Journal of Agricultural Technology 2011 Vol. 7(2): 497-505
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Cowdung: soil amendment agent for the sandy upland sugarcane ecology in Nigeria

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Gana, A.K. (2011). Cowdung: soil amendment agent for the sandy upland sugarcane ecology in Nigeria. Journal of Agricultural Technology 7(2): 497-505.

In sandy soils, especially in upland sugarcane experimental field of the National Cereals Research Institute NCRI Badeggi, Nigeria loss of mineral nutrients, water and herbicides through leaching is very high thereby making the soil unproductive. Poor growth performance and yield of 60ton / ha was obtained by Gana and Busari 2001 when inorganic fertilizer at the recommended rate of 120N - $60P_20_5$ - $90K_2O$kg / ha was applied to chewing sugarcane at Badeggi. Field experiments were established at the upland sugarcane experimental field of NCRI Badeggi to evaluate cow dung with its combination with inorganic fertilizer at various rates as soil amendment in 2004-2005, 2005-2006 and 2006-2007 wet and dry seasons. From the results obtained in the three trials, the application of combined fertility rates of cow dung with inorganic fertilizer at all rates increased the soil total percent nitrogen, available phosphorus, exchangeable potassium, calcium, percent organic carbon, organic matter and cation exchange capacity (CEC) and chewing sugarcane stalk yield (ton / ha) obtained from the lowest combined rate were significantly the same with the remaining higher combined rates. However, the effect of fertility rates had no significant effect on percent sand, silt, and clay and soil pH in the three trials.

Key words: Cow dung, inorganic fertilizer, soil amendment and chewing sugarcane stalk yield.

Introduction

Soil is the most valuable of all the possessions that have been handed on to us by our ancestors and it is the layer upon which the entire plant and animal worlds still depend for food to sustain life. The value of the any region of the earth therefore, is measured by its ability to grow the plants we need as raw material and as food (Deliparthy *et al.,* 1994). In sandy soils especially the upland ecologies where the soils have been over mined, loss of mineral nutrients, water and herbicides through leaching is very high thereby making the soil unproductive. Poor growth performance and yield of 60ton/ha of chewing sugarcane stalk was obtained by Gana and Busari, (2001) when

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inorganic fertilizer alone at the recommended rate of 120N - $60P_2O_5$ - $90K_2O$kg/ha was applied to chewing sugarcane at the upland sugarcane experimental field of NCRI Badeggi. Rao and Sharma (1981) observed poor canopy formation of sugarcane in a low nutrient soil which resulted in poor weed control. Nutrient budget for Sub-Saharan Africa shows a net annual depletion of N, P and K as a result of long term cropping with little or no external nutrient inputs (Fagbernro, 2001). Uses of chemical fertilizers decreased recycling of crop residues and losses of crop nutrient due to leaching and erosion. In recent years, a growing consensus has emerged on the need for both organic and inorganic fertilizer to reverse the negative nutrient balances in cropping systems in agriculture in Sub-Saharan Africa (ASS) as continuous sole application of either of these inputs tend to create soil related constraints to crop production.

The application of cow dung is needed not only to replenish lost nutrient but also to improve the physical, chemical and biological properties of sandy upland ecologies which will enhance the performance of soil applied inputs. According to Giller (2002), manure increase organic matter content, water holding capacity and plant nutrients. It also increases the efficiency of mineral fertilizer by improving the physical properties of the soil. Soil incorporated with cow dung contains enough suitable phosphoric acid, potash and lime (Deliparthy *et al*., 1994).

Farmers in the Sudan Savannah zone, use a lot of organic fertilizer for their crop production because of high cost of inorganic fertilizer (Mainasara, 1989). Gibberd (2002) recommended further research work on the use of manure for semi - arid areas being the cheapest source of nitrogen and phosphorus and also being a soil amendment agent. Therefore, the objective of this study was to evaluate the influence of cow dung plus inorganic fertilizer rates as a soil amendment agent on the soil phsico chemical properties of upland sugarcane experimental field NCRI Badeggi, Nigeria.

Materials and methods

Field trials were conducted at the upland sugarcane experimental field of National Cereals Research Institute Badeggi (Lat. 9°45|N, Long. 06°07|E, 70.5 metres above mean sea level) in the Southern Guinea Savanna ecological zone of Nigeria in 2004-2005, 2005-2006 and 2006-2007 wet and dry seasons. The soil of experimental site has been classified as ultisol and sandy loam with a bulk density of 1.489 m^{-1} (Ayotade and Fagade, 1993). It has an average annual rainfall of 1124mm and mean temperature of 23°-33°C respectively. Details of the physico - chemical properties of the soil and the analysis of the cow dung during the periods of experimentation are presented in Table 1 and 2.

