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Appropriate method for organic manure application for higher sugarcane yield in Nigeria

A.K. Gana*

National Cereals Research Institute P.M.B.8, Bida, Niger State, Nigeria

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Field trials were conducted at the upland sugarcane experimental field of the National Cereals Research Institute Badeggi (lat.9° 45/ N, long. 0.6° 07/ E, 70.5 meters above sea level) in the Southern Guinea Savannah ecological zone of Nigeria in 2007-2008 and 2008-2009 wet and dry seasons to evaluate for the most appropriate cattle manure application method for higher sugarcane yield. From the results, application of cattle manure broadcast on the soil surface and the incorporated in 2007-2008 and 2008-2009 favoured weed productivity than the remaining methods of application at three months after planting. The effect of cattle manure application methods was not significant on percent germination count at 1 month after planting (MAP), plant height at 3 MAP, and crop vigour score at 3MAP and percent brix at harvest12 MAP in both years of the experimentation. However, incorporation, side band placement, basal and top band placement methods produced significantly similar number of tillers per plot but was significantly higher than the tiller obtained through broad casting cattle manure on the soil surface in the two trials. The number of chewable stalks per plot and stalk yield (t/ha) obtained from the incorporated, basal application and top band application methods of cattle manure were significantly similar. However, all these values were significantly higher than values obtained from the plots treated with cattle nanure through broad casting on the soil surface in both years of the experimentation.

Key words: Cattle manure, sugarcane, appropriate application methods.

Introduction

Manure refers to substance added to the soil in order to increase the supply of plant nutrients for higher productivity (Gana, 2010). The application of organic manure has the aim of increasing soil fertility, and thus productivity, but the effect of the addition depends partly on the existing fertility of the soil and possibly the application method. According to Gupta *et al*. (2004), the effect varies according to the inherent physical and chemical properties of the soil particularly on the nature and content of the clay and humus colloid. In

* Corresponding author: A.K. Gana; e-mail: andrewgana2@yahoo.com

recent years, a growing consensus has emerged on the need for both organic matter to reverse the negative nutrient balances in cropping systems in agriculture in Sub Saharan Africa (SSA) as continuous sole application of inorganic fertilizer tends to create soil related constraints to crop production. (Vanlauwe *et al.,* 2011). Farmers in the Sudan savannah zone use a lot of organic fertilizer for their crop production because of high cost of inorganic fertilizer and its unavailability (Mainasara, 1987; Gana, 2010). The application of nutrients either as chemical fertilizer or Farm Yard Manure (FYM) reduced infestation by striga species and improved crop yield (Lagoke *et al*., 1987). Thus a usual practice is to coral livestock on the field after harvest is highly practiced by the local farmers in the savanna zone of Nigeria (Randall and Bandel, 1987).

Farmers in Nigeria commonly apply cattle dung through broadcasting on the soil surface (Gana, 2010). According to Gana, this method is cheap, simple and easy, and does not require the use of any special equipment. Women who cultivate chewing sugarcane find it also easy. Farmers worked the inorganic fertilizer into the top 5 to 7cm of soil and being careful not to damage plant roots by applying too close to roots (Gibberd, 1995). Row or band fertilizing is a common and economical method of application. (Hseih, 1996). According to Sreewarome *et al.* (2006) narrow bands of granular fertilizer sprinkled at 3 inches to each side all along the plant row in sugarcane influences yield.

Cattle manure is an alternative source of inorganic fertilizer and has been reported as a good soil amendment agent. However, farmers have being using this without any scientific data and record on the most appropriate method of application. Gibberd, (1995) recommended for further research work on the use of manure in the semi-arid areas being the cheap source of nitrogen and phosphorus for agricultural crops. Hence, the objective of the trials was to determine the best method for cattle manure application.

Materials and methods

Field trial was conducted in 2007/2008 and 2008/2009 wet and dry seasons at the upland sugarcane experimental field of the National Cereals Research Institute (NCRI) Farm, Badeggi (lat. 9°45$^{|}$N, long. 0.6°07$^{|}$E; 70.5 meters above sea level) in the Southern Guinea Savannah ecological zone of Nigeria. The soil of the experimental site had been classified as ultisol and sandy loam in texture with a bulk density of 1.459 g cm^{-3} (Ayotade and Fagade, 1993). The area has an average annual rainfall of 1124mm and mean temperature of 23°-33°C.

