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Research Article

Effect of Compost, Blended (NPSZn), and Potassium Chloride Fertilizers on Soil Bulk Density and Moisture Content in Two Soil Textural Groups of Tigray, Northern Ethiopia

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The growing needs for agricultural production require maintaining and improving soil fertility through fertilization. However, most research to date in Ethiopia particularly in the Tigray regional state has focused on the effects of soil chemical properties and relatively little work has been done on soil physical properties. The objective of this study was to assess the effects of compost, blended (NPSZn), and potassium chloride (KCl) fertilizers on soil bulk density (BD) and moisture content (SMC). Therefore, a field experiment was carried out for 2018-2019 years to study the influence of sole and combined application of compost, NPSZn, and KCl fertilizers on BD and SMC in clay loam and loamy sand soil textures in Tigray. Two compost (0 and 20 $t \cdot ha^{-1}$), three NPSZn (0, 60, and 120 $kg \cdot ha^{-1}$), and four KCl (0, 120, 210, and 300 $kg \cdot ha^{-1}$) rates replicated three times were arranged in split-split plot design and allocated to main, sub, and sub-subplots, respectively. BD ($g \cdot cm^{-3}$) and SMC (%) data were collected from 0 to 10 and 0 to 30 cm soil depths before and after harvesting in 2018 and 2019, respectively. Sole and combined application of the fertilizers considerably influenced BD and SMC in both soil textural groups and years. Compost applied in combination with NPSZn at 120 $kg \cdot ha^{-1}$ and KCl at 300 $kg \cdot ha^{-1}$ significantly reduced BD (1.24 $g \cdot cm^{-3}$ in 2018 and 1.22 $g \cdot cm^{-3}$ in 2019) in clay loam soils as compared to all treatments. Similarly, the lowest BD (1.5 $g \cdot cm^{-3}$ in 2018 and 1.47 $g \cdot cm^{-3}$ in 2019) was observed in loamy sand soils. The highest volumetric SMC (21% in both years) was observed in clay loam soil in plots treated with compost. Likewise, the highest SMC (12% in 2018 and 11% in 2019) was found in loamy sand soils in compost-treated plots. This study demonstrated that SMC and BD can be improved through compost and compost combined with NPSZn and KCl application, respectively, in the drylands of Northern Ethiopia.

1. Introduction

Soil degradation poses a significant challenge to agriculture and environmental sustainability in Northern Ethiopia and many other regions around the world [1]. It refers to the gradual deterioration of the quality, fertility, and overall health of soils in agricultural areas. Soil degradation encompasses processes that involve physical, biological, and chemical degradations [2]. Physical deterioration of soil involves the destruction of soil structure, dispersion of soil particles, sealing of pores, compression and increasing density, consolidation, compaction and reduced root penetration, low infiltration, waterlogging and runoff, and accelerated erosion [3]. These processes lead to soil degradation and thus desertification in the arid and semiarid regions. At the same time, the growing needs for agricultural production require the maintenance and improvement of soil fertility. Chemical and organic fertilizers play crucial roles in agriculture where they can have significant positive effects on soil fertility and crop productivity [4, 5].

Soil physical properties play a central role in the transport and reaction of water, solutes, and gases in soils. Thus, their knowledge is very important in understanding soil behavior to applied stresses, fertilizer inputs, and transport phenomena in soils and hence for soil conservation and planning of appropriate agricultural practices. Consequently, soil physical properties have been proposed as suitable indicators for assessing the effectiveness of different agricultural practices, especially in terms of soil compaction management [6]. The ideal soil would hold sufficient air and water to meet the needs of plants with enough pore space for easy root penetration, while the mineral soil particles would provide physical support and plant essential nutrients [7].

Soil bulk density (BD) is a basic soil property influenced by some soil physical and chemical properties. It is the proportion of the weight of a soil relative to its volume expressed as a unit of weight per volume and is commonly measured in units of grams per cubic centimeter (g cm^{-3}) [7]. It is an indicator of soil compaction and the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space [8]. Soil bulk density provides important information about soil compaction, porosity, and the degree of soil compaction. This approach has been used extensively by several authors to monitor land cover and land-use change patterns [9, 10]. It is frequently influenced by the amount of organic matter in soils, their texture, constituent minerals, and porosity. The effect of sand content on BD is found to be higher than that of the other soil properties, but clayey soils tend to have lower bulk densities and higher porosities than sandy soils [7]. The normal range of BD for clay is 1.0 to 1.6 $g{\cdot}cm^{-3}$ with potential root restriction occurring at ≥1.4 $g{\cdot}cm^{-3}$ [11]. Similarly, Aubertin and Kardos [11] reported that the BD for sand texture soil ranges from 1.2 to 1.8 $g{\cdot}cm^{-3}$ with potential root restriction occurring at ≥1.6 $g{\cdot}cm^{-3}$.

Low soil moisture content (SMC) remains the most frequently noted critical challenge for being less effective of the recommended blanket fertilizer rate in moisture-stressed areas such as in the Tigray regional state. Low SMC limits soil nutrient uptake and availability and thus, poor response has been reported as a key challenge for fertilizer adoption by farmers. Such unfavorable effects of soil moisture on the fertilizer technology adoption can be minimized using suitable agronomic practices that improve soil moisture such as ridge construction, using organic fertilizer, and/or adoption of moisture stress tolerant crop varieties [12–14]. Agricultural practices and efforts in Tigray must be directed towards the improvement of soil moisture availability for sustainable crop production by smallholder farmers using a combination of the above agronomic practices [13, 15]. The removal of organic matter-rich topsoil continuously by erosion is more severe on overcultivated soils which has resulted in poor soil structure and infiltration and thereby poor soil moisture holding capacity. Such poor soil characteristics make water a key limiting factor for crop production, especially with fertilizer application in Tigray [16].

