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Effects of Brewery Beer Bio-sludge and Liquid Bio-fertilizer on Performance of the Malt Barley Yield, Grain Quality and Soil Fertility at Arsi and West Arsi Zone, 2017 Ethiopia

Aschalew Sisay[1*], Tarekegn Garomsa[2], Lemmi Legesse[3]

[1,3]EUCORD, CREATE Project, P.O. Box 15526 A.A, Ethiopia*
[2]Heineken Brewery Share Company, P.O. Box 15526 A.A, Ethiopia

Corresponding Email: [1]aadmassu@eucord.org*

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Abstract:** This study was conducted to investigate the effects of beer bio-sludge, liquid bio-fertilizer and inorganic fertilizer application to barley (Hordeum vulgare L.) var. traveler on the plant performance, grain quality and some soil properties. Treatments applied were: (1) Beer Bio-Sludge (BBS) (2) Liquid Bio-Fertilizer (LBF) (3) Chemical Fertilizer (CHF) (4) No Fertilizer (Control). The experiment was laid-out in simple plot design and randomized over locations. The plot sizes were 10m x 10m = 100m^2. Phonologic, diseases, agronomic and yield, data were collected. Grain quality, sludge, liquid fertilizer and soil analysis were done. Sample sizes of ten plants/plot were used for agronomic data i.e., for plant height, panicle length, number of tiller and spikelet/panicle. Yield and yield related data; Thousand Kernel Weight (TKW), Straw Weight (STW) and Yield (YLD) were collected from 1m x 1m = 1m^2 plot size. Significantly ($p<0.05\%$) higher thousand kernel weight (51.63g), straw weight (1145 kg ha^1) and grain yield (70.34 qt ha^1) were obtained from soil applied with BBS and followed by LBF (50.25g, 1035kg ha^1 and 65.08 qt ha^1). Beer bio-sludge increased the yield of barley by (2.2, 4.12 and 9.17%) over that of LBF, CHF and Control, respectively. The linear correlation analysis indicated that, seed yield of malt barley had a positive and significant correlation with most of growth parameters and yield. The soil analysis result revealed that, soil in the two locations were in silt-clay textural classification and moderately acidic ranging from 5.53 to 5.53. Similarly, BBS improved soil chemical (acidity) and physical properties (textural classes) as compared to inorganic and non-fertilizer. The BBS treated soil showed higher value for some of major and secondary soil elements namely; available phosphors (17.11mg/kg (ppm)), potassium (553.22mg/kg (ppm)) calcium (2,499.01mg/kg (ppm)), magnesium (277.33 mm/kg(ppm), Sulfur (16.93mg/kg(ppm), high total nitrogen (0.32%), organic carbon (4.42%) and Cation Exchange Capacity (CEC) (32.01Meq/100g soil) as compared to others treatments. There was no effects of BBS treated soil on heavy metals concentration such as, Cu, Mo, Ni, Zn,

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Pb, Cd and Hg is comparably in accepted international standard ranges. H/ever, Nitrogen Percentage (14.80 and 12.00%), respectively in grain were little higher than the standard (≤12%) in both BBS and untreated soil (control). In this study one can concluded that, the beer bio-sludge can improve both the physical & chemical properties of soil. Hence, BBS can serve as one of the best source of bio-fertilizers in the study areas and areas with similar agro-ecology zones.

Keywords: Beer Bio-Sludge, Liquid Bio-Fertilizer, Inorganic Fertilize, Heavy Metals and Protein Content and Barley.

1. INTRODUCTION

Application of sludge to agricultural soil is widely practiced means of soil inexpensive waste disposal and improvement land reclamation, soil physical properties and nutrient status. Most sewage wastes contain valuable nutrients that could be used to improve soil fertility. Agricultural practices often leads to a gradual decrease in soil organic matter content, with the consequent decrease of soil fertility through an impoverishment of the physical, chemical and biological properties of soils (Perucci *et al*., 1997).

Bio-sludge is among the useful byproducts of the breweries, by-products are (spent grains, excess yeast and sludge) from the waste water treatment plant at different stages of the manufacturing process. Bio Sludge's are usually rich in organic matter and essential nutrients. As a result, they have great potential for use as fertilizers and soil conditioners, and when they meet the necessary requirements concerning the concentration of heavy metals and pathogens, can replace part or all of mineral fertilizers (Silva *et al.,* 2002).

Because, research revealed that, sludge contain considerable amounts of heavy metals that persist in the soil long after application as well as contamination with enteric pathogens and parasites (Juste and Mench, 1992). There are scientific evidences of increase in productivity of different crops with the application of sludge (Silva *et al.*, 2002; Basta *et al.*, 2005; Bjuhr, 2007). According Bjuhr (2007), the benefits of application of bio-solids can exceed those achieved with mineral fertilizers, especially in terms of productivity and economy with fertilizers, mainly nitrogen (N) and in some cases phosphorus (P) and metallic ions like calcium (Ca) and magnesium (Mg). In line with this, (Yohannes Gelan, 2011) reported an increment in maize crop yield from 2.70 t ha-1 in the control plot to 5.23 t ha-1 with the application of 8 t ha-1 of sludge of textile factory in Kombolcha town area, northern Ethiopia. However, studies on the viability of brewery sludge from industries for agricultural use are few and specific for certain industrial by-products such as tannery and coal (Korboulewsky *et al.,* 2002; Ferreira *et al.,* 2003).

