Effect of liquid bio-slurry and nitrogen rates on soil physico-chemical properties and quality of green bean (Phaseolus vulgaris L.) at Hawassa Southern Ethiopia

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Abstract
Green bean (Phaseolus vulgaris L.) is one of the most important food legumes grown in developing countries including Ethiopia. However, its cultivation is constrained by low soil fertility. A field experiment was conducted to evaluate the effect of LBS and N rates on soil physico-chemical properties and yield of green bean at Hawassa, Ethiopia. Four levels of LBS (0, 20.6, 41.2 and 61.8 m³/ha) and four N levels (0, 20.5, 41 and 61.5 kg/ha) were used in factorial RCBD with three replications. Results revealed that the application of LBS and N rates significantly affected most parameters. The application of LBS (20.6 m³/ha) and N (41 kg/ha) increased CEC by 120% as compared to control. Similarly the application of LBS (41.2 m³/ha) and N (20.5 kg/ha) gives the highest OC as compared to control. The addition of 41 N with 20.6 m³/ha LBS also scored the highest (14.3 t/ha) total pod yield as compared to control. Therefore 41 N with 20.6 m³/ha recommended both soil and green bean improvement.

1. Introduction
Green bean (Phaseolus vulgaris L.) is one of the most important food legumes grown in developing countries including Ethiopia. However, its productivity is very poor due to low soil fertility, lack of improved varieties, and poor agronomic practices including zero-inputs of both organic and inorganic fertilizers. The use of organic fertilizers with inorganic fertilizers successfully maintain and sustain soil fertility and crop productivity (Widowati et al. 2012). Although inorganic nitrogen (N) fertilizers have immediate effects on plant productivity, they are expensive and out of reach of most small-scale farmers. As a result, reduced dependence on nitrogen fertilizer and adopting farming practices that is economically viable and environmentally prudent organic material such as liquid bio-slurry will benefit both agriculture and the environment.

Liquid bio-slurry is rich in major plant nutrients (nitrogen, phosphorous, and potassium) and its organic matter (humus) improves the physico-chemical properties and fertility of the soil. The use of liquid bio-slurry could be an alternative way to enhance soil fertility and improve crop productivity in developing countries (Alberdi et al. 2018). Liquid bio-slurry is a carbon-rich material produced through the heating of organic materials through hydrolysis, fermentation, acetogenesis, and methanogenesis under the absence of oxygen at high temperatures (Warnars and Oppenoorth 2014). It has high surface area, thus its application to soils improves a range of soil properties such as aggregate stability, porosity, soil bulk density, water holding capacity, soil pH, and nutrient retention. Liquid bio-slurry has been used as a soil amendment to enhance soil fertility especially in acid and nutrient deficient subtropical and tropical soils (Zhang et al. 2012). Other than improving soil fertility and crop yield, organic fertilizers like liquid bio-slurry used to enhance carbon sequestration in soils, thus mitigate the effect of climate change (Abridhankesh et al. 2016). Vegetable crops play an important role through contributing for household food security, generation of income in the study area. However, the use of chemical fertilizers for garden vegetable production in urban agriculture is not affordable due to the high cost of chemical fertilizers. The owners of the biogas digester (farmers) are facing a challenge where to dispose the liquid bio-slurry and use of it as a source of fertilizer is common in Hawassa area. Liquid bio-slurry that generated from the biogas digester has a disadvantage for them to handle wisely (Widodo and Hendriadi 2005). Poor utilization of liquid bio-slurry in this area was also part of the problem maintaining water quality and conditioning of environmental safety. Thus the utilization of liquid bio-slurry as a fertilizer in this area could solve soil fertility and the waste management issue while providing an alternative energy source for the communities. Several studies have shown the potential effect of liquid bio-slurry application to improve soil chemical and physical properties (Atkinson et al. 2010; Busscher et al. 2010). But in Ethiopia, there are few studies in the literature which demonstrate the effect of liquid bio-slurry application on soil physical and chemical properties under field conditions on sandy and clay textured soils (Nigussie et al. 2012). But most available data in the literature for the effect of liquid bio-slurry on soil properties have been conducted in China, Bangladesh, and Europe (Groot and Bogdanski 2013). Therefore, there is a need to evaluate the potential benefits of liquid bio-slurry as soil amendment to improve soil physico-chemical properties and green bean quality under field conditions. The main objective of this study was to evaluate the effect of liquid bio-slurry and nitrogen
fertilizer rates on selected soil physico-chemical properties and quality of green bean at Hawassa Southern Ethiopia.

