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Time of sowing sorghum (*Sorghum bicolor* L.) as affected by nitrogen mineralization from farm yard manure in three soil types

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ABSTRACT

Synchronizing inorganic nitrogen during mineralization of added organic matter uptake by the subsequent crop is an environmentally sound. In this study, laboratory and field experiments were conducted to estimate (in the first) potential mineral N (NH_4-N + NO_3-N) release pattern from farm yard manure (FYM) applied to three soil types and to determine (in the second experiment) the optimum time for sowing (one, two and three weeks after manure application) fodder sorghum (Sorghum bicolor L.) after application of the manure (10 t ha^{-1}). Potentially mineralizable N was determined by mixing farmyard manure with surface soil (0-30 cm) collected from sandy clay, clay loam and clay soils. The mixture was aerobically incubated for 12 weeks at about 70% water holding capacity and mineral N was determined at a week interval time. All amended soils immobilized N during the first week, but later had net release of inorganic N. Maximum N mineralization (14 - 15.6% and 13.9%) from added N were obtained after 9 and 7 weeks in the light and heavy textured soils, respectively. By the end of the incubation period, total net mineral N accumulated in the sandy clay, clay loam and clay soils were 91.7, 91.5 and 34.2 mg N kg -1, respectively. In the light soils, sowing sorghum after two to three weeks from incorporation of manure had significantly higher dry matter yields than after one week, whereas, in the heavy textured soil, sowing date had no significant effect. It could be concluded that adjusting sowing date, in light texture soils, of the subsequent crop after manure incorporation might better improve yield.

KEY WORDS: farm yard manure; N mineralization; soil type; synchrony; uptake

INTRODUCTION

Forage production is of paramount importance for livestock production in Sudan. That is mainly attributed to the large number of animal wealth. The main cereal forage crops under irrigated areas in Sudan are of wide range, chief among them is fodder sorghum which is locally named "Abu Sabien" (Sorghum bicolar (L), Moench). It has a potential yield of up to 8 tones dry matter per hectare (Kambal, 1975). It is predominantly used in dairy and beef farms as the sole forage (Fad Alla, 1980). The economic volume of this fodder was very high, the crop is palatable for animal and it is used in enormous quantities in milk farms. Because it contains high content of sugar, also this fodder contains 50% of crude protein, 2% of digestible protein and about 55% of total digestible nutrients. On the other hand, the crop can be toxic to animals in its early stages of growth. The toxicity is caused by the formation of prussic acid and HCN acids which are very toxic for animals in the first stage of growth but it decease after three-four weeks from sowing. In Sudan, there are few studies that focus on N mineralization from farm yard manure, either in the laboratory (Yousif and Mubarak, 2009; Mubarak et al., 2010) or in the field (Mubarak et al., 2010). Nevertheless, there are no studies on adjusting sowing date of the subsequent crop after incorporation of normal wastes. Therefore, the objectives of this study were: to (1) determine potentially mineralizable N from farm yard manure in three types of soils, (2) to determine the suitable sowing date of fodder sorghum after manure application. Farmyard manure (FYM) is considered to be a good source of plant nutrients which contains approximately 70 – 80% of nitrogen, 60 – 85% of phosphorus and 80 – 90% of potassium in feeds excreted manure. The use of organic manures as amendments to improve soil organic matter level and long term soil fertility and productivity is gaining importance. The benefits of composite organic wastes to soil structure, fertility as well as plant growth have been increasingly emphasizing (Chen et al., 1992). Nitrogen is essential for crop growth, being a constituent of proteins, amino acids, chlorophyll, nucleic acids and cell walls. It is absorbed by plant roots from the soil solution as ammonium (NH_4^+) or nitrate (NO_3^-). Mineral nitrogen in the soil originates from mineralization of the soil organic matter, including roots and crop residues.

Mineralization of nitrogen from the FYM mixed with soil is determined using aerobic or anaerobic incubation techniques (Chani, 1991). The plant available nitrogen content of dairy manure is commonly calculated using concentration and availability coefficients for organic nitrogen (N) and ammonium nitrogen (NH_4^+) but the carbon (C) fraction of the manure also influences the availability of nitrogen overtime. Nitrogen fertilizers that come from manure are necessary to meet the nitrogen requirement of intensively grown crops and field vegetable. Nitrogen mineralization rate is generally considered to be affected by soil type, temperature, moisture, aeration, pH and depth as well as by physiochemical properties of the waste material (Standford and Smith, 1972).