Nevertheless, brewery sludge wastes are diverse, with characteristics that vary according to the raw materials and manufacturing processes/processing systems followed, Ferreira *et al.,* (2003). The Author added that, these justify the need for investigating utilization of this by-products by small holding malt barley producers, and determine the nutrient improvements for soil fertility, determining the levels of hard metal found in the products and, the

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contribution towards crop agronomic performances and yield and yield components of malt barley.

The current daily sludge production of the Harar, Kilinto, Bedele and other Breweries in Ethiopia has increased significantly along with the expansion and increase in its beer production. It is therefore inevitable to focus on the development of appropriate brewery sludge waste management strategy and management plan that enables to reutilize the industrial liquid waste for other purposes in an environmentally friendly manner. One way of reutilizing such byproducts is application on cultivated lands as fertilizer for improvements of soil fertility and Alemu *et al.*, 2017 *in* crop production which is also a common practice in many countries. This practice stands out as a way to reduce soil fertility depletion and input cost for smallholder farmers. This also avoids final destination options such as incineration and disposal in landfills that involve higher production costs on the factory and greater impact on the environment (Abdousalam, 2010).

The fact that malt barley is the major crop cultivated in Arsi and West Arsi zones using inorganic fertilizers for the decades or in some place they used growing barley following cereal like wheat that have exacerbated the process of soil fertility depletion. Research indicated that in east Hararghe some farmers in the region have already started using the brewery sludge of the Harar Beer factory as a fertilizer input for crop production for sorghum, Alemu *et al.*, 2017. However, there is no scientific study carried out yet to investigate the impact of brewery waste sludge on malt barley production, grain quality and soil fertility in the areas. Keeping this in view, the present study was planned to investigate the impact of brewery waste sludge as bio-sludge/organic fertilizer on malt barley yield components, yield and grain quality and soil fertility.

2. MATERIALS AND METHODS

Descriptions of the study area:
The study was conducted in potential barley growing areas of Arsi and West Arsi zones, during the main cropping season from June to Nov 2017 cropping season under rain-fed conditions. The areas were located in southern Eastern parts of Ethiopia at a radius of between 26-75km from the zonal town Assela and 23 to 105km from the zonal town Shashamane. Geographically, the study areas were located at 7^{o} 57N 39^{0}'7E 'longitude for Assela and 7^{o} 57N, 38^{0} 6E for Shashamane at an altitude ranging from 2200 and 2800 meters above sea level. The average annual rainfall is 800 to 1200 mm and its distribution pattern is uni- modal and bimodal in some of the area. The rainy period covered from April to Nov. It has a cold climate with mean minimum, mean maximum and average temperatures of 8.58^{o}C, 21.61^{o}C and 15.08^{o}C and 11.2^{o}C, 23.12^{o}C and 18.23^{o}C, respectively for Arsi and West Arsi zones (Zonal BoA, 2017). The soil tested result from the two location showed that, is more of acidic in nature and silty-clay in classification, table 1.

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Soil properties:

Table 1: The Physico-chemical properties of the soil in the study areas

Physical proprieties	Units	West Arsi	Arsi
Sand	%	20	18
Silt	%	40	42
Clay	%	40	40
Textural Class	-	Silt-clay	Silt-clay
Chemical Properties	Units		
pH	--	5.26	4.92
Available N	%	0.28	0.32
Available P	ppm	10.56	15.52

pH =measuring of the level of soil acidity and alkalinity (0-14) and ppm= parts per meter

Experimental Materials and Procedures:

Treatments and Experimental Design: The experiment consisted of four treatments; a) Brewery Bio-Sludge (BBS) collected from 'Heineken Brewery S.C',(Kilinto Beer factory) applied at the rate of 15t ha[1], b) Liquid Bio-Fertilizer (LBF) collected from 'Eco-green liquid fertilizer factory' and applied at the rate of 200lt/ha but spilt, and c) Recommended rate of NP or mineral fertilizer: N (46 kg N ha-1) and P (48 kg P2O5 ha-1) (CHF) and d) No fertilizer (Control). The experiment was laid out in a single randomized design replicated over two zones and four districts of Arsi and West Arsi zones. Malt barley variety "traveler' or locally named as 'Waliya' was planted at a plot size of 10 m x 10 m (100 m^2) in rows inter space of 20cm and drilled.

BBS was applied two weeks before planting and incorporated into the plow depth of (2-5cm). Half of LBF was applied right after crop emerged from (21 to 26) days as suggested by ZadoK *et al*., 1974, as foliar application and the second half was applied one month after the first application at forty five (45) days (ZadoK *et al*, 1974 cereal growth stage). Half of the Nitrogen (N) and the full rate of the Phosphorus (P) fertilizers on the plots of the fertilized treatments were applied right during sawing. The second half of the N fertilizer was applied 25 to 35th days after crop emerged at basal application nearly 3-5 cm away from the plant as two side dressing at about 5 cm below the surface.