As part of the Ethiopian Government's Agricultural Policy Initiative, the Ethiopian Ministry of Agriculture (MoA) and Agricultural Transformation Agency (ATA) developed a soil fertility atlas for Tigray and recommended 12 major blended fertilizers for rain-fed agriculture in the region [17]. The new fertilizer recommendation included sulfur (S), potassium (K), iron (Fe), zinc (Zn), and boron (B) in addition to the previously used nitrogen (N) and phosphorus (P) nutrients depending on the level of deficiency [18]. However, K is not included in the recommendation list (NPSZn) for the experimental areas, Kallamino-Veterinary College farm (Mekelle City) and Wukro *St*. Mary's College farms (Wukro town) which require further investigation. Moreover, the response of potassium fertilizer to soil fertility and crop productivity in Ethiopia was not prioritized for many years as a result of the view that this nutrient was not deficient in Ethiopian soils [19]. Contrary to this, other researchers found that K was deficient in different parts of the country [20, 21]. Likewise, out of the assessed vertisol-dominated soil reference groups of Tigray, 76% were deficient in K [20]. The study by the ATA was also limited to rain-fed agriculture. However, the recommended blended fertilizer rate could be too small for irrigated crop production.

To improve soil physical properties and soil quality, the importance of fertilization is often reported [22–24]. However, in view of our knowledge, there are few studies that focus on assessing the impacts of fertilizer on soil physical properties in Tigray. Moreover, there were no studies on the impacts of the combined application of compost with the newly proposed blended and potassium chloride fertilizers on soil physical properties in Tigray, Northern Ethiopia.

This study hypothesizes that sole and combined application of compost, NPSZn, and KCl can play a significant role in improving soil BD and SMC with resultant effects of enhancing water infiltration (in clay loam soil), holding (in loamy sand soil), and improving BD. These, in turn, reduce moisture stress and soil erosion which are the two most important problems in Ethiopian agricultural production and environmental sustainability. The objective of this study was therefore to evaluate the impact of compost, NPSZn, and KCl fertilizers on BD and SMC in two soil textural groups of Tigray, Northern Ethiopia.

2. Materials and Methods

2.1. Site Location and Description. The experiment was carried out in two study sites at Wukro St. Mary's College's farm in Tigray regional state which is 45 km from Mekelle, the capital city of Tigray, and Kallamino-Veterinary College's farm (Mekelle City), Figure 1. The geographical location of Kallamino-Veterinary College's farm is 13° 27′ 283″ N and 39° 27.996′ E with an average altitude of 2161 meters above sea level while Wukro St. Mary's College's farm is 13° 46′ 874″ N and 39° 36.282′ E with an elevation of 2025 meters above sea level.

The climate of the study areas is semiarid with a mean annual rainfall of 400 mm most of which falls in the main/heavy rainy season (locally known as *Kiremt*) and lasts from June to mid-September [25, 26]. Furthermore, the study sites also receive a small rain shower (locally known as *Belg*) from February to May [25, 26]. The monthly mean air temperature throughout the year at the Kallamino-Veterinary

