0.7	0.23
K, mg/kg	4.3	2.6	1	1.7	1.7
Ca ,,	0.8	1.6	3.6	1.2	0.6
Mg ,,	0.3	0.4	0.5	0.8	0.2

Table 2
Growth parameters and pruned dry matter yield (g/plant)

Treatments (Equivalent weight/ha)	Height, cm	Girth, cm	Leaves	Leaf area, cm^2	Pruned dry matter yield
Cocoa husk (11.85 t/ha) + Urea (81.5 kg/ha)	16.13	3.85	18	939.7	5.08
Cow dung (5.44t/ha) + Urea (81.5 kg/ha)	32.5	3.86	17	1005	5.87
Poultry droppings (3.75 t/ha) + Urea (81.5 kg/ha)	23.13	3.55	27	885.9	7.58
Siam weed (4.5 t/ha) + Urea (81.5 kg/ha)	14.75	3.75	10	395.9	5.67
Tea fluff (3.9 t/ha) + Urea (81.5 kg/ha)	25.83	4.5	22	726.3	8.14
NPK (5:1:1) Urea (326 kg/ha) SRP (206.9 kg/ha) MOP (60.3 kg/ha) (150 N, 30 P & 30 K kg/ha)	24.38	4.33	21	966.9	4.48
Control	17.33	3.2	17	387.9	3.07
LSD (5 %)	5.21	0.35	6.14	475.1	2.21

SRP = Sokoto rock phosphate; MOP = Muriate of patash; LSD = Least significant figure

Table 3
Nutrient uptake (mg/plant) of pruned tea materials

Treatment	N	P	K	Ca	Mg	Organic C
Cocoa husk + Urea	250	7	23.4	19.8	8.8	2070
Cow dung + Urea	230	6.8	13.2	22	12.1	2510
Poultry droppings + Urea	340	12.8	54.5	37.3	18	3620
Siam weed + Urea	220	7.5	32.3	26.7	13.5	2320
Tea fluff + Urea	280	9.3	15.2	22.6	14.4	2880
NPK	240	8	7	41.1	11	2460
Control	220	5.3	5.9	9.3	2.3	2340
LSD (5 %)	18.1	2.1	6.2	10.3	5.7	154.1

LSD = Least significant difference

Table 4
Some soil nutrient contents after 12 months of tea cropping and treatment to enrich organic and NPK fertilizers

Treatment	N, g/kg	P, mg/kg	K	Ca	Mg	Organic C, g/kg
			cmol/kg			
Cocoa husk + urea	1.4	5.1	0.61	0.59	1.98	14.6
Cow dung + urea	2.4	6.3	0.84	0.59	2.7	14.2
Poultry droppings + urea	2.3	3.5	1.03	0.58	3.02	13.8
Siam weed + urea	2.4	4.6	0.48	0.61	1.7	11.9
Tea fluff + urea	2.3	3.4	0.55	0.61	2.08	13.1
NPK	1.3	5.5	0.37	0.25	1.74	11.9
Control	1	2	0.48	0.24	1.32	10.2
LSD (5 %)	0.4	1.1	0.26	0.19	0.25	0.81

LSD = Least significant difference

lower values in nutrients and organic carbon for the soils under NPK and control indicated that tea production would not be sustainable without external organic matter sources to probably modify the physical, chemical and biological conditions of the soil. This is more so in that most Nigerian soils as in other tropical regions, are fragile due to low organic matter contents (Ayoola and Agboola, 2002).

The Mg contents in the soils treated with NPK and control were twice lower in values compared to the enriched manured soils. The difference might have been from the applications of the organic manures which are rich in Mg contents (Table1). This shows that with time, the soils treated with NPK and control would be in acute supply of Mg and its deficiency symptoms would manifest. For sustainable management of the soil for optimal and good quality tea production, the use of manures in combination with urea as sources of balanced nutrient supply to tea plants would be more appropriate. The use of inorganic fertilizers as sole source of nutrient supply to tea plants on the field has been reported to lead to acute supply of Mg and the manifestation of its deficiency symptoms on tea bushes at Kusuku in Mambilla plateau area of Nigeria (Obatolu, 1999).

Conclusion

The use of the urea –enriched organic manures enhanced better tea growth, pruned dry matter yield and nutrient uptake than the sole use of NPK (5:1:1) and helped to maintain the soil quality in terms of reserved soil nutrient and organic carbon contents. The poultry droppings and tea fluff were more outstanding compared to other manures in this regard and were therefore recommended for optimal nutrient supply to tea plants as well as to help to maintain the soil quality for sustainable tea production over a long period.

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