Crop management: These practices were conducted in two phases, the 1st phase was conducted between '25 to 35' to prevent pest occurrence and the second was done between '45 to 55'days for pest minimization or if at all occurred to keep the crop free of any barley pests. Barley pests are; barley insect, weeds and foliar diseases. Accordingly, Rex-dio (Fungicide) was used twice at the rate 05lt/ha to control of scald (*Rhncosporium scalis*) and spot and net blotch (*Helmonthosporium spps*). Similarly, Axial-1 (Herbicides) was used twice at the rate of 1lts/ha for the control of both grassy and broad leaved weedy species.

Harvesting and threshing: Malt barley was harvested right after the crop attained 90% physiological maturity. The crops were harvested manually at the base of the crop using sickle and threshed manually on a separate materials.

Data Collections: Soil sample was collected from the depth of 30cm 'barley root zone' using soil auger before planting and after harvesting from all plots. Phonological (days to 50% heading and 90% physiological maturity), growth parameters; tiller capacity (TC), plant height (PHT) data were recorded from ten central rows and randomly selected barley plants,

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whereas the plant population (PP), yield and yield components data were collected using quadrat (1mx1m=1m^2) area and diseases data record was taken from the entire fields using (1-9 scale) as suggested by Prescott, *et al.*, 1986, for foliar disease severity.
Procedurally, days to 50% heading and 90 % physiological maturity of barley were taken when 50% and 90% of the plant reached their respective heading and physiological maturity stages. Total straw weight (biomass) determination was done, using the above ground entire plants by sun drying of the sampled plants to the 70 ^{0}C. Thousand seed weight (TKW) of barley was counted and weighted from the bulk of the seeds of barley at 13.5% moisture level and measured in gram basis using sensitive balance.

Grain yield was taken after harvesting from the (1mx1m=1m^2) quadrat from randomly and diagonally thrown quadrat. Seed yield was adjusted to 13.5% moisture after the seed moisture was measured using moisture tester (Dickey-john) and used the following formula for the yield adjustments.

$$\text{Adj. Seed yield (kg/ha)} = \frac{\text{100-Actu.M\%}}{\text{100-stan. M\%}} \times \frac{\text{S. yield (g/plot)} \times 10}{\text{plot size (m}^2\text{)}}$$

Soil analysis was conducted at Horticoop Ethiopia (Horticulture) PLC Soil and Water Analysis Laboratory found at Bishoftu Ethiopia, using standard procedures as indicated on the attached appendix 3. The Ethiopian, Public Health Institute was conducted malt barley grain analysis.

Statistical Analysis: The data analysis was carried out using statistical package and procedures out lined by 'General Linear model' using SAS version 9.0 software (SAS Institute Inc. 2002). Square root transformation was used to make the assumption of normality scales and then to stabilized the variances for given data especially scale data and count data. Mean separation was computed using 'Least Significance Difference' (LSD) at 5% and 1% probability level. One ANOVA was used for the crop data analysis. The result was presented for each treatments over the treatments and locations.

3. RESULT AND DISCUSSION

Phonological Parameters: The analyses data were presented in table 2 and 4, respectively. Significant (P<0.05) variations were observed on days to 50% heading and days to 90% physiological maturity due to treatments effects. This result agreed with different studies, M. Carmen Antolı´n (2005), found that days to 50% heading and 90% physiological maturity of barley were prolonged by using organic fertilizers. This might be associated with organic fertilizer that releases different nutrients till to end plants received organic fertilizer were remain green. The shortest number of 50% heading and 90% physiological maturity days of (79 and 87.57) and (149.87 and 150) were recorded from soil treated with no fertilizer and CHF respectively. On the contrary, longer 50% heading and 90% physiological maturity (93.58 and 92.62) and (154.60 and 152.60) days recoded for the BBS and LBF respectively, which might help to have a longer time for grain filling and physiologically matured. Thus, in the present study it is hardly possible to say the days to 50% heading and 90% physiological maturity were significant affected due to the treatments.

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The mean values for days to 50% of heading and 90% maturity were (88.20 and 151.76) days across the treatments and locations. The days to 50% heading and 90% physiological maturity were ranging from (79-93.58 and 149.87 - 154.60) days. This days to 90% physiological maturity was relatively late by two weeks (18days) as compared to last year result (132 to 154). This might be resulted from organic bio-fertilized soil, which had significant contribution to late maturity, as increased some of the growth parameters, such as (tillers, leafs and plant heights) that might prolong the physiological maturity of the crop, as stated by M. Carmen *et.al.*, 2005.

Table 2: Mean performance of days to heading (DH) and DM (days to maturity) of barley as influenced by BBS (beer bio-sludge), LBF (liquid bio-fertilizer) and CHF (chemical fertilizer) fertilizers at Arsi and west arsi zone, 2017 cropping season

Treatments	DH	DM
Beer Bio-Sludge (BBS)	93.58^{a}	154.60^{a}
Liquid Bio-Fertilizer (LBF)	92.62^{a}	152.60^{a}
Chemical Fertilizer (CHF)	87.57^{ab}	150.00^{ab}
Zero Fertilizer (Control)	79.00^{b}	149.87^{c}
Mean	88.20	151.76
CV	13.50	4.64
EMS	6.52	7.05

DH = days to heading DM= days to maturity, CV = Coefficient of Variance, EMS= Error Mean Square, and figures followed the same alphabet shows no significant differences.