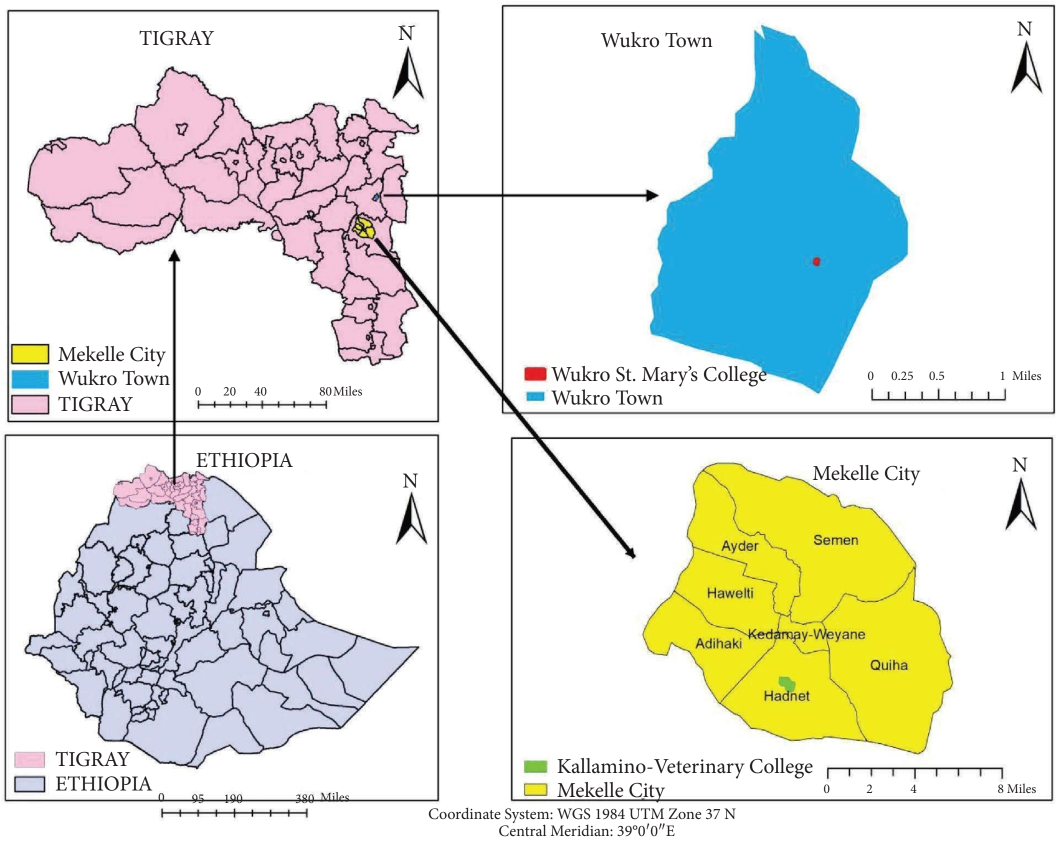

Figure 1: Location map of the study areas.

College site ranges from 9.41°C in December to 27.37°C in May. Similarly, the monthly mean temperature of the Wukro St. Mary's College site ranges from 8.13°C in December to 30.35°C in May.

The soil types of Kallamino-Veterinary and Wukro St. Mary's Colleges are classified as Vertisols and Cambisols, respectively [27]. The textural soil of the experimental sites at Kallamino-Veterinary College was clay loam and at Wukro St. Mary's College, it was loamy sand.

The farming system in both study sites includes both crop and livestock production. Crop rotation at both study sites includes cereals and vegetables. The major cultivated cereal crops are wheat (*Triticum aestivum*), teff (*Eragrostis tef*), finger millet (*Eleusine coracana*), hanfets (*Hordeum vulgare* + *Triticum aestivum*), and barley (*Hordeum vulgare*). Furthermore, major vegetable crops are onion (*Allium cepa*), garlic (*Allium sativum*), cabbage (*Brassica oleracea*), lettuce (*Lactuca sativa*), carrot (*Daucus carota*), and tomato (*Solanum lycopersicum*).

2.2. Experimental Design and Treatments. The experiment was carried out for two consecutive years (2018-2019) arranged in a split-split plot design [28]. The experimental treatments include three factors, namely, compost with two rates (0 and 20 $t{\cdot}ha^{-1}$), blended NPSZn fertilizer with three rates (0, 60, and 120 $kg{\cdot}ha^{-1}$), and potassium chloride fertilizer (KCl) with four rates (0, 120, 210, and 300 $kg{\cdot}ha^{-1}$). The main plot was allocated to compost, the subplot was allocated to blended NPSZn fertilizer, and the sub-subplot was allocated to KCl treatments. The individual experimental sites have 24 treatment combinations replicated three times (Table 1). The plot size was 6 m^2 (2 m $*$ 3 m = 6 m^2), and each block was separated by 1 m with a variation of 0.5 m between plots. The intra and inter-row spacing of onion crops was 10 and 30 cm, respectively.

2.3. Experimental Materials and Procedure. Adama red onion variety was grown as a test crop in both experimental sites and years. The experimental sites were plowed by tractor to a depth of 30 cm which is the most agricultural plow layer [29]. Additionally, the experimental sites were plowed twice by oxen before planting. Lastly, furrow preparation was carried out by daily laborers. The seedlings were raised on nursery beds and transplanted to the experimental plots after 55 days at 10 cm (intra-row) and 30 cm (inter-row) spacing [30].

The amount and frequency of irrigation water applied in both sites were calculated using the Cropwat model [31]. This was done to avoid overirrigation which can lead to water wastage and water logging during excess application and moisture stress during low water application on onion yield. Thus, seedlings were watered to some extent immediately after transplanting uniformly to all the treatments. Hereafter, the seedlings were irrigated every 4 days in sandy

Table 1: Description of the treatments.