The treatments evaluated consisted of five cattle dung application methods namely: incorporation method- in this method, the cattle manure was

broadcast on the soil surface and immediately incorporated into the soil using hand towel. Basal application method-cattle manure was applied on the surface of the sugarcane setts laid or planted before been covered with soil. Broad casting method- here, the cattle manure was only broad cast on the surface of the soil without incorporation. This was the farmers practice (check). Side band placement- after planting the setts and covered with soil, on the side an opening was made from the beginning of the row to the end and cattle manure was applied and covered. Top band placement here instead of side opening, the top that was opened and the cattle manure was applied and covered. The treatments were applied on the same day the trial was established and later supplemented with inorganic fertilizer at the rate of 60 kg N ha^{-1} – 13 kg P ha^{-1} – 18.5 kg K ha^{-1} (half of the NCRI recommended rate for sugarcane production).Each treatment was accommodated in a gross plot area of 30 m^2 (6m x 5m) containing 6rows of sugarcane and net plot of 18m^2 (6m x 3m) using randomized complete block design with three replications.

The experimental field was cleared, ploughed, harrowed once and manually leveled. The same operations were repeated for the second trial in 2008-2009. The chewing sugarcane variety, Bida Local used for the trials was obtained from National Cereals Research Institute Bida and was sown at the seed rate of 7 t ha^{-1}. This variety is more robust, with less sucrose (much water), and softer than the industrial type and less drought resistant. Chewing sugarcane is highly preferred by the local farmers as it does not possess the kind of milling characteristics desired by the industries, and it is produced all over the country. It is purple in colour, and can attain a stalk length of 2-3 meters and takes 10 months to mature. It starts flowering as from October. The production of this crop is in the hands of the local farmers who cultivate farm holdings of 0.2-2.0 ha accoeding to Ojehomon *et al.* (1996).

The inorganic fertilizer was applied 6MAP during ear thing up through band placement method. Nitrogen (N) was supplied by urea (46% N), phosphorus (P) was supplied by single super phosphate (18% P_20_5), while muriate of potash (60% K_2O) supplied the potassium (K). Healthy tender young (6 months old) stalks of chewing sugarcane (Variety -Bida Local were cut into setts, each sett contained three buds were used as planting material for the first year trial in 2007/2008; while for the 2008/2009) stalks obtained from the preceding year was used as planting material. The cane setts were laid end to end (planted) horizontally and covered with soil. Ear thing up was carried out at 6 months after planting. This involved scooping the soil round the stools of standing sugarcane to give a strong support to sugarcane against heavy storm that can cause logging. Harvesting was done at 12 MAP using a cutlass. The sugarcane stalks from the net plot were tied into bundles and weighed on 50 kg

scale on the same day of harvest. The stalk yield for each plot was expressed in tones per hectare. Soil samples were collected using a soil auger from the soil depth of between 0–25 cm from four different randomly selected spots and bulked to determine the initial physicochemical properties of the soil. The soil parameters included the followings.

Particle size analysis: Particle size distribution was analysed by using the hydrometer method and textural class was determined by the soil textural triangle (IITA, 1979).

Soil pH: Soil pH was determined in water by using a soil solution ratio of 1:2.5 by means of a Philip analogue pH meter (IITA, 1979).

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

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

Exchangeable bases: The exchangeable bases namely, calcium (Ca) magnesium (Mg) potassium (K) and sodium (Na) were extracted using ammonium acetate (pH 7.0) (Bremner, 1965).

Soil organic carbon: This was determined using Walkley - Black method (IITA, 1979).

Soil organic matter: This was determined by multiplying product of organic carbon with a factor of 1.724 (IITA, 1979).

Cat ion exchange capacity (CEC): Cat ion exchange was determined by ammonium saturation method using IN ammonium acetate (pH 7.0) saturation followed the displacement of the absorbed ammonia (IITA, 1979).

Weed infestation

Weed cover score: was taken at 3MAP through visual observation using the scale (0–10), 0 = Clean plot, 10 = completely weed covered plots

Crop growth characters

Percent germination count: This parameter was assessed at 1 MAP within the net-plot. The total number of emerged buds per net plot was counted. The obtained figure per net plot was divided by the total number of buds on setts planted as expressed in% percentage i.e.

$$\frac{\text{No of sprouted buds per net plot}}{\text{Total No of buds on the setts planted per net plot}} \times \frac{100}{1}$$

Tiller count: Tillers represent the secondary growth. The count of the secondary growth was taken from the gross plot at 3 MAP.

Crop vigour score: This was determined at 3 MAP through visual observation using the scale 0-10, where 0 = weak, diseased plant, 10 = most vigorous and healthy plant.

Plant height and stalk length (cm): Plant height (cm) at 3 MAP and stalk length at 12 MAP were taken using a graduated meter rule from the base (ground level) of the plant to the tip of the last unfolded leaf for plant height or to the last node at the top for stalk length. This was taken from the five randomly selected tagged sugarcane plants within the net-plot.

Number of chewable stalks: Sugarcane stalks with internodes that can be chewed were counted from the net plot at12 MAP.