The treatments tested consisted of seven fertility rates (F) and were F_0 = Control (no cow dung, no inorganic fertilizer), F_1 = 120N - $60P_2O_5$ - $90K_2O$ kg/ha alone (NCRI recommended rate for sole chewing sugarcane), F_2 = 10 tonnes / ha of air dried cow dung alone (NCRI recommended rate), F_3 = 10 tonnes / ha of air dried cow dung + 120N - $60P_2O_5$ - $90K_2O$ kg/ha, F_4 = 10 tones / ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$ kg/ha, 5 tonnes / ha of air dried cow dung + 120N - $60P_2O_5$ - $90K_2O$ kg/ha, 5 tonnes / ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$ kg/ha. Straight fertilizer were used to work out the various rates of N, P and K using Urea for N, single super phosphate for P and Muriate of potash for K. The experiment was laid out in a randomised complete block design with four replications. Each treatment was accommodated in a gross plot area of $15m^2$ (5 x 3m) containing 6 rows of sugarcane and a net plot of 3 x 3m ($9m^2$) containing 4 rows. The same field and plots were maintained throughout the periods of the experiment following the practice of local farmers (no ratoon). Bida Local or Ajax was the variety used as the planting material for establishment of the trial. This variety was obtained from NCRI Bida, at the seed rate of 7 tonnes / ha. Air dried cow dung was incorporated into the soil manually using short handle hoe a month before establishing the trial. The inorganic fertilizer was applied split at planting (½N - $½P_2O_5$ - $½K_2O$ basal application) and at 6 months after planting (MAP) during ear thing up, the remaining ½N - $½P_2O_5$ - $½K_2O$ was applied. Harvesting was done at 10 MAP using cutlass.

The data collection includes:

Soil samples were collected using a soil auger at the establishment of the first experiment in 2004 from four different randomly selected spots and subsequently, soil samples collections were after harvest per treatment for three years from the soil depth of 0-25cm to determine the physico-chemical properties of the soil

Particle size distribution was analysed by using hydrometer and textural class was determined by the soil textural triangle.

Soil pH was determined in water by using a soil solution ratio of 1:2.5 by means of a Philip analogue pH meter.

The nitrogen content of the soil was determined by Macro Kjeldahl procedure (Bremner, 1965).

Available phosphorus was determined by Trough method. The extracted phosphorus was determined by the molybdate blue colour method (Bremner, 1965).

The exchangeable bases, calcium (C_a) magnesium (M_g) potassium (K) and Sodium (N_a) were extracted using IN acetate (pH 7.0). Percent organic carbon was determined using Walkley - Black method (IITA, 1979). Percent organic matter, this was determined by multiplying product of organic carbon with 1.724, %om = OC x 1.724.

Cation exchange capacity was determined by ammonium saturation method using IN ammonium acetate (pH 7.0) saturation followed the displacement of the absorbed ammonia.

Stalk yield was determined at harvest (10MAP) using cutlass to harvest the stalks from the net plots, which were tied into bundles and weighed on a 50kg scale.

All data obtained were subjected to statistical analysis to test treatment effects for significance using 'F' test as described by Snedecor and Cochran (1969). Where 'F' test showed significance, the means were compared using Duncan's multiple range test (DMRT).