Treatment	Treatment description
Control	An experimental plot without any application of compost, NPSZn, and KCl fertilizers
120KCl	120 kg·ha^{-1} of KCl
210KCl	210 kg·ha^{-1} of KCl
300KCl	300 kg·ha^{-1} of KCl
60NPSZn	60 kg·ha^{-1} of NPSZn
60NPSZn + 120KCl	60 kg·ha^{-1} of NPSZn plus 120 kg·ha^{-1} of KCl
60NPSZn + 210KCl	60 kg·ha^{-1} of NPSZn plus 210 kg·ha^{-1} of KCl
60NPSZn + 300KCl	60 kg·ha^{-1} of NPSZn plus 300 kg·ha^{-1} of KCl
120NPSZn	120 kg·ha^{-1} of NPSZn
120NPSZn + 120KCl	120 kg·ha^{-1} of NPSZn plus 120 kg·ha^{-1} of KCl
120NPSZn + 210KCl	120 kg·ha^{-1} of NPSZn plus 210 kg·ha^{-1} of KCl fertilizers
120NPSZn + 300KCl	120 kg·ha^{-1} of NPSZn plus 300 kg·ha^{-1} of KCl fertilizers
20Com	20 t·ha^{-1} of compost
20Com + 120KCl	20 t·ha^{-1} of compost plus 120 kg·ha^{-1} of KCl
20Com + 210KCl	20 t·ha^{-1} of compost plus 210 kg·ha^{-1} of KCl
20Com + 300KCl	20 t·ha^{-1} of compost plus 300 kg·ha^{-1} of KCl
20Com + 60NPSZN	20 t·ha^{-1} of compost plus 60 kg·ha^{-1} NPSZn
20Com + 60NPSZn + 120KCl	20 t·ha^{-1} of compost plus 60 kg·ha^{-1} NPSZn plus 120 kg·ha^{-1} KCl
20Com + 60NPSZn + 210KCl	20 t·ha^{-1} of compost plus 60 kg·ha^{-1} NPSZn plus 210 kg·ha^{-1} KCl
20Com + 60NPSZn + 300KCl	20 t·ha^{-1} of compost plus 60 kg·ha^{-1} NPSZn plus 300 kg·ha^{-1} KCl
20Com + 120NPSZn	20 t·ha^{-1} of compost plus 120 kg·ha^{-1} NPSZn
20Com + 120NPSZn + 120KCl	20 t·ha^{-1} of compost plus 120 kg·ha^{-1} NPSZn plus 120 kg·ha^{-1} KCl
20Com + 120NPSZn + 210KCl	20 t·ha^{-1} of compost plus 120 kg·ha^{-1} NPSZn plus 210 kg·ha^{-1} KCl
20Com + 120NPSZn + 300KCl	20 t·ha^{-1} of compost plus 120 kg·ha^{-1} NPSZn plus 300 kg·ha^{-1} KCl

KCl (kg·ha^{-1}): potassium chloride (K_2O form) fertilizer; NPSZn (kg·ha^{-1}): 17.7N-35.3P2O5-0 + 6.5S + 2.5Zn; +: plus (treatment combinations); Com: compost (t·ha^{-1}).

loam soil and 5 days in clay loam soil for the first month. Subsequently, the plots were irrigated every 5 and 7-day interval in sandy loam and clay loam soils until maturity, respectively. However, when the neck falling stage started which was two weeks prior to harvesting, irrigation ceased and soil dried completely in both sites to promote maturity and keep the quality of onion bulbs.

Compost was prepared in three-month duration mostly from plant-based materials [32]. Materials used during compost preparation include crop residue and leaves (70%); cattle and chicken manure (12%); fresh grass clippings (10%); old compost and forest soil (6%); and tap water and animal urine (2%). It was applied, in the 1st year (2018), a week before transplanting of seedlings to the individual plots so as to mix well with the topsoil and protect nutrient loss by volatilization.

The NPSZn and KCl fertilizers were applied in the banding or side-dressing method. Within this method, NPSZn and KCl fertilizers were positioned in bands beside the furrowed rows during the transplanting of the onion seedlings.

2.4. Data Collection and Measurements. Prior to planting and after the harvest of the onion, soil samples were taken in a diagonal pattern over the trial areas. These samples were collected to determine soil texture, BD, and SMC. A total of 288 soil samples were taken after harvesting from both experimental plots to determine the soil's BD and SMC of the experimental sites. Soil samples used to measure soil texture were air-dried under shade, grounded using a pestle and mortar, and sieved to pass through 2 mm. Consequently, texture analysis was performed using the hydrometer method [33]. Soil samples were thoroughly mixed in water and allowed to settle. Thus, the larger particles (sand) were settled out of the suspension faster than the smaller (silt and clay) particles in less than 1 minute. Sequentially, all the silt was settled in about 6 hours. The clay took a day to settle. Then, the percentage of the particle size distribution against the total dry weight was computed. Finally, the USDA soil texture class's triangle was used to classify the soil textural groups [34]. Moreover, undisturbed soil samples were collected to determine BD at 0–5 cm soil depth using a soil core sampler with a volume size of 100 cubic centimeters and calculated using equation (1) after the soil samples were oven-dried [35]. Soil samples were taken from each plot using an auger at 0–30 cm to determine the SMC. The gravimetric water content method was used to determine the SMC [36]. Soils were sampled, put into the container, weighed in the sampled (moist) condition, oven-dried, and weighed again after drying. Drying was done at 105°C until the soil samples were constant. Then, the mass of water content was obtained from the weight difference between wet and oven-dried samples divided by the mass of oven-dried soil and calculated according to equation (2) [36]. Finally, the volumetric soil moisture content (wet-based) was found from the mass of water multiplying by bulk density.

$$\mathrm{BD}\left(\mathrm{g\ cm}^{-3}\right) = \frac{M_s}{V_t}, \quad (1)$$

where M_s is the mass of dry soil (g) and V_t: is the total volume of the soil sample (cm^3).

$$\mathrm{SMC}\,(\%) = \frac{M_2 - M_3}{M_3 - M_1} \times 100, \quad (2)$$

where SMC is gravimetric soil moisture content, W_1 is the weight of a soil core (g), W_2 is the weight of the fresh soil sample with a core (g), and W_3 is the weight of the dry soil at 105°C with a core (g).

2.5. Data Analysis. The impact of compost, NPSZn, and KCl fertilizers on BD and SMC was statistically tested. Analysis of variance (ANOVA) was carried out using Gen Stat 18th Edition [37]. For variables showing statistically significant differences between treatments ($p < 0.05$), further analysis of mean separation was carried out using Duncan's Multiple Range Test (DMRT) at 5% probability.