Stalk girth (cm): A veneer calliper was used for measuring the stalk girth at 12 MAP. It is graduated in centimeter. Five sugarcane stalks tagged within the net plot were measured each at middle of the stalk.

Yield characters

Percent brix at harvest: This is the percentage by weight of soluble solids in juice as measured by a hand refractometer (Payne, 1968). Hand refractometer is graduated in percent and was used to determine the level of soluble sugar in the juice squeezed out of crushed sugarcane stalk. This was taken from the five-tagged sugarcane stalks in the net plot.

Stalk yield: The sugarcane stalks harvested at 12 MAP from the net plot were tied into bundles and then weighed using a 50 kg balance. The weight of stalks harvested from the net plot was then converted to stalk yield in tones per hectare.

All the data that were obtained from the experiments were subjected to statistical analysis of variance (ANOVA) to test for the significance of treatment effects as described by Snedecor and Cochran (1967). Where the 'F' test showed significance, the means were then partitioned using the Duncan's multiple range test (DMRT) (Steel and Torrie, 1980).

Results and discussions

Application of cattle manure broadcast on the soil surface and the incorporated method produced significantly higher weed cover score than the

remaining methods of application in both years of 2008 and 2009 (Table 3 and 4). This could be as a result of cattle manure been uniformly spread on the soil thereby, made the released nutrients readily available to both the crop and weeds. Delipathy *et al.* (1994) earlier stated that broad casting and incorporation methods influenced the severity of weeds than any other possible cattle manure application method. Rhoadesre, (1994) reported that the difference in performance of weeds could be as a result of cattle excrement aids in disseminating weed seeds (Black Shaw and Rode, 1991). Pleasant and Schlather (1994) reported 75,100 wild seeds per 100 kg of cattle manure. Rupende *et al*. (1998) found a total of 124 species of both narrow and broad leave weeds in manure. According to Mugawi *et al*. (1995) reported that over 50% of farmers who applied cattle manure in their fields in Chinyika Resettlement Area reported a high occurrence of Pig weeds *Amaranthus hybridus, Eleusine indica* and *Cynodon dactylon*. In maize field, application of cow dung at 10 tonnes/ha significantly increased the population of *Cynodon dactylon* and *Eleusine coracan* (Baig *et al*., 2001). Effective control of viable weed seeds disseminating by cow dung and enhancement of N and K availability are achieved by heaping manure to a height of 1.5m for three months before field application (Rupende *et al*., 1998).

Table 1. Physico-chemical characteristics of soil taken from 0-25cm depth at the experimental site before the establishment of the trial at Badeggi in 2007

Soil properties	Value
Physical property	
Sand (%)	75.60
Silt (%)	18.00
Clay (%)	6.40
Textural class	Sandy loam
Chemical property	
pH in water	6.2
Organic carbon (g/kg)	0.50
Organic matter (g/kg)	1.10
Total nitrogen (g/kg)	0.039
Available phosphorus (Mg/kg)	8.95
Exchangeable base (cmol / kg soil)	
K	0.35
Mg	0.29
Ca	1.00
Na	0.16
CEC	5.85

Table 2. Laboratory analysis of cattle manure component at beginning of the trial in year 2007

	2007 g kg^{-1}
Nitrogen	1.22
Phosphorus	0.96
Potassium	0.65

Source: Cattle manure was obtained from the cattle market behind Gwadabe New Market, Bida, Niger State, Nigeria.

Table 3. Effect of cattle manure application methods on weed and growth Parameter of chewing sugar cane at Badeggi, 2008

Treatments	**Germination % count 1 MAP**	**Weed cover score 3 MAP**	**Plant height (cm) 3 MAP**	**Tiller count/plot 3MAP**	**Crop vigour score 3 MAP**
Cattle manure incorporated	78.33	3.87 a	164.87	109.86 a	5.67
Basal application of cattle manure on the setts	77.67	2.17 b	164.73	108.33 a	5.20
Cattle manure broadcast on the soil surface (farmers practice)	78.33	3.88 a	164.40	83.33b	5.16
Side band placement of cattle manure	78.33	2.19 b	167.40	109.33 a	5.17
Top band placement of cattle manure	78.00	2.17 b	165.40	107.00 a	5.67
SE (±)	4.21	0.40	1.96	2.50	0.49

Plot size 30m^2 (6m x 5m); MAP = Months after Planting
Weed cover score (0 – 10), 0 = Clean plot, 10 = completely weed covered plots
vigour score (0 – 10), 0 = weak and diseased plants, 10 – Very healthy, greenish and vigorous plants.