2. Materials and methods

2.1. Description of study area

A field experiment was conducted at Hawassa University experimental field station, southern Ethiopia. The site is located at 270 km south away from the capital city Addis Ababa. Geographically the area lies at 7° 03′ 05.77″ N and 38° 30′ 21.1″ E with mean altitude of 1712 m above sea level. It receives a mean annual rainfall of 952 mm with mean minimum and maximum temperature of 12.1°C and 26.7°C, respectively (Hawassa Meteorological Center, 2018). Major crops grown in the study area are maize, common bean, cabbage, wheat, enset, beet root, lettuce, sweet potato, and chilli.

2.2. Experimental design and experimentation

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications that have 16 treatments combined from 4 levels of liquid bio-slurry (0, 20.6, 41.2 and 61.8 m³/ha) and 4 levels of nitrogen (0, 20.5, 41.2 and 61.5 kg N ha⁻¹). Liquid bio-slurry that was used has 93.5% water and 6.5% dry matter and rates adjusted based on the recommended rate of N respected to its N content. Urea was used as a source of synthetic N whereas P was applied in the form of triple super phosphate (TSP) to all treatments except control. For this experiment, green bean variety Volta was used as a test crop. Total plot size was 3.2 m wide and 2 m length having 1 m space between plots and 1.5 m between blocks. Plants were spaced 0.1 m between plants and each plot consisted of eight rows at 0.4 m interval, and 1.5 m between blocks. Plants were spaced 0.1 m between plants and each plot consisted of eight rows at 0.4 m interval, out of which data were collected from the middle six rows. Recommended seed rate (i.e. 60 kg/ha) of green bean seeds was planted within rows (Varity register, 2016). Liquid bio-slurry was incorporated into the soil 1 week before planting in order to prevent its burning effect on crop growth. Concerning inorganic N fertilizer split application was used, half dose added during planting and the remaining half dose was used after 21 days of planting and P (20 kg ha⁻¹) was applied as basal during sowing period of time for all plots.

2.3. Liquid bio-slurry analysis

Liquid bio-slurry in the tank of the bio-digester that was obtained from cow dung mainly feeds local grass and residue of brewery factory around Hawassa town stir in circular movement with a stick; preventive measure was taken to avoid scrape of the bottom and corners of the tank. Then five representative liquid bio-slurry samples were collected with 2 liter sampling plastic. Then mixed in the plastic container, 1 liter representative sample was taken for the analysis of acidity (pH), organic carbon (OC%), cation exchange capacity (CEC), total nitrogen (TN%), available phosphorus (Av P ppm), and available potassium (Av K ppm) into soil laboratory of Hawassa Agricultural Research Center by following laboratory procedures that listed in soil analysis (Table 1).

2.4. Soil sampling and analysis

The major chemical properties of soil such as OC, pH, CEC, total N, available P and K were analyzed following the compiled laboratory manual of Sahlemedihn and Taye (2000). Soil pH was measured in water at the ratio of 1:2.5 using glass electrode pH meter. The soil OC content was determined following the wet digestion method as outlined by Walkley and Black which involves digestion of the OC in the soil samples with potassium dichromate (K₂Cr₂O₇) in sulphuric acid solution. AvP was determined by Olsen extracting method. Total N content in the soil samples was determined following the Kjeldahl method. CEC was determined by extracting the soil samples by ammonium acetate (1N NH₄OAc) followed by repeated washing with ethanol (96%) to remove the excess ammonium ions in the soil solution. Percolating the NH₄⁺ saturated soil with sodium chloride would displace the ammonium ions adsorbed in the soil and the ammonium liberated from the distillation was titrated using 0.1N NaOH. However, the analysis of available potassium was done by extracting Morgan solution at pH 4.8 and determined by flame photometer.