Results and discussion

The effect of fertility rates (cow dung with inorganic fertilizer rates) was not significant on percent sand, silt and clay in 2004-2005, 2005-2006 and 2006-2007 trials (Table 3). This result shows that cow dung with inorganic fertilizer cannot easily influence the soil texture. However, according to Gupta *et al*., (2004) application of cow dung helps in improving soil structure, soil aeration and therefore improves the activities of soil micro-organisms. In the three trials, the effect of fertility rates was significant on percent organic carbon, organic matter and cation exchange capacity (CEC) (Table 3). The application of combined fertility rates produced significantly greater values of soil percent organic carbon, organic matter and cation exchange capacity than at separate application of cow dung, and inorganic fertilizer. This result confirms the result obtained by Giller (2002), who in his experiment with cow dung combined with inorganic fertilizer obtained increased soil percent organic carbon, organic matter and cation exchange capacity. In 2004-2005, 2005-2006 and 2006-2007 trials, the application of combined fertility rates of 10 tonnes / ha of air dried cow dung + 120N - $60P_2O_5$ - $90K_2O$ kg/ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$ kg/ha produced higher values of soil total nitrogen, available phosphorus, exchangeable potassium, calcium and chewable sugarcane stalk yield than at separate application of cow dung and inorganic fertilizer (Table 4). This improvement in the soil physico - chemical properties by the application of combined fertility rates, may be attributed to cow dung which might have improved the sandy structure of the sugarcane upland experimental field of NCRI Badeggi, hence the leaching of these nutrients added (mineral fertilizer) was reduced thereby making the nutrients more readily available for sugarcane growth which might have also accounted for the higher chewing sugarcane stalk yield (ton/ha) obtained. Gibberd (1995) earlier stated that soils with high fertility influence the stalk yield. Gupta *et al*., 2004, found that yield of sugarcane was significantly influenced by organic matter, cation exchange capacity, nitrogen, phosphorus and potassium. Soils incorporated with cow dung contain enough suitable phosphoric acid, potash and lime (Dalipathy *et al*., 1994). Vanlauwe *et al*., (2001) reported that soil incorporated with cow dung supply nitrogen, sulphur, phosphorus and potassium. Phosphorus in manure is neither volatilized nor leached to any significant degree and coupled with the mineral phosphorus supplied through the application single super phosphate justified for higher values of phosphorus. However, the lowest combined fertility rate of 5 tonnes/ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$ kg/ha produced significant similar percent organic carbon, exchangeable calcium and chewing sugarcane stalk yield (ton/ha) compared to higher rates. According to Gibberd (1995) the efficiency portion of manure is obtained when applied in small amounts with inorganic fertilizer and more often.

The increase in sugarcane stalk yield yearly was being supported by Belay, *et al*., (1997) who associated this to increase in soil organic carbon, organic nitrogen and exchangeable cations. Also Yadev and Prasad (1982) reported that frequent combined application of cowdung plus inorganic fertilizer rates increased production from successive cane cropping.

Through the use of cow dung, the unproductive over mined sandy upland sugarcane experimental field of NCRI Badeggi has been made productive leading to higher increase of chewing sugarcane stalk from 60 ton / ha to between 70.63 - 76.23 ton/ha. Therefore, the use of cow dung as a soil amendment agent could be recommended for this ecology. The use of cow dung combined with inorganic fertilizer (N, P & K) becomes necessary as sugarcane is a long duration crop and application of cow dung alone cannot sustain the production. And also some cow dung having very low percent nitrogen content, a supplement is needed to sustain sugarcane production for higher yield. Based on the positive influence of combined fertility rates on soil organic matter, organic carbon, cation exchange capacity and soil chemical properties and stalk yield of chewing sugarcane, the lowest combined fertility rate of 5 tonnes / ha of air dried cow dung + 60N - $30P_2O_5$ - $45K_2O$ kg/ha can be recommended as soil amendment for this ecology and similar ecologies and also being the lowest combined fertility rate it can easily be affordable by the farmers.

Table 1. Physico-chemical characteristics of soil taken from experimental site before the establishment of the trial.

Soil properties 0 - 25cm depth	**Badeggi 2004**
Physical properties	
Sand (%)	91.00
Silt (%)	8.00
Clay (%)	1.00
Texrural class	Sandy
Chemical properties	
pH in water	6.2
Organic carbon (%)	0.50
Organic matter (%)	1.10
Total nitrogen	0.039
Available phosphorus (ppm)	8.95
Exchangeable cation (cmol / kg^{-1})	
K	0.35
M_g	0.29
C_a	1.00
N_a	0.16
CEC (cmol / kg^{-1})	5.85

Table 2. Laboratory analysis of cow dung components.

Chemical components	**Percent (%) 2004-2007**
Nitrogen	0.914
Phosphorus	0.26
Potassium	0.34
Organic	16

Table 3. Influence of cow dung with inorganic fertilizer rates on the soil physical properties of upland sugarcane experimental field of NCRI Badeggi, 2004-2005, 2005-2006 and 2006-2007 wet and dry seasons.