Growth Parameters: The analysis of variance revealed statistically significant ($P<0.05$) difference in plant height due to treatments applications (Table 3). The maximum plant height (84.56cm) was recorded from soil applied with beer bio-sludge and followed by liquid organic fertilizer (80.19cm). The least plant height (71.70cm) was recorded from the soil treated with inorganic fertilizer. The result revealed that, bio-fertilizer treated soil increase plant height by 3.73% and 12.93%, respectively as compared to the chemical fertilizer and no fertilizer treated plots. The mean plant height was 76.94cm. This increment in plant height might be resulted from the beer sludge which might increase and improve cell elongation and cell division as a result of application of brewery sludge that enhanced availability of essential nutrients for the growing plants. Similar findings, revealed that application of beer sludge at the rate of 2.5t/ha increased plant height to some extent and then no significant difference observed if applied more than this rate, Alemu, *et.al.* 2017. Similarly, Olowu R. A *et.al. 2012* revealed that beer sludge is a rich source of organic matter and nutrients that have greater contribution to plant growth.

Similarly, ANOVA result reviled that, plant population from ($1m x 1m = 1m^2$) showed significant ($P<0.05$) variation between soil treated with fertilizers (organic and inorganic) and no fertilizer applied soil, (table 3). No significant variation of plant population per plots were observed between soils treated either of fertilizers (organic and inorganic). The maximum plant population of (275, 269.1 and 265.37), respectively were recorded from soil treated with beer bio-sludge, liquid bio-fertilizer and inorganic fertilizer. The least plant population

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of (250.75) was obtained from no fertilizer/control plots and the mean of plant populations were 265 which less by 55 plants/m^2 from standard plant population/m^2 ~ 320 pp/m2.

Productive number of tillers per plant showed significant difference (p<0.05%) between the treatments. The highest number of productive tillers per plant (17.13) still recoded from the BBS applied plot and followed LBF (16.50) as compared to the standard check CHF (14.80). The least number of tiller (12.37) was from no fertilizer applied plot. The mean number productive tillers per plant for traveler in all tested location was 15.22. The best reason for and the best quality of this varieties is its tiller capacity which attributed to the yield increment, The more the number of tillers, the better the stand of crop, which ultimately increase the yield (Jamawal and Bhagat, 2004). The probable reasons for the significance variation of number of productive tiller rise from high level of micro and macro nutrients level found in the beer bio-sludge, that might contributed for the increasing of number of productive tillers. Similar research findings revealed that, high level of both soil nutrients will increases productive tiller of food barley, (Wakene, *et al* (2001).

Traveler is peculiar in its spike length and completely different from other local varieties, this is one the best quality character for the variety, which had directly attachment with yielding potential. Since the arrival of the variety, constant spike length recoded was obtained from time to time from the varieties i.e., (9 to 12cm), this is to mean that the spike length, will contributed to a significant level of number of seed per plant, which had direct relation with yield potentiality.

The study revealed that, there was significant differences of spike length (cm) and number of seed per spike at (P<0.05%) among the treatments. Maximum spike length and number of seed per spike (9.01cm and 29.06), respectively were obtained from plot treated with BBS and followed by plots treated with LBF (8.62cm and 27.76). However, still there was significant effect on the growth parameters of the barely due to the two organic fertilizers (beer bio-sludge and liquid bio-fertilizer) over the inorganic and no fertilizer applied plot. CHF and zero fertilizers treated soil is less by (3.52 and 12.59%) of spike length and (3.00 and 10.17%) of number of seed per spike. In other hand, the BBS increased spike length and number of seeds per spike by (3.52 and 3.00%) as compared to inorganic and similarly by (12.59 and 10.17%) over the zero fertilized soil. Similar study, but on sorghum, Nano, *et al* 2017 revealed that, the ear length and number of seed per ear of sorghum increased for soil treated with organic as compared to inorganic and zero fertilized soil.

Yield and Total Biomass: Grain yield of barley in the present study, was highly significantly affected (P<0.01) by the application of BBS as compared to other soil fertilizer, which gave the highest yield of (70.34qt ha-1) (table 3), which was by far better than the other fertilizers sources. The percent yield (qt/ha) difference obtained from BBS treated soil was more by (2.2, 4.12 and 9.17%), respectively over the yield obtained from soil treated with LBF, CHF and no fertilizer applied soil respectively. On the other hand, yield obtained from soil treated with LBF, CHF and no fertilizer applied were less far by (2.2, 4.12 and 9.17%), respectively than the yield obtained from soil treated with BBS. Oudeh (2002) and AlZoubi *et al*. (2008) reported that BBS applications, increased crop productivity. Alike some studies have shown a

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high yield after BBS application, because it's content of macro/ micro nutrients (Barriquelo *et al*., 2003; Arslan *et al.*, 2007). Also, (Berti and Jacobs, 1996) reported BBS may be used in agriculture for increasing crops yield.