Table 4. Effect of cattle manure application methods on weed and growth Parameter of chewing sugar cane at Badeggi in 2009

Treatments	**Germination% count 1 MAP**	**Weed cover score 3 MAP**	**Plant height(cm) 3 MAP**	**Tiller count/plot 3MAP**	**Crop vigour score 3 MAP**
Cattle manure incorporated	79.33	3.85 a	167.87	111.86 a	6.67
Basal application of cattle manure on the setts	78.67	2.18 b	169.73	112.33 a	6.20
Cattle manure broadcast on the soil surface (farmers practice)	78.63	3.87 a	168.90	86.33 b	6.16
Side band placement of cattle manure	78.53	2.19 b	168.99	112.33 a	6.17
Top band placement of cattle manure	79.00	2.18 b	168.90	112.00 a	6.67
SE (±)	4.21 4.66	0.31	2.16	2.5	0.51

Plot size 30m^2 (6m x 5m); MAP = Months after Planting
Weed cover score (0 – 10), 0 = Clean plot, 10 = completely weed covered plots
vigour score (0 – 10), 0 = weak and diseased plants, 10 – Very healthy, greenish and vigorous plants

Non-significant uniform germination count was obtained from the application of cattle manure methods in both years. This confirms the result

obtained by Gana and Busar (2003) in their cattle manure evaluation trial at Badeggi, proving that sugarcane setts does not need soil nutrients to germinate, but made use of the stored sucrose to develop the sett roots. However, incorporation, basal application, side band placement and top band placement methods produced significantly similar stalk length and tiller counts, but were significantly greater than the remaining method (broad casting) (Tables 3, 4, 5 and 6). This may be as a result of high quantity of released nutrients derived from each of the method and were accessible by the roots.

Exception of broadcasting of cattle dung on the soil surface application method, all other cattle dung application methods produced significantly similar stalk yield (t/ha) in both 2008 and 2009 (Tables 5 and 6). The poor growth performance and yield obtained from the broad cast method could be as a result of reduction in the nutrients quantity and nutrient released of cattle manure caused by rain fall, wind and irrigation water which might have carried or washed away part of the cattle manure on the surface of the soil thereby, reducing the amount of nutrients released (mineralized).

Table 5. Effect of cattle manure application methods on the yield and yield Attributes of chewing sugar cane at Badeggi, 2008

Treatments	Number of chewable stalks/plot 12map	Stalk length (cm) 12map	Stalk girth (cm) (12mapcm)	Brix% 12map	Stalk yield (ton/ha) 12map
Cattle manure incorporated	181.33 a	204.67 a	3.37	17.40	82.27 a
Basal application of cattle manure on the setts	176.33 b	201.48 a	3.23	17.73	81.33 a
Cattles manure broadcast on the soil surface (farmers practice)	163.33 c	191.27 b	2.80	16.83	75.32 b
Side band placement of cattle manure	176.00 b	202.86 a	3.00	16.83	82.23 a
Top band placement of cattle manure	176.00 b	201.13 a	3.27	16.60	83.03 a
SE (±)	1.32	1.58	0.99	0.53	1.00

Plot size 30m2 (6m x 5m)
MAP = Months after Planting

Table 6. Effect of cattle manure application methods on the yield and yield Attributes of chewing sugar cane at Badeggi , 2009

Treatments	Number of chewable stalks/plot 12map	Stalk length (cm) 12map	Stalk girth (cm) 12map	Brix % 12 12map	Stalk yield (ton/ha) 12map
Cattle manure incorporated	198.89 a	206.20 a	3.47	17.46	85.27 a
Basal application of cattle manure on the setts	183.98 b	205.89 a	3.33	17.74	84.33 a
Cattles manure broadcast on the soil surface (farmers practice)	169.75 c	192.34 b	2.90	16.89	79.32 b
Side band placement of cattle manure	183.99 b	204.78 a	3.10	16.86	85.23 a
Top band placement of cattle manure	183.78 b	205.87 a	3.37	16.67	84.28 a
SE (±)	1.29	1.55	1.09	0.59	1.04

Plot size 30m2 (6m x 5m)
MAP = Months after Planting

Though, there was no significant difference among the yield and yield attributes obtained from the four application methods, it is easier and cheaper to apply cattle manure through incorporation than the remaining methods. Incorporation allows evenly and uniformly distribution of manure on the field thereby making nutrients uptake by the roots of plant possible at different stages.

Conclusion

Incorporation, basal application, side band placement and top band placement methods produced sugarcane with better uniform stalk yield (t/ha) in both 2008 and 2009 than the remaining method (broad casting cattle dung on the soil surface (the farmers practice). Based on the better growth performance and yield (ton/ha) of sugarcane obtained from these three methods, any one of the methods could be recommended. Preferably, incorporation method as it does not involve technicality and at the same time allows uniform spread of the applied cattle manure thereby, facilitating availability of the mineralized nutrients to the crop at different stages of growth and development.

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