	Sand %			Silt %			Clay %			OC %			OM%			CEC Cmol kg^{-1}		
Treatments	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006
Fertility rates (F)																		
0 Control no cow dung and inorganic fertilizer	91.00	91.00	91.00	8.00	8.00	8.00	1.00	1.00	1.00	0.40c	0.37d	0.28d	0.80f	9.70f	0.69f	4.35e	3.9e	2.78
120N-60P_2O_5-90K_2O kg/ha (NCRI recommended)	91.00	91.00	91.00	8.00	8.00	8.00	1.00	1.00	1.00	0.80b	0.93e	1.02e	1.04e	1.10e	1.20e	6.71d	8.10d	9.43d
10 ton/ha air dried cow dung (NCRI recommended)	91.00	90.99	90.98	8.00	8.01	8.02	1.00	1.00	1.00	0.86b	1.16e	1.20b	1.94d	2.20d	2.42d	9.94c	11.79c	14.88c
10 ton/ha air dried cow dung 120N-60P_2O_5-90K_2O kg/ha	90.20	90.75	90.13	8.80	8.85	8.87	1.00	1.00	1.00	1.20a	1.68a	1.93a	3.0a	3.87a	4.05a	13.41a	16.98a	26.62a
10 ton/ha air dried cow dung 60N-30P_2O_5-45K_2O kg/ha	90.92	90.79	90.72	8.08	8.20	8.21	1.00	1.00	1.00	1.18a	1.48a	1.79a	2.20cd	2.40cd	2.78cd	10.41b	13.49b	17.52b
5 ton/ha air dried cow dung 120N-60P_2O_5-90K_2O kg/ha	90.96	90.88	90.86	8.04	8.12	8.14	1.00	1.00	1.00	1.18a	1.48a	1.79a	2.20cd	2.40cd	2.78cd	10.41b	13.51b	17.59b
5 ton/ha air dried cow dung 60N-30P_2O_5-45K_2O kg/ha	90.98	90.89	90.87	802	8.11	8.13	1.00	1.00	1.00	1.18a	1.44a	1.72a	2.10cd	2.30cd	2.57cd	10.32b	13.49b	17.52b
SE (±)	0.74	0.80	1.28	0.46	0.47	0.82	0.26	0.17	0.19	0.24	0.20	0.15	0.13	0.10	0.17	0.17	0.12	0.14

Keyword:- OC = Organic Carbon, OM = Organic Matter, CEC = Cation Exchange Capacity
Means followed by the same letter(s) in both column are not significantly different at 5% level of probability using Ducan's multiple range test (DMRT).

Table 4. Influence of cow dung with inorganic fertilizer rates on the soil chemical properties of upland sugarcane experimental field of NCRI Badeggi, 2004-2005, 2005-2006 and 2006-2007 wet and dry seasons.\

	Sand %			Silt %			Clay %			OC %			OM%			CEC Cmol kg^{-1}		
Treatments	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006
Fertility rates (F)																		
0 Control no cow dung and inorganic fertilizer	6.90	6.80	6.80	0.030e	0.024e	0.19e	6.50f	3.10g	2.31f	0.30c	0.25c	0.22d	0.64	0.28c	0.20c	14.82d	10.70e	8.25d
120N-60P_2O_5-90K_2O kg/ha (NCRI recommended)	6.80	6.40	6.30	0.089d	0.10d	0.19d	30.03d	41.63c	48.45d	1.12b	1.19b	1.24c	0.69	0.79b	1.00b	27.86b	36.75c	41.00b
10 ton/ha air dried cow dung (NCRI recommended)	6.40	6.50	6.60	0.29c	0.45c	0.56c	20.10e	30.43f	35.34e	1.13b	1.28b	1.37cd	0.70	3.62a	3.69c	18.83c	28.19d	31.21c
10 ton/ha air dried cow dung 120N-60P_2O_5-90K_2O kg/ha	6.30	6.40	7.0	0.89a	1.0091	1.30a	50.91a	58.91a	62.10a	1.65a	2.01a	2.60a	0.87	3.84a	3.90a	70.63a	72.61a	76.23a
10 ton/ha air dried cow dung 60N-30P_2O_5-45K_2O kg/ha	6.30	6.40	6.9	0.69b	0.79b	1.09b	44.10c	50.91c	56.42b	1.62a	1.86a	2.30b	0.80	3.70a	3.87a	68.63a	70.81a	74.40a
5 ton/ha air dried cow dung 120N-60P_2O_5-90K_2O kg/ha	6.30	6.40	6.9	0.87a	0.98a	1.28a	48.10b	54.63b	57.10b	1.63a	1.91a	2.51ab	0.75	3.57a	3.79a	68.18a	71.82a	75.90a
5 ton/ha air dried cow dung 60N-30P_2O_5-45K_2O kg/ha	6.40	6.40	6.9	0.60b	0.72b	1.00b	39.01c	46.70d	51.10c	1.60a	1.79a	2.28b	0.75	3.66a	3.78a	67.61a	70.00a	74.98a
SE (±)	0.97	0.53	0.53	0.17	0.60	0.24	0.16	1.30	0.55	0.40	0.44	0.24	0.01	0.17	0.56	0.60	2.29	2.01

Keyword:- N = Nitrogen, P = Phosphorus

Means followed by the same letter(s) in both column are not significantly different at 5% level of probability using Ducan's multiple range test (DMRT).

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(Recieved 13 July 2010; accepted 18 March 2011)