The next, maximum yield (qt ha^{1}) of (65.08qt ha^{1}) was recorded from the soil treated with LBF and followed by CHF treated soil (60.31qt ha^{1}) which was similar to the overall mean yield (60.93qt ha^{1}). Grain yield of traveler is higher on soil treated with fertilizers as compared to no fertilizer treated soil. However, still the variety can withstand stresses (with no fertilizer) and gave comparable yield which shows the adaptability and tolerant level of variety to different ecological stresses.

The result of analysis indicated that, a significant ($P<0.05$) variation observed for both thousand kernel weight (TKW) and total straw yield among treatments (SWT) (table 3). Soil treated with BBS resulted with a significant variation on thousand kernel weight and total straw weight of (51.63g and 1145kg ha^{1}) over the other soil treatments. Still figures showed that, there was a significant variations among soil treated with either of the fertilizer (organic and inorganic) as compared to the zero fertilized soil. Nevertheless, no significant variations were observed on TKW and SWT (50.25g and 48.25g) and (1035.25 and 954.13 kg ha^{1}) between LBF and CHF treated soil. The mean values of (49.22g and 1000.84kg ha^{1}), respectively recoded for thousand kernel weight and total straw weight.

Table 3: Mean performance of plant height, tiller capacity, spike length, number of spike pre plant, thousand kernel weight, straw weight, and yield of barley as influenced by BBS, LFS and CHF fertilizers at Arsi and west arsi zone, 2017 cropping season

Treatments	PH (cm)	No. of TC	SL (cm)	NSPS	TKW (g)	SWT (kg)	YLD (Qt) & % diff
Beer Bio-Sludge	84.56^{a}	17.13^{a}	9.01^{a}	29.06^{a}	51.63^{a}	1145^{a}	70.34^{a} -
Liquid Bio-Fert.	80.19^{a}	16.50^{a}	8.62^{ab}	27.76^{b}	50.75^{ab}	1035.25^{ab}	65.08^{b} (2.2)
Chemical Fertilizer	79.30^{ab}	14.80^{ab}	8.51^{ab}	27.58^{b}	48.25^{ab}	954.13^{ab}	60.31^{c} (4.12)
Zero Fertilizer	71.70^{b}	12.37^{b}	7.71^{b}	25.52^{c}	46.25^{b}	869.00^{b}	48.01^{d} (9.17)
Mean (x)	78.94	15.22	8.47	27.48	49.22	1000.84	60.93
CV (%)	8.60	15.34	5.45	4.36	8.30	19.48	6.43
EMS	6.79	2.33	0.46	1.19	4.08	194.97	3.92

PH= plant height (cm), TC= tiller capacity, SL= Spike length (cm), NSPS = Number of spike per plant, TKW (g) = Thousand kernel weight, SWT (kg ha^{1}) = straw weight and YLD = yield qt ha^{1}, figures followed by the same letter(s) are not significantly different from each other at 5% level of significance, CV = Coefficient of Variance, ERM = Error Mean Square and numeric in in the bracket showed percentage diff b/n treatments.

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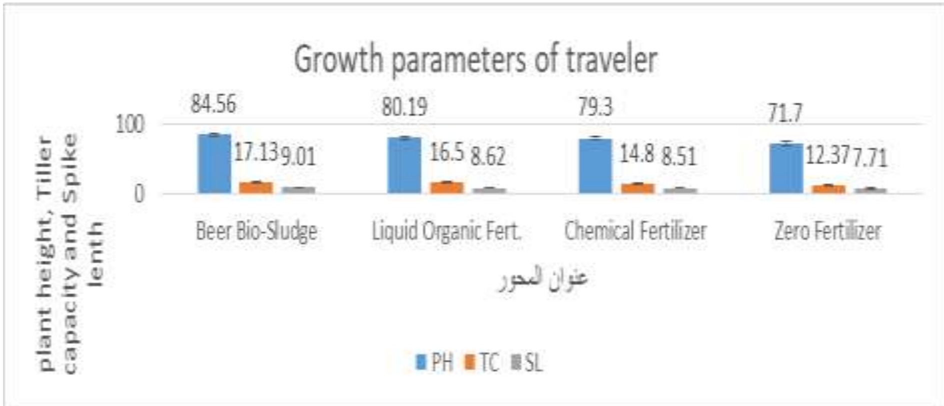
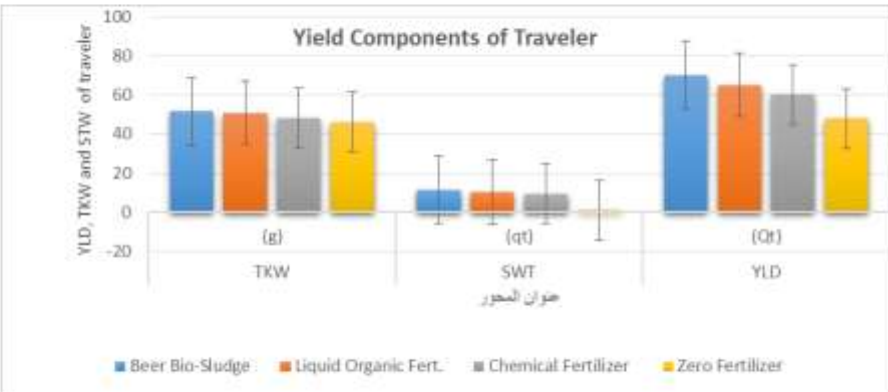
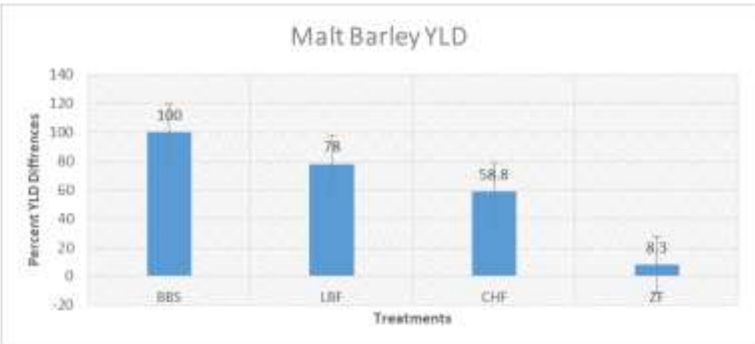