3. Results

Prior to planting and applications of compost, NPSZn, and KCl fertilizers, the experiment showed that the Kallamino-Veterinary College contained 30% sand, 34% silt, and 36% clay, whereas the Wukro St. Mary's College had 78% sand, 16% silt, and 6% clay at a depth of 0–30 cm. According to the USDA soil textural triangle classifications, Kallamino-Veterinary and Wukro St. Mary's Colleges had clay loam and loamy sand soil textures, respectively [34]. Additionally, the bulk densities of the experimental sites were 1.35 g·cm^{-3} at Kallamino-Veterinary and 1.69 g·cm^{-3} at Wukro St. Mary's Colleges. According to the classifications of BD developed by Hazelton and Murphy, these were grouped under moderate and high rating scales [38]. Likewise, Kallamino-Veterinary and Wukro St. Mary's Colleges had 19.17% and 10.97% of gravimetric soil moisture contents, respectively. As per the SMC classifications developed by Lee and Pradhan, these were grouped under dry and very dry conditions, respectively [39].

3.1. Effect on Soil Bulk Density. Soil bulk density (BD) was significantly affected by the treatments in clay loam textural soil in both years (Figure 2). The lowest BD was found in plots treated with 20 t·ha^{-1} of compost combined with 120 kg·ha^{-1} of NPSZn and 300 kg·ha^{-1} of KCl. A significantly higher reduction of BD by 6% in 2018 and 8% in 2019 kg·ha^{-1} was observed in plots treated with compost combined with the highest rates of NPSZn and KCl as compared to the other treatments in clay loam soil.

Similar to the clay loam textural soil, BD was significantly affected by the treatments in loamy sand textural soil in both years (Figure 3). The lowest BD was found in plots treated with 20 t·ha^{-1} of compost combined with 120 kg·ha^{-1} of NPSZn and 300 kg·ha^{-1} of KCl. A significantly higher reduction of BD by 11% in 2018 and 12% in 2019 kg·ha^{-1} was observed in plots treated with compost combined with the highest rates of NPSZn and KCl as compared to the other treatments in loamy sand soil.

3.2. Effect on Soil Moisture Content. Sole and combined application of compost, NPSZn, and KCl fertilizers influenced the volumetric soil moisture content (SMC) in both soil textural groups (Figure 4). The highest amount of volumetric SMC (21% in 2018 and 2019) was recorded in plots treated with compost and compost combined with the smallest rates of KCl as compared to all treatments in clay loam soils. Likewise, volumetric SMC (12% in 2018 and 11% in 2019) in plots treated with compost fertilization was higher as compared to all treatments in loamy sand soils.

Similarly, the lowest volumetric SMC (19% in 2018 and 2019) was recorded in plots treated with 120 kg·ha^{-1} of NPSZn and 300 kg·ha^{-1} of KCl in clay loam soil textural soils. As a result, increased inorganic fertilization decreased SMC in Kallamino-Veterinary College's farm characterized by clay loam textural soils. Equally, the control (non-fertilized) had higher SMC (10% in 2018 and 9%) than plots treated with sole and combined application of NPSZn and KCl in loamy sand textural soils. Thus, the lowest volumetric SMC (10% in 2018 and 8% in 2019) was recorded in plots treated with 120 kg·ha^{-1} of NPSZn and 300 kg·ha^{-1} of KCl. Consequently, increased inorganic fertilization rates decreased SMC in Wukro St. Mary's College's farm characterized by loamy sand textural soils (Figure 5).

4. Discussion

The influence of the treatments that decreased BD (Figures 2 and 3) could be due to the addition of root and plant biomass and the conversion of some soil micropores into macropores in both sites. This conversion might be because of the cementing action of the organic acids and polysaccharides which are formed during the decomposition of organic residues by higher microbial activities [40]. This indicated that organic soil amendments and their combination with inorganic fertilizer inputs have a great role in reducing soil BD in clay loam and loamy sand soils. Though BD reduction was considerably observed in plots treated with sole and combined applications of compost, NPSZn, and KCl fertilizers, its highest reduction was observed in plots treated with 20 t·ha^{-1} of compost combined with 120 kg·ha^{-1} of NPSZn and 300 kg·ha^{-1} of KCl in both research terms and sites (Figures 2 and 3). This could be due to that compost mainly contributed to higher organic matter content of the soil because of higher microbial activities which leads to better aggregation of soil. This result is in line with the findings of Tripathi et al. [41] and Pant and Ram [42]. They found out that the application of farmyard manure along with inorganic fertilizers decreases the BD of soil. This result also corroborates with the findings of Mandal et al. [43] and Wang et al. [44]. They reported that soil bulk density significantly decreased with the addition of organic matter. Lower BD values in clay loam soils at fertilized treatments were reported also by Kroulík et al. [45]. Reduction in BD when incorporating compost into clay and loam soils was also reported [42]. Lower BD values in sandy loam soil that fertilized treatments were also reported [24]. They found out that loamy sand and sandy loam soils had reduced their BD post-compost and inorganic fertilizer application.