Bulk density was determined by core sampling method and total porosity was obtained from the calculation of bulk density and particle density values. The determination of particle size distribution was done using the hydrometer method (procedures) compiled by Sahlemedihn and Taye (2000) and the sand, silt, and clay percent were calculated and identified using FAO textural triangle. Soil moisture content was determined from disturbed soil samples collected from the respective plots and then calculated by using the formula:

\[ W = (\frac{Mw - Dws}{Dws}) \times 100 \]

where \( W \) is the gravimetric soil moisture content, \( Dws \) is the dry weight of soil and \( Mw \) is the wet weight of soil. Bulk density was determined using cylindrical core sampling procedures as indicated by Sahlemedihn and Taye (2000).

\[ \rho_b = \frac{Wd}{Vt} \]

where \( \rho_b \) is the bulk density (g cm⁻³), \( Wd \) is the weight of dry soil (g) and \( Vt \) is the volume of the bulk soil (cm³). Similarly, the total porosity of a soil also computed from the values of bulk density and particle density using the equation:

\[ f = \left(1 - \frac{\rho_b}{\rho_s}\right) \times 100 \]

where \( f \) is the total porosity (%), \( \rho_b \) is the bulk density (g cm⁻³), and \( \rho_s \) is the particle density (g cm⁻³) (Sahlemedihn and Taye 2000).

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Table 1. Physico-chemical analysis of liquid bio-slurry before incorporation.

| Liquid bio-slurry Concentration | Water % | Dry matter % | OM % | OC % | TN % | Av P (mg kg⁻¹) | Av K (mg kg⁻¹) | pH (H₂O,1:2.5) | CN ratio | CEC (cmol kg⁻¹) |
|-------------------------------|---------|-------------|-------|------|------|----------------|----------------|----------------|----------|----------------|
|                               | 93.5    | 6.5         | 30.6  | 17.8 | 1.5  | 301.4         | 715.3          | 7.3            | 11.9     | 64             |

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2.4. Data collection

2.4.1. Soil data

Both physical (bulk density, texture, moisture content and total porosity) and chemical (pH, OC, TN, av K, av P and CEC) were taken before and after soil analysis.

2.5. Growth and yield parameters

Shoot dry matter: Five plants were randomly taken from central rows at mid-flowering stage then immediately measured their fresh weight by sensitive balance and averaged for single reading of mean. Then fresh shoots were dried using the oven at 65°C until it reached constant dry weight and recorded by sensitive balance for averaging mean value that used for determination shoot dry matter through the calculation of

\[
SDM\% = \frac{SDW}{SFW} \times 100
\]

where SDM\% is the shoot dry matter percent, SDW is the shoot dry weight and SFW is the shoot fresh weight.

Fresh shoot biomass: It was measured by taking of all plants from central row then there fresh weight was measured by digital balance.

 Marketable pod yield: This was determined by using the sieve size measurement at harvesting period of time from five randomly selected plant pods which were more than 5.8 mm sieve size (size 1) was considered as marketable (USDA, 1993).

Total pod yield: Fresh pod yield was measured by harvesting fresh marketable and non-marketable pods from the net middle plot area of 2 m × 2 m to avoid border effects.

Harvesting index: It is measured through computing of economical fresh pod yield to biological fresh above biomass yield and is multiplied by 100.

2.5.1. Statistical analysis

All data were subjected to analysis of variance through Proc-Mixed procedure by using SAS software program version 9.00 (SAS Institute, 2002). Fisher list significant test (LSD) at 0.05 probability level was employed to separate treatment means where significant differences exist (Gomez and Gomez, 1984).