MATERIALS AND METHODS

The soils used in this study were collected from three different locations with different soil properties and texture. The first soil sample was collected from the topsoil of south, (Seilit) Scheme, Khartoum North. The soil is classified as medium, mixed, iso-hyperthemic, typic, natragid. The second soil is collected from Omdurman Islamic University, (Fitahab) and was classified as fine loamy, mixed, hyperthermic typic hapargid. The third sample was collected from the Experimental Research Farm of the Faculty of Agriculture, University of Khartoum (Shambat) and is classified as fine montmorillonitic, isohyperthemic, entic cromustert.

All soil samples were collected from surface (0 to 30cm) and transferred to the laboratory for characterization, chemical and physical properties were determined according to the methods reported by John Ryan,et al,.(2002).

Nitrogen mineralization from farmyard manure mixed with soils was determined using aerobic incubation technique using plastic containers, parafilm wax, thermometer, distilled water deep freezer and stoppered vials, 500 gm of air dried soil (2mm) were weighed into plastic containers with diameter of 6.5cm (total area 132.66 cm2). Manure was added at the rate of 10 t ha-1 (i.e 13.3 g farmyard manure per 500 g soil). Distilled water was added to bring the moisture content to 65 to 70% of field capacity.

Field experiments were conducted at three demonstration farms to study the nitrogen mineralization from farmyard manure and uptake by plant. All sites were prepared by disc ploughing to the depth of about 30 cm, disc harrowing to break clods and leveling to obtain good seed bed. The treatments were similar in all sites and were as follows: Sorghum sown after one week, two week and three weeks from application and control. All treatments were arranged in a randomized block design with four replications. The following plant parameters were measured: Plant height, number of leaves, Fresh and dry matter weights. Statistical analysis was performed using SAS (1985) and differences between treatments means were determined using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Mineralization of farmyard manure (FYM) under laboratory conditions during 12 weeks of incubation was measured by estimating the amounts of NH_4-N and NO_3-N in mg/kg soil. These amounts were plotted against incubation time in graphs to estimate maximum rate of mineralization. As shown from the results after eight weeks of incubation higher values of N mineralization were obtained in light textured soils when compared with heavy textured ones, whereas after twelve weeks at the end of the incubation it was very clear that very high rate of minerlization occured in light textured soil than in heavy textured and accordingly the sandy clay, clay loam and clay soils were recorded values 91.7, 91.5 and 34.2 mg N kg -1, respectively.

The percentage of N mineralization of the total nitrogen of FYM was equal to 66.85, 57.04 and 49.20% in sandy clay (Sileit Soil), clay loam (Fitehab Soil) and clay (Shambat Soil), respectively, and the mineralization nitrogen as ammonium percentage was equal to 29.82 %, 31.33 % and 24.52 % in Fitehab Soil, Sileit Soil and Shambat Soil respectively.

Table.(1) Dry matter yield (t ha^{-1}) of sorghum after FYM application (W1, W2 and W3 = sowing after 1, 2 and 3 weeks, respectively)

Weeks after application	Soil type		
	Sandy clay	**Clay loam**	**Clay**
W1	14.7 b ± 1.1	6.5 b ± 1.9	11.1 a ± 1.1
W2	15.3 b ± 2.5	8.6 a ± 0.7	11.8 a ± 1.7
W3	16.6 a ± 1.5	5.3 b ± 1.3	11.7 a ± 1.4