Graph 1: Growth parameters of traveler as influenced by treatment difference at Arsi and West Arsi zones, 2017 CS



Graph 2: Yield components of traveler as influenced by treatment diff at Arsi and West Arsi zones 2017



Graph 3: Percent diff observed on malt barley yield due to treatment difference, 2017 CS

Pearson correlation coefficient: Pearson correlation coefficient, showed that there was positive (+) and significant (P<0.05%) correction between growth parameters namely; Spike Length (SL), Number of Seed Per Spike (NSPS) and Tiller Capacity (TC) and Plant Population (PP) with that of yield components such as Thousand Kernel Weight (TKW), Total Straw Weight (SWT) and Yield (YLD) except disease Scald (SC) and Net Blotch (NB) which were significantly and negatively (-) correlated with all yield components and growth

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parameters (table 4). Even though, leaf diameters was not analyzed, the beer bio-sludge increased leaf areas which had a significant contribution for the increments of the yield, as it increased plant leaf 'photosynthetic areas'.

Table 4: Pearson correlation coefficient of traveler growth parameters and disease vs the yield components of traveler malt barley variety, as influenced by BBS, LBF and CHF fertilizers at Arsi and west arsi zone, 2017 cropping season

Pearson CC	SL (cm)	NSPS	TC	SC (1-9scale)	NB (1-9 scale)	TKW g/1000seed	SWT Kg/ha	YLD Qt/ha
PP	0.39*	0.34*	0.49**	-0.13	-0.14	0.18	0.32	0.57**
SL	1	0.39*	0.39*	0.22	0.56	0.56**	0.56**	0.6*
NSPS	-	1	0.34	0.32	0.21	0.50**	0.46**	0.31*
TC	-	-	1	0.11	0.07	0.17	0.19	0.50**
SC	-	-	-	1	0.67*	-0.12*	-0.19	-0.12
NB	-	-	-	-	1	-0.17	-.0.09	-0.10*
TKW	-	-	-	-	-	1	- 0.51**	-0.02**
SWT	-	-	-	-	-	-	1	0.47**
YLD	-	-	-	-	-	-	-	1

PP= plant population, SL= spike length, NSPS= number of seed per spike, TC= tiller capacity, SC= scald, NB= net blotch, TKW= thousand kernel weight, SWT= straw weight, YLD= yield and CC correlation coefficient.

Treatments Vs Locations: Data (table 5, 6 & 7) revealed that significant ($P<0.05\%$) variations were recoded between the two zones. Significantly, early heading and maturity (88.61 and 149.56) days, high plant height (83.61cm), higher TKW, STW and YLD of (54.2g, 1104.40kg and 62.78qt ha^{1}) respectively, were obtained from Arsi as influenced by the treatments, soil and physical environment variations. Significantly, higher days of heading and maturity (91.05 and 155.87), lower number of PH, TKW, STW and YLD of (74.26cm, 44.30g, 897.30kg and 59.55 qt ha^{1}) respectively, were obtained from West Arsi zone, this might be associated with difference in physical and soil environment in the two zones. Soil and physical environmental variations might had a greater impact on crop metabolic activities, there by affects crop physiological characteristics at large.

Table 5: Mean performance of plant height, tiller capacity, spike length, number of spike pre plant, thousand kernel weight, straw weight, and yield of barley as influenced by BBS, LBF and CHF fertilizers over the two zones, 2017 2017 cropping season

Zones	DH	DM	PH (cm)	SC(1-9)	NB(1-9)	TKW (g)	STW kg/ha	YLD (qt/ha)
Arsi	88.61b	149.56^{b}	83.61^{a}	3.22^{b}	3.47^{b}	54.2^{a}	1104.40^{a}	62.78^{a}
West Arsi	91.05a	155.87^{a}	74.26^{b}	3.87^{a}	4.18^{a}	44.3^{b}	897.30^{b}	56.31^{b}
Mean	89.83	152.68	78.94	3.55	3.83	49.22	1000.84	59.55
CV%	13.50	3.98	4.66	14.48	20.83	8.30	15.06	14.25
EMS	6.52	312.50	698.25	3.45	4.13	790.03	343413	334.75

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DH (days to heading), DM (days to maturity), PH (plant height), SC (scald severity), NB (net blotch severity), TKW (thousand kernel weight), SWT (straw weight), YLD (yield), CV = Coefficient of Variance, EMS = Error Mean Square, letter of the same alphabet showed no-significant differences at 1 and 5% respectively.