3. Results and discussion

3.1. Soil chemical properties before sowing

Results of soil chemical analysis before planting were presented in Table 2. The results revealed that the soil was moderately alkaline in reaction with a pH (H₂O 1:2.5) value of 7.35, which is within the range of optimum soil pH for bean production (Tekalign, 1991). The total N, available P, available K, OC, C/N ratio, and CEC of the soil before planting were 0.42%, 13 mg kg⁻¹, 162.4 mg kg⁻¹, 4.2%, 10 and 24.2 cmol (+) kg⁻¹, respectively (Table 2). The total N content of the soil was within the range of high according to Tekalign (1991) who classified the range of total N <0.1, 0.1–0.15, 0.15–0.25 and >0.25% as very low, low, medium and high, respectively. Olsen et al. (1954) classified available P content of the range <5 as low, 5–10 as medium and >10 mg kg⁻¹ as high. Hence the available P of the soil before planting lies under the high range. According to Horneck et al. (2011), the available K value lies under medium range. According to Landon (1991), the soil OC content ranges of 1–2%, 2–4%, and 4–6% are rated as low, medium, and high, respectively. The OC and CEC ranges of 5–15, 15–25 and 25–40 cmol kg⁻¹ are rated as low, medium, and high, respectively. Based on these ratings, the OC (4.2%) and CEC (24.2 cmol kg⁻¹) before planting of the experimental field were in the high and medium ranges, respectively. Generally, the nutrient content of the study site is good in terms of availability of major plant nutrients. However, moderately alkalinity of a soil may cause the sorption of available P since it has a capacity of reduce soil pH by increasing organic acid. Thus the application of OM is very essential in order to neutralize soil solution.

3.2. Soil chemical properties after harvest

After harvest soil pH, total N, available P and K as well as C/N ratio were not affected significantly by the application of liquid bio-slurry and N rates. However, combined application of liquid bio-slurry and N rates had significant (P < 0.05) effect on OC% and CEC of a soil when compared to the control (Table 3). Numerically, the highest soil OC content was obtained from the combined application of 41.2 m³/ha liquid bio-slurry and 20.5 kg N/ha fertilizer as compared to control. The observed increase on soil OC by applied treatments might be due to the improvement of soil organic matter. These results were in agreement with the investigation of Faisal et al. (2017) who reported that the combined application of farm yard manure (FYM) with inorganic NPK in maize has increased the soil OC content after harvest by 65% as compared to control. Similarly, Tilahun et al. (2013) also indicated that soil OC content just after the rice harvest responded significantly to the application of FYM and the highest carbon (8.7%) being recorded from the application of FYM at the rate of 15 t/ha. The current study also enriched the findings of Geremew (2017) who observe the highest value of OC content due to the application of full dose of dry bio-slurry (14 t/ha) as compared to control.

The combined application of the 20.6 m³/ha liquid bio-slurry and 41 kg N/ha caused a 120% increment on CEC compared to control (Table 3). Such increment in CEC might be due to combined application of liquid bio-slurry and N on a negatively charged colloidal site and store house of basic cations. These results are in agreement with the findings of Tamado and Mitiku (2017) who reported that the use of organic FYM and inorganic fertilizers significantly increased CEC over the control. Therefore, OM/OC of the soil might serve as the reservoir of basic cations and thereby, increasing the CEC of the soil. Alem and Fassil (2017) also reported similar results on CEC, OM, and OC content of soil which are increased with the integrated use of organic manure and inorganic fertilizers.

| Table 2. Soil chemical properties before sowing. |
|-----------------------------------------------|
| Composite sample | pH (H₂O 1:2.5) | TN | Av P | Av K | OC | C/N ratio | CEC (cmol (+) kg⁻¹) |
|------------------|----------------|----|------|------|-----|----------|-------------------|
|                  | 7.35           | 0.42 | 13   | 162.4 | 4.2 | 10       | 24.2              |

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Table 3. Soil chemical properties after sowing.