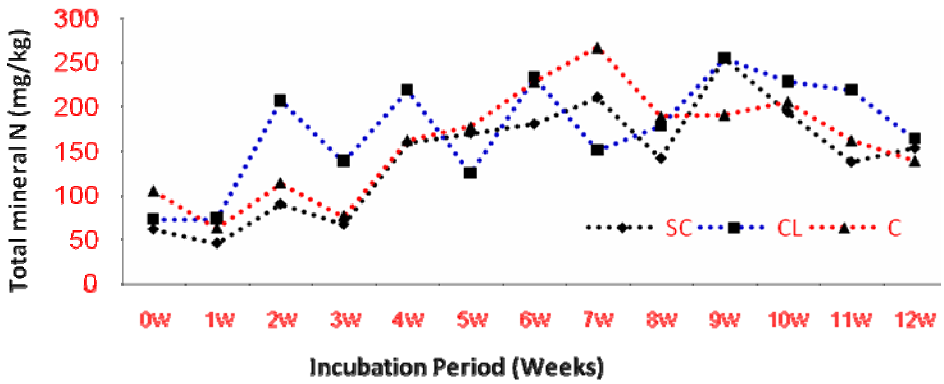

Fig (1) N mineralization and recommended sowing date after FYM application

Table (2): Plant parameters at harvest as affected by time of sowing after addition of FYM in Sileit soils

Times of sowing after FYM application	Plant Parameters			
	Plant height cm	**Number of leaves**	**Fresh matter ton/ha**	**Dry matter ton/ha**
Week 1	125.00^{ab}±5.00	9.00^{a}±0.00	19.50^{a}±1.42	14.67^{a}±1.11
Week 2	125.00^{ab}±15.00	9.67^{a}±0.67	21.88^{a}±2.25	15.29^{a}±2.47
Week 3	151.67^{a}±10.93	9.00^{a}±0.00	23.13^{a}±1.25	16.59^{a}±1.51
Control	105.00^{b}±5.00	9.00^{a}±0.00	17.92^{a}±3.28	13.05^{a}±2.16

- Each value is the treatment mean of three replications.
- Each mean in columns followed by the same letters does not differ significantly at the 0.05 level according to Duncan's Multiple Range Test .

Table (3): Plant parameters at harvest as affected by time of sowing after addition of FYM in Fitehab location

	Plant Parameters			
Times of sowing after FYM application	**Plant height Cm**	**Number of leaves**	**Fresh matter ton/ha**	**Dry matter ton/ha**
Week1	133.33 $^{a b}$ ±16.91	10.33 ^{a} ±0.67	29.38 ^{a} ±8.46	6.51 ^{a} ±1.85
Week2	125.00 $^{a b}$ ±20.21	11.67 ^{a} ±0.67	34.59 ^{a} ±3.27	8.57 ^{a} ±0.72
Week3	153.33 ^{a} ±1.67	11.00 ^{a} ±1.15	27.71 $^{a b}$ ±5.96	5.34 ^{a} b ±1.27
Control	90.00 b ±20.82	9.67 ^{a} ±1.33	9.42 ^{b} ±3.40	1.76 ^{b} ±0.51

Table (4): Plant parameters at harvest as affected by time of sawing after addition of FYM in Shambat soil

Times of sowing after FYM application	**Plant Parameters**			
	Plant height Cm	**Number of leaves**	**Fresh matter ton/ha**	**Dry matter ton/ha**
Week 1	153.33^{b}±4.41	12.67^{a}±0.67	49.17^{a}±4.91	11.10^{a}±1.12
Week 2	173.33^{a}±10.93	12.33^{a}±0.67	46.46^{a}±5.18	11.76 ^{a}±1.71
Week 3	163.33^{ab}±1.67	11.67^{a}±0.33	43.75^{a}±5.91	11.73^{a}±1.44
Control	150.00^{b}±7.64	11.00^{a}±0.00	44.58^{a}±3.00	11.65^{a}±0.68

CONCLUSIONS

The process of nitrogen mineralization from applied farmyard manure mixed with three different samples of soils of semi-desert region was investigated. The soils locations (Siliet, Fitehap and Shambat Soils) were selected from Khartoum State to represent different soils which are normally planted with Abu Sabein. Laboratory incubation experiments followed by field experiments were conducted to assess the rate of mineralization and to specify the time at which maximum mineralization of nitrogen from FYM takes place during incubation period. Synchronization between the rate of N mineralization obtained from laboratory experiments and the timing of sowing after addition of FYM was assessed. Four plant parameters, plant height, number of leaves, fresh matter and dry matter were assessed. As a conclusion in the light textured soils, sowing sorghum after two to three weeks from incorporation of manure had significantly higher dry matter yields than after one week, whereas, in the heavy textured soil, sowing date had no significant effect. In otter words adjusting sowing date, in semi arid region in light texture soils, of the subsequent crop after manure incorporation might better improve yield.

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