Table 6: Mean square values of days to maturity, plant populations, scald severity, net blotch severity of barley as influenced by BBS (beer bio-sludge), LBF (liquid bio-fertilizer) and CHF (chemical fertilizer) fertilizers at Arsi and West Arsi zones

Source of variances	DF	DH	DM	PP	SC	NB
Zone	1	85.01*	195.03*	32.0ns	3.45**	4.13*
Districts	7	87.32*	156.11*	468.89*	0.51ns	1.99*
Treatments	3	56.02*	33.45*	853.88**	0.15ns	0.45*
Error		26.03	49.76	148.80	0.42	0.80
CV%		13.50	4.64	4.60	18.17	23.40

DH= days to heading, DM (days to maturity), PP (plant population), SC (scald severity), NB (net blotch severity), CV = Coefficient of Variance ** = significant at P<0.01, *= significant at P<0.05, ***, highly significant at 1%, ns= not significant, CV = coefficient of variation, df= degree of freedom,

Table 7: Mean square values of plant height, tiller capacity, spike length, number of seed per spike, thousand seed weight, straw weight, and seed yield of barley as influenced by BBS (beer bio-sludge), LBF (liquid bio-fertilizer) and CHF (chemical fertilizer)

Source of variances	DF	PH (cm)	No. of TC	SL (cm)	NSPS	TKW (g)	SWT (kg)	YLD (Qt)
Zone	1	698.25**	3.78ns	12.37**	100.46**	790.03**	343413**	246.9**
Districts	7	231.73**	5.90ns	1.31**	12.61**	125.28**	120469*	264.8**
Treatments	3	228.22**	35.95**	11.18**	17.11**	47.69*	110747*	727.8**
Error		46.12	5.45	0.21	1.44	16.69	38016	15.35
CV%		8.6	15.34	5.45	4.36	8.30	19.48	6.43

DF (degree of freedom), PH (plant height), TC (# of tiller capacity), SL (spike length), NSSP (number of seed per spike), SLS (scald severity), NBS (net blotch severity), TKW (thousand kernel weight), SWT (straw weight), YLD (yield), ** = significant at P<0.01, *= significant at P<0.05, ns= not significant, CV = coefficient of variation, df= degree of freedom.,

Disease Situations: The major leaf diseases of barley in areas are scald (Rhyncosporium secalis), Net blotch (Pyrenophorateres) and spot blotch, (Cochliobolus sativum Syn Helminthosporium sativum). Of these, scald and net blotch are of significant importance in barley production in Arsi and West Arsi zones. In this cropping season, the incidence and severity of scald is less than that of net and spot blotch. No significant (P<0.05) severity differences were observed between the treatments. However, the maximum score (3.75 & 4.12) at 1-9 scoring scale were recorded for scald and net blotch, respectively on traveler on

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the soil treated with liquid bio-fertilizer. The mean values for both scald and net blotch were (3.54 & 3.75), (table 8). The prevalence and incidence of the scald (Rhyncosporium secalis) was decrease from the year to year as compared to net blotch (Pyrenophorateres) and spot blotch, (Cochliobolus sativum Syn Helminthosporium sativum). Currently, the level of tolerance of traveler for both diseases were increased from year to year. This showed the co-existence of the pathogen with that of the variety is increasing. Despite, higher net blotch disease scored (4.12) on the variety the variety gave high yield which was negatively correlated with the yield, (table 4). Ref

Table 8: Mean square values of scald severity, net blotch severity as influenced by BBS (beer bio-sludge), LBF (liquid bio-fertilizer) and CHF (chemical fertilizer) at Arsi and West Arsi zones, 2017 Cropping Season

Treatments	**SC (1-9) scale**	**NB (1-9 scale)**
Beer Bio-Sludge	3.50[a]	3.87[a]
Liquid Bio-Fert.	3.75[a]	4.12[a]
Chemical Fertilizer (CHF)	3.44[a]	3.56[a]
Zero Fertilizer (Control)	3.50[a]	3.75[a]
Mean	3.54	3.83
CV	18.17	23.40
EMS	0.64	0.89

SC= Scald, NB = Net blotch, CV= Coefficent of Variance, EMS = Error Mean Square, and figures followed the same alphabet showed non-significant at 5% among each other's.