| Treatment | Soil chemical properties after harvest |
|-----------|--------------------------------------|
| RN (kg/ha) | LBS (m³/ha) | pH (H₂O,1:2.5) | TN (%) | Av P (ppm) | Av K (ppm) | OC% | C/N ratio | CEC (cmolc (+) kg⁻¹) |
| 0         | 0           | 7.4           | 0.23    | 12.2   | 167.3 | 3.4g | 14.4 | 17.1 |
| 20.5      | 0           | 7.4           | 0.27    | 12.3   | 204.0 | 5.1a-c | 20.0 | 18.4f |
| 41        | 0           | 7.3           | 0.32    | 14.3   | 226.0 | 4.7a-d | 15.0 | 27.4de |
| 61.8      | 0           | 7.3           | 0.32    | 11.5   | 217.3 | 4.7a-e | 20.5 | 33.7ab |
| 20.6      | 0           | 7.4           | 0.25    | 11.1   | 227.3 | 5.4a-f | 23.4 | 36.3a |
| 41.2      | 0           | 7.2           | 0.23    | 18.0   | 214.0 | 3.9e-g | 17.3 | 25.5de |
| 61.8      | 0           | 7.3           | 0.23    | 9.0    | 214.0 | 3.9e-g | 17.3 | 25.5de |
| 41        | 0           | 7.5           | 0.22    | 14.6   | 221.3 | 3.8f-g | 17.2 | 18.7f |
| 20.6      | 0           | 7.4           | 0.20    | 11.8   | 196.0 | 4.8a-d | 24.5 | 37.6a |
| 41.2      | 0           | 7.2           | 0.27    | 16.9   | 225.3 | 4.9a-c | 18.3 | 29.7a-e |
| 61.8      | 0           | 7.4           | 0.22    | 11.3   | 222.0 | 4.5a-f | 20.3 | 35.5a |
| 20.6      | 0           | 7.4           | 0.30    | 11.9   | 212.7 | 5.1abc | 18.9 | 29.5b |
| 41.2      | 0           | 7.3           | 0.20    | 14.9   | 198.0 | 5.2ab | 20.4 | 33.2a-c |
| 61.8      | 0           | 7.2           | 0.25    | 13.7   | 230.7 | 4.3c | 18.0 | 24.7e |
| 41        | 0           | 7.2           | 0.27    | 16.9   | 225.3 | 4.9a-c | 18.3 | 29.7a-e |
| 20.6      | 0           | 7.4           | 0.22    | 11.7   | 244.7 | 4.0d-g | 18.2 | 29.7b-e |
| 41.2      | 0           | 7.3           | 0.20    | 14.9   | 198.0 | 5.2ab | 20.4 | 33.2a-c |
| 61.8      | 0           | 7.2           | 0.25    | 13.7   | 230.7 | 4.3c | 18.0 | 24.7e |
| 41        | 0           | 7.2           | 0.27    | 16.9   | 225.3 | 4.9a-c | 18.3 | 29.7a-e |
| 20.6      | 0           | 7.4           | 0.22    | 11.7   | 244.7 | 4.0d-g | 18.2 | 29.7b-e |
| 41.2      | 0           | 7.3           | 0.20    | 14.9   | 198.0 | 5.2ab | 20.4 | 33.2a-c |
| 61.8      | 0           | 7.2           | 0.25    | 13.7   | 230.7 | 4.3c | 18.0 | 24.7e |
| CV%       | 2.3         | 21.2          | 24.8   | 16.9   | 15.2  | 22.5 | 23.7 |
| LSD       | NS          | NS            | NS     | 0.2859 | 1.7394 |

Means followed by the same letter(s) within the column are not significantly different at $P \leq 0.05$.

### 3.3. Soil physical properties before sowing

Soil physical properties of experimental site before sowing are presented in Table 4. The results revealed that the soil was sandy loam in texture and the silt to clay ratio of experimental plots before sowing was 3.4. This ratio is one of the tools used to assess the rate of weathering and determine the relative stage of development of a given soil. According to Young (1976), a ratio of silt to clay <0.15 is considered as low and indicative of an advanced stage of weathering. Whereas when the values >0.15 indicate that the soil is young and it contains easily weatherable minerals. Hence, the soil of the study area is young that contains easily weatherable minerals. Similarly, soil bulk density was 1.2 g cm⁻³. Gravimetric soil moisture content and total porosity values are rated as medium and high according to Brady and Weil (2004). In general, the physical property of the study soil was suitable for crop production.