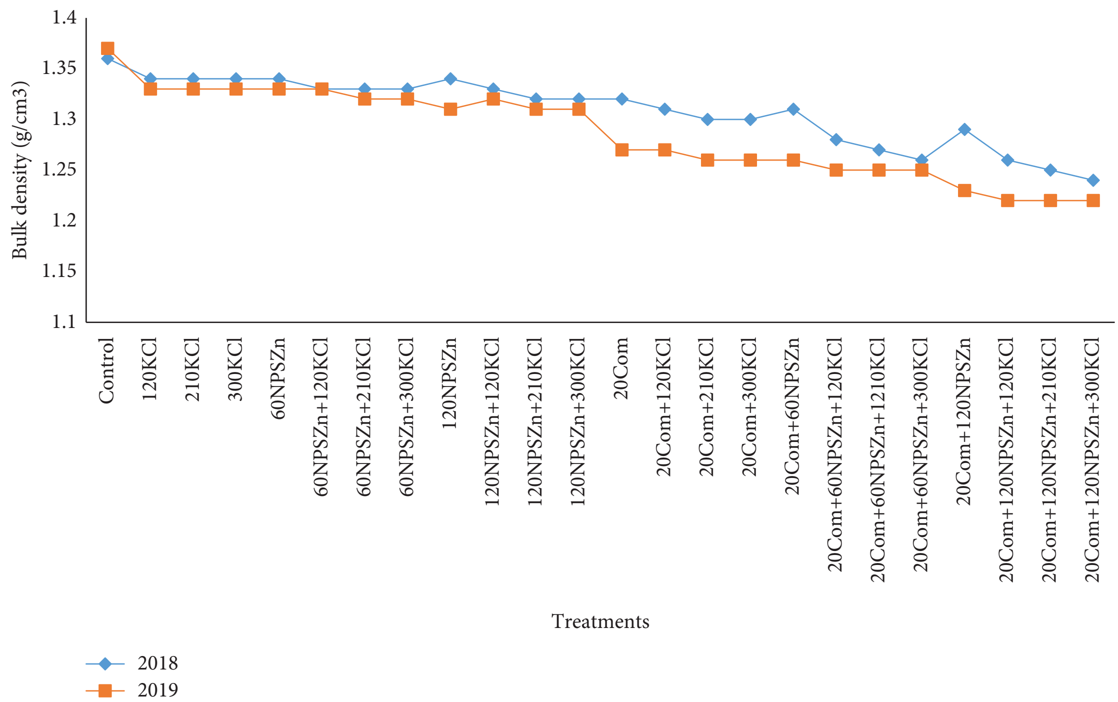

Figure 2: Effects of different rates of compost (Com), blended (NPSZn), and potassium chloride (KCl) fertilizers on soil bulk density in two consecutive years under clay loam soil.

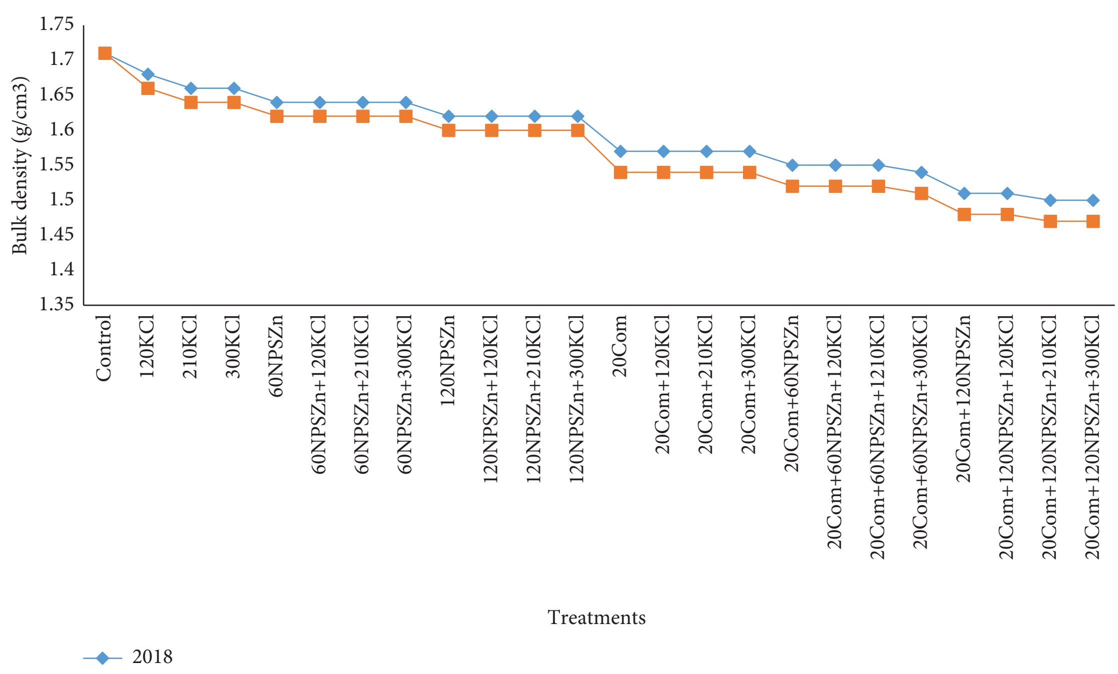

Figure 3: Effects of different rates of compost (Com), blended (NPSZn), and potassium chloride (KCl) fertilizers on soil bulk density in two consecutive years under loamy sand soil.