Soil Physio and Chemical Analysis: This study also helps to examine the concentrations of heavy metals in sludge from a brewery plant and liquid bio-fertilizers in order to assess the pollution extent of the of these organic fertilizers before be use as a cheap soil fertilizer. BBS and LBF samples were collected before and after the experimentation and analyzed for Zn, Mn, Fe, Mo, Pb, Cu, Cd and Cr. Most of the heavy metals were found in the acceptable and tolerable range except that of Fe which was even a little higher in untreated soil or in the areas, table 9, 10 & Appendix 2. This showed, that these two heavy metals were there initially in the areas at higher level, application of these bio-fertilizers don't showed significant increments over that of the untreated soil. The standards taken as comparison were both European and American standardization (European Union (EU) and United state environmental protection agency (USEPA) standards, Appendix 3). The mean concentration value ranges of some heavy metals in soil treated with both beer bio-sludge and liquid bio-fertilizer were similar with that of untreated soil and which are in acceptable and tolerable levels, for instant, Zn, (4.79-5.07mg/kg (ppm)), B (0.50-0.55mg/kg (ppm)), Cu (3.73-4.04mg/Kg (ppm)), Cd (0.21-0.22mg/kg (ppm)), and Cr (0.18mg/kg (ppm)), table 11. At this level these heavy metals were useful for plants. Even, little higher concentration records for some of heavy metals for untreated (zero fertilizer soil) as compared to the two bio-fertilizers. For instance, higher records of Zn, Cd, Ni and Mn of (5.83, 0.22, 4.03 and 264.38 mg/kg (ppm) were obtained from untreated soil as compared to the bio-fertilizer treated soil, table 10. Besides, having similar or even less concentration of heavy metals with that of untreated

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soil, the soil analysis revealed that, these two bio-fertilizers improved soil pH (soil acidity) increased soil pH from 4.92 to 5.45, from more acidic to neutral level. Even, this level of acidity was not good for barley growing. As a result, beer bio-sludge improved soil pH by 5.11% of the study areas as compared to untreated soil. Some of important soil chemical properties were significantly improved, e.g Cation Exchange Capacity (CEC) and Carbon Nitrogen ratios as compared to that of untreated soil. Both Total Nitrogen (TN) and Organic Carbon (OC) were maximum for bio-fertilizers than the untreated soil. Most of the essential soil elements, namely available Phosphorus (P=17.11mg/kg (ppm)), Potassium (K^+ = 553.22mg/kg (ppm)), Calcium (Ca^{2+}=2,499.01mg/kg (ppm)) and Sulphur (S=16.93mg/kg (ppm)) which were higher in beer bio-sludge treated soil than the untreated soil. In this study, one can concluded that beer bio-sludge can improve soil physical and chemical properties even comparted to the chemical fertilizers. Beer Bio-sludge can serve as one of the best bio-fertilizer in the area with high acidic soil conditions and for soil having lower CEC and OC. Those higher concentrated heavy metals (Fe and Mn) were not significantly affects organisms as compared to Cd, Cr and Pb. Soil of Arsi and West Arsi are more of acidic and need to amend the soil before gating worst with soil amendment chemicals.

Table 9: Mean concentration of heavy metals (mg kg-1 (ppm)) sludge treated soil, soil before application of sludge and brewery sludge used for the experiment

Heavy Metals	**Concentration of heavy metals**			
	Sludge treated Soil	Soil with no Sludge	Sludge	Standard range
Zn	5.07	5.85	112.29	1.50-10.00
Fe	344.04	327.28	354.32	80.00-300.00
Cd	0.21	0.22	0.22	-
Ni	3.99	4.03	2.44	-
Mn	201.83	264.38	106.19	>110
Cu	4.04	3.74	9.47	3.00-7.00
Mo	0.36	0.36	0.45	0.05-1.00
Cr	0.18	0.17	0.55	-
As	0.65	0.69	1.17	-
Pb	1.45	1.48	4.48	-
Hg	0.30	0.30	0.41	-

Table 10: Accumulation of heavy metals in the soil (mg/kg (ppm) after malt barley harvest, 2017 cropping season

Heavy metals	**Mean Concentration of heavy metals in mg/kg of soil**							
	Zn	Fe	Cd	Ni	Mn	Cu	Mo	Cr
Target range	1.5-10	80-300	-	-	>110	3-7	0.05-1.0	-
BBS	5.07	344.04	0.21	3.99	201.33	4.04	0.36	0.18
LBF	4.79	346.34	0.22	4.31	224.64	3.73	0.38	0.18
CHF	5.14	340.76	0.22	4.25	211.35	3.85	0.37	0.17
Zero	5.83	327.28	0.22	4.03	264.38	3.74	0.36	0.17

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Malt Barley Grain Analysis: The grain analysis result was indicated on (table 11). The analysis result showed that, the grain harvested from both the sludge treated soil and untreated soil showed a little higher protein percentage which were (14.8 & 12%) respectively, as compared to the standard acceptable range (9-12%). This might be from the land history were the land was planted with pulse crops (faba bean) which might helped in nitrogen fixation and which might contributed to the increase of protein content in the grain. The rest of the parameters were under the standard ranges.

Table 11: Summary of the nutrient contents in percent in the malt barley grain, 2017

Treatments	*Crude Fiber % w/w	Fat % w/w	Ash %	*Protein % w/w	Moisture % w/w
Sludge treated	4.13	2.17	2.33	14.80	10.73
Control Field	4.44	2.47	2.11	12.00	11.13
Test Methods	AOAC 962.09, 2016	AOAC 2003.06, 2016	AOAC 923.03, 2016	AOAC 2001.11, 2016	AOAC 930.15, 2016

w/w = weight by weight and % = percentage

4. CONCLUSION AND RECOMMENDATION