### 3.4. Soil physical properties after harvest

The combined application of liquid bio-slurry and N rates had no significant influence on bulk density, gravimetric moisture content and total porosity (Table 4). The non-significant effects of applied treatments on soil a physical property after harvest might be due to a shorter experimentation period that makes organic matter not decomposed easily to bring expected change on it. Similar result is also reported by Ehiokhilen et al. (2017) who reported that the application of organic fertilizer with NPK on watermelon cultivation did not bring a significant change on soil bulk density and hydraulic conductivity of soil when compared to before organic fertilizers incorporation (Table 5).

### 3.5. Effect of liquid bio-slurry and N rates on yield and yield components

The analysis of variance revealed that yield and yield components of green bean are significantly different at ($P < 0.05$) due to the combined effects of liquid bio-slurry and applied N (Table 6). Application of 61.5 N kg/ha alone resulted in numerically the highest fresh shoot biomass and total pod yield while the lowest fresh shoot biomass and total pod yield were recorded from the application of liquid bio-slurry at the rate of 41.2 m³/ha alone and control treatments, respectively (Table 6). This might be due to the release of N from liquid bio-slurry and urea to soil solution that is essential for plants better growth and development. Moreover, it could be due to the addition of both macro and micro-nutrients from the liquid bio-slurry beyond improving of soil physico-chemical properties. The study is in line with the findings of Yalemteshay and Fisseha (2016) who revealed that the supplying of recommended inorganic fertilizer bio-slurry gives maximum yield of cabbage as compared to the control treatment. Similarly, the study done by Tsegaye (2017) revealed that the lowest values of fresh shoot biomass

Table 5. Soil physical properties before sowing and after harvesting.

| Treatment | Soil physical properties after harvest |
|-----------|--------------------------------------|
| RN (kg/ha)| Bulk density (g cm⁻³) | Moisture content (%) | Total porosity (%) |
| 0         | 1.16       | 21.12           | 59.57           |
| 20.6      | 1.04       | 34.16           | 63.93           |
| 41.2      | 1.06       | 34.07           | 64.45           |
| 61.8      | 1.04       | 34.91           | 64.83           |
| 0         | 1.01       | 14.19           | 61.11           |
| 20.6      | 1.06       | 27.14           | 62.01           |
| 41.2      | 1.04       | 22.37           | 62.65           |
| 61.8      | 1.02       | 31.32           | 63.55           |
| 41        | 1.02       | 19.35           | 59.95           |
| 20.6      | 1.11       | 27.55           | 60.08           |
| 41.2      | 1.11       | 28.15           | 60.34           |
| 61.8      | 1.08       | 24.67           | 60.72           |
| 0         | 1.04       | 22.41           | 57.77           |
| 20.6      | 1.08       | 30.53           | 60.72           |
| 41.2      | 1.02       | 27.66           | 62.65           |
| 61.8      | 1.10       | 27.20           | 60.72           |
| CV%       | 6.2        | 29              | 4.5             |

Means followed by the same letter (s) within the column are not significantly different at $P \leq 0.05$. 

### Table 4. Soil physical properties before sowing.

| Texture | Bulk density (g cm⁻³) | Moisture content (%) | Total porosity (%) |
|---------|-----------------------|----------------------|--------------------|
| Clay    | 18                    | 61                   | 21                 | 1.2 | 19.7 | 55 |

Means followed by the same letter(s) within the column are not significantly different at $P \leq 0.05$. 

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Table 4. Soil physical properties before sowing.
and marketable yield of potato tuber were achieved from control while the highest values were obtained in plots that treated combined application of FYM and recommended N and P fertilizers.