Sole and combined application of compost enhances significantly ($p < 0.05$) volumetric soil moisture content (SMC) in clay loam soil (Figure 4). The highest volumetric SMC (21% in 2018 and 2019) was obtained in plots treated with compost and compost combined with the lowest rate of KCl fertilizers. This could be due to that compost application immediately enhances SMC in clay loam soil as compared to NPSZn and KCl fertilizer applications. Application of

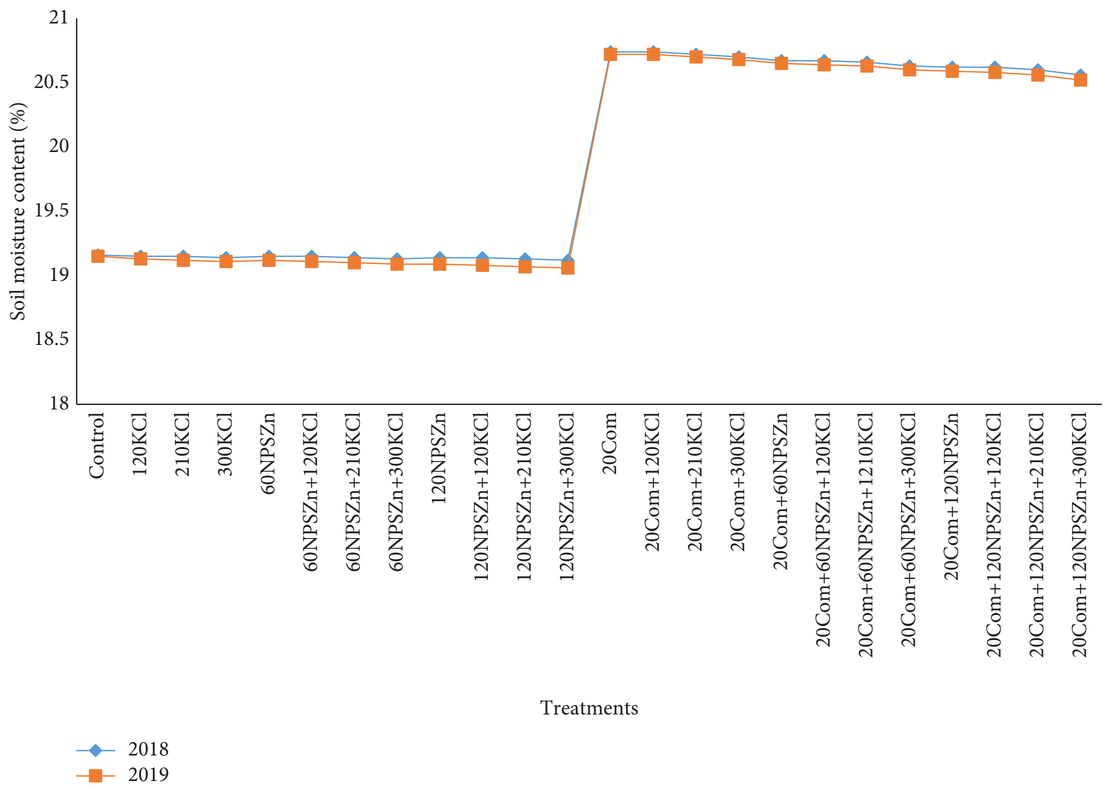

Figure 4: Effects of different rates of compost (Com), blended (NPSZn), and potassium chloride (KCl) fertilizers on soil moisture content in two consecutive years under clay loam soil.

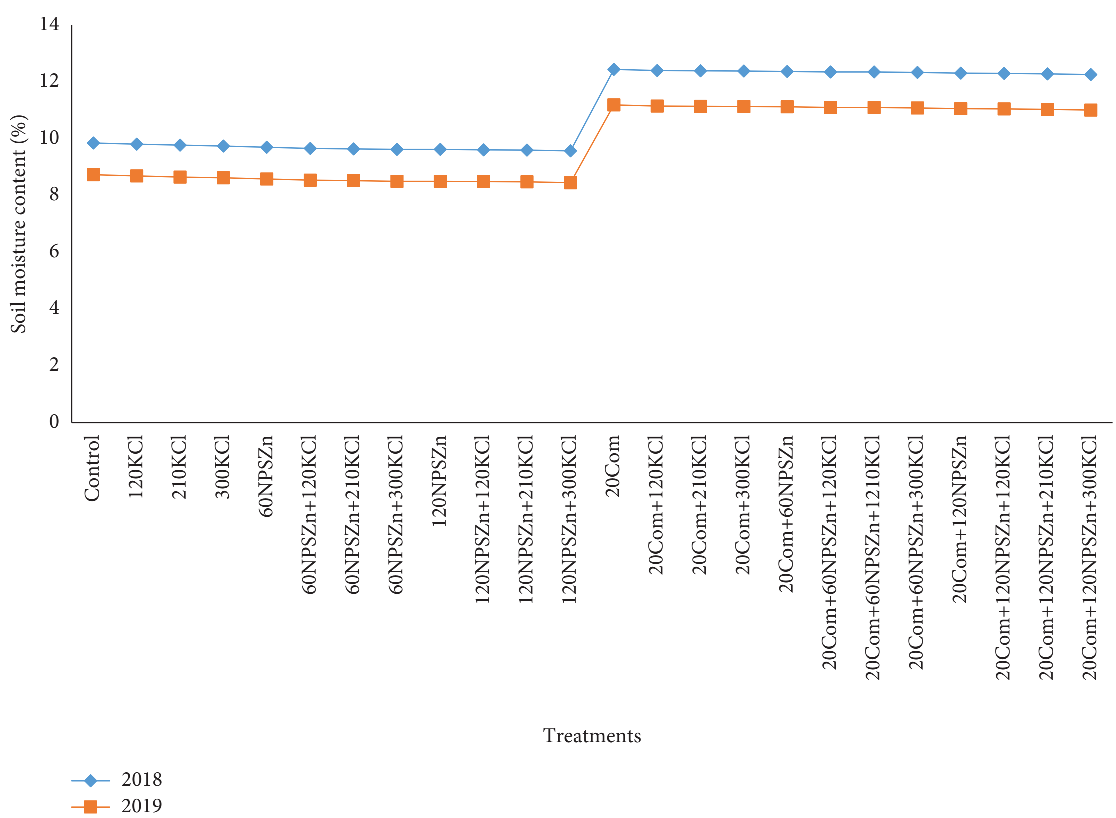

Figure 5: Effects of different rates of compost (Com), blended (NPSZn), and potassium chloride (KCl) fertilizers on soil moisture content in two consecutive years under loamy sand soil.

inorganic fertilizer might increase root biomass; however, decomposition of the root biomass might take a longer time to reflect its benefits on enhancing SMC. This result was in line with the findings of Kroulík et al. [45] who found out that application of compost increases the amount of organic matter in soil which has a long-lasting beneficial effect on infiltration and water retention in the clay loam soil. Ouattara et al. [46] proposed also that organic matter input significantly improved soil water content. This result was also in agreement with the findings of Aggelides and Londra [47]. These authors found that water retention was increased with higher compost rates in both clay and loam textural soils due to the effects of compost on soil pore spaces. Likewise, the nonfertilized treatment had higher SMC than in plots treated with sole and combined application of NPSZn and KCl. As compared to all treatments, the lowest volumetric SMC (19% in 2018 and 2019) was observed in plots treated with 120 kg·ha^{-1} of NPSZn combined with 300 kg·ha^{-1} of KCl. Generally, the experimental results (Figure 4) showed that increased inorganic fertilization decreased SMC in Kallamino-Veterinary College's farm characterized by clay loam soil. This result is also in line with the findings of Song et al. [48] who reported that nonfertilized treatment had higher soil water content than the fertilized ones under clay loam soil.

Similarly, sole and combined application of compost enhances significant ($p < 0.05$) volumetric SMC in loamy sand soil (Figure 5) compared to all treatments. However, the highest volumetric SMC (12% in 2018 and 11% in 2019) was obtained in plots treated with 20 t·ha^{-1} of compost. This could be because the application of compost reduced erosion, runoff, and infiltration rate which enhances the water-holding capacity of the loamy sand soil. This result is in line with the findings of Aranyos et al. [49, 50]. They found that the runoff and water erosion on sandy soil were significantly reduced by the compost application. Badalíková and Bartlová [51] found out within the study period that the application of the higher compost doses showed a positive effect on infiltration rate in loamy sand and sandy loam soils. Schmid et al. [52] also reported that the addition of compost resulted in an increase in water content compared to the control. Likewise, the nonfertilized treatment had higher SMC than plots treated with sole and combined application of NPSZn and KCl. As compared to all treatments, the lowest volumetric SMC (10% in 2018 and 8% in 2019) was observed in plots treated with 120 kg·ha^{-1} of NPSZn combined with 300 kg·ha^{-1} of KCl. Generally, the experimental results (Figure 5) showed that increased inorganic fertilization rates decreased SMC in Wukro St. Mary's College's farm characterized by loamy sand soil. This result was in line with the findings of Song et al. [48] who reported that nonfertilized treatments had higher soil water content than fertilized ones.

5. Conclusions

This research demonstrated that sole and combined application of compost, NPSZn, and KCl fertilizers considerably reduced the BD compared to the control in both soil textural groups and years. However, higher reduction of BD in clay loam (1.24 g·cm^{-3} in 2018 and 1.22 g·cm^{-3} in 2019) and loamy sand (1.5 g·cm^{-3} in 2018 and 1.47 g·cm^{-3} in 2019) soils was observed in plots treated with compost combined with the highest rates of NPSZn and KCl compared to all treatments. Additionally, the experiment showed a higher degree of BD with more sand content while a considerably lower degree of BD with more clay content in soil samples. Likewise, soil moisture content was considerably influenced by the short-term effects of the sole and combined applications of compost, NPSZn, and KCl fertilizer rates in both years (2018 and 2019) and cropping seasons in both study areas. However, the highest volumetric SMC in clay loam soil (21% in 2018 and 2019) and loamy sand (12% in 2018 and 11% in 2019) soils was observed in plots treated with compost compared to all treatments. Similarly, the lowest volumetric SMC in clay loam (19% in 2018 and 2019) and loamy sand (10% in 2018 and 9% in 2019) textural soils was recorded in plots treated with the highest rates of NPSZn combined with KCl fertilizers compared to all treatments. Thus, it can be concluded that SMC and BD can be improved through compost and compost combined with NPSZn and KCl inputs, respectively, in the drylands of Northern Ethiopia.

Data Availability

The data used to support the findings this study are available upon request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

All the authors considerably contributed to this article. Material preparation, data collection, analysis, interpretation, and preparation of the first version of the manuscript were carried out by Kelali Haftu. Tesfay Araya, Mitiku Haile, and Kassa Teka designed, coordinated, and conceived the study and reviewed and edited the manuscript. All the authors also revised and commented on the manuscript. Finally, all the authors have read and approved the ultimate manuscript.

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