Numerically the lowest (41.7%) values of harvest index were recorded from the combined application of liquid bio-slurry (61.8 m³/ha) and 20.5 kg N/ha whereas the highest (55.0%) value was recorded from the application of 20.5 kg N/ha (Table 6). Such increment in harvest index with combined application of liquid bio-slurry and N fertilization might be due to the harmonization of organic and inorganic fertilizers for uptake and assimilation of nutrients to different parts of plants. The result coincides with Tsegaye (2017) who observed that an application of combined half farm yard manure and blended fertilizers increases harvest index by 16% over the control plots. Another study done by Muhammed et al. (2014) showed that an addition of 600 kg/ha bio-slurry with 50% recommended nitrogen gives the maximum (16%) harvesting index of okra as compared to the lowest value (11.9%) which comes from the control treatment. On the other hand, total pod yield and marketable pod yield values were higher in most of the applied treatments compared to the control. The possible reason for the decreasing of total pod yield and marketable pod yield by 62% and 66.3%, respectively on control as compared to maximum values treatments could be the rate supplied for the plant is below its optimal nutrient requirement of the plant and consequently it restricts this yield and yield components. These results are in line with the finding of Geremew (2017) who obtained the maximum marketable and total fruit yield of tomato from treatment which supplied blended fertilizers with dry bio-slurry by increasing of about 35% and 28% yield advantage than the lowest values of control. Shoot dry matter is also significantly affected by the combined application of liquid bio-slurry and N rates (Table 6). Related to this maximum value was obtained with the application of 61.8 m³/ha liquid bio-slurry while the lowest was recorded with the combined application of 20.5 N kg/ha and 20.6 m³/ha. This might be due to the ability of liquid bio-slurry make of suitable condition by optimizing plant growing environment in terms of improving of soil moisture beyond supplying of nutrients that enhance plant growth and development. Due to the fact nitrogen is an essential element in different metabolic reaction-like protein synthesis and organic compound formation, it makes plants grow rapidly very well because of this application of inorganic N, and liquid bio-slurry significantly affects the parameter (shoot dry matter). The current study is in line with Tsegaye (2017) who reported that minimum value of dry matter of potato tuber was obtained from recommended nitrogen and phosphorus as compared to FYM treatments.

4. Conclusion

The result shows that the combined application of liquid bio-slurry (20.6 m³ ha⁻¹) with nitrogen (41 kg N ha⁻¹) has the potential to improve both soil physico-chemical properties and green bean production in the study area. The combined application effect of liquid bio-slurry and nitrogen was significant on green bean yield components. Due to this application of nitrogen (41 kg N ha⁻¹) with liquid bio-slurry (20.6 m³ ha⁻¹) scored the highest total pod yield of green bean than control. Therefore an application of nitrogen (41 kg N ha⁻¹) with liquid bio-slurry (20.6 m³ ha⁻¹) could improve both soil physico-chemical properties and green bean yield. But this study was conducted for one season only and organic fertilizers like liquid bio-slurry need enough decomposition time, more research is needed to evaluate the effect of liquid bio-slurry and nitrogen on soil physical and chemical properties, involving various types of liquid bio-slurry from different feedstocks, application rates, and soil types under field conditions on two and more cropping season in the study area.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Abrishamkesh S, Gorji M, Asadi H, Bagheri-Marandi GH, Pourbabaee AA. 2016. Effects of rice husk biochar application on the properties of alkaline soil and lentil growth. Plant Soil Environ. 61:475–482.
Alberdi H.A, Sagala S.A.H, Wulandari Y, Srajan S L and Nugraha D. 2018. Biogas Implementation as Waste Management Effort in Lembang Sub-district, West Bandung District. Plano Cosmo International Conference.
Alem R, Fassil K. 2017. Effects of integrated use of organic and inorganic fertilizers on soil properties performance, using rice (Oryza sativa L.) as an indicator crop in Tseletmi District of North-Western Tigray, Ethiopia. RIJAST. 1(1):6–14.
Atkinson C, Fitzgerald J, Hipps N. 2010. Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils: a review. Plant Soil. 337:1–18.
Brady NC, Weil RR. 2004. The nature and properties of soils, 13th ed. New Delhi: Pearson Education, Inc.
Busscher WJ, Novak JM, Evans DE, Watts DW, Niandou MAS, Geremew B. 2017. Effect of dry bio-slurry and chemical fertilizers on yield and yield components of tomato and soil chemical properties in Arbaminch Zuria, Southern Ethiopia. An MSc Thesis Presented to School of Plant and Horticultural Science of Hawassa University. 46p.
Gomez KA, Gomez AA. 1984. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley and Sons.
Groot L, Bogdanski A. 2013. Bio-slurry Brown Gold? A Review of Scientific Literature on the Co-Product of Biogas Production. Environment and Natural Resources Series. FAO, Rome, Italy. 32pp.
Hornick DA, Sullivan DM, Owen JS, Hart JM. 2011. Soil text interpretation guide. USA: Oregon State University.
Landon JR. 1991. Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. New York: Routledge.
Muhamood A, Javid S, Ahmad ZA, Majeed A, Rafique RA. 2014. Integrated use of bio-slurry and chemical fertilizers for vegetable production. PJAS. 51(3):565–570.
Nigussie A, Kissi E, Misanaw M, Ambaw G. 2012. Effect of biochar application on soil properties and nutrient uptake of lettuces (Lactuca sativa) grown in chromium polluted soils. Am-Eurasian J Agric Environ Sci. 12:369–376.
Olsen SR, Cole CV, Watanabe FS, Dean LA. 1954. Estimation of available phosphorus in soils by extraction with sodium carbonate. USDA Circular, 939:1–19.
Sahlemedihin S, Taye B. 2000. Procedures for soil and plant analysis. Addis Ababa, Ethiopia.
Tamado T, Mitiku W. 2017. Effect of combined application of organic and mineral nitrogen and phosphorus fertilizer on soil physico-chemical properties and grain yield of food barley (Hordeum vulgare L.) in Kaffa Zone, South-western Ethiopia. MEJS. 9(2):242–261.
Tekalign T. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.
Tilahun T, Nigussie D, Wondimu B, Setegen G. 2013. Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. AJPS. 4:309–316.
Tsegaye G. 2017. Potato productivity, nutrient use efficiency and soil chemical property as influenced by organic and inorganic amendments in Arbegona District, Southern Ethiopia. [MSc. Thesis]. Presented to School of Plant and Horticultural science of Hawassa University. p. 22.
USDA (United States Department of Agriculture). 1993. United States Standards for Grades of Canned Green Beans and Canned Wax Beans. Washington, DC. p. 9–12.
Warnars L, Oppenoorh H. 2014. Bio slurry: A supreme fertilizer, a study on bio slurry results and uses. [site visited on 16/2/2016] http://www.laviniaes.com/les/6113/9576/2986/Bioslurry book.pdf.
Widodo TW, Hendriadi A. 2005. Development of biogas processing for small scale cattle farm in Indonesia. Proc. Int. Semin. Biogas Technology. 17–20 Oct 2005 (October). p. 255–261.
Widowati I, Utomo W, Guritno B, Soehono L. 2012. The effect of biochar on the growth and N fertilizer requirement of maize (Zea mays L) in greenhouse experiment. J Agric Sci. 4:255–262.
Yalentsheay D, Fisheha I. 2016. Comparative study on the effect of applying biogas slurry and inorganic fertilizer on soil properties, growth and yield of White Cabbage (Brassica oleracea var. capitata f. Alba). JBAH. 6(19):4.
Young A. 1976. Tropical soils and soil survey. London: Cambridge University Press. p. 468.
Zheng J, Ren X, Xu X, Hua X, Zhang X, Han X, Yu X. 2012. Effects of biochar amendment on soil quality, crop yield and greenhouse gas emission in a Chinese rice paddy: a field study of 2consecutive rice growing cycles. Field Crops Res. 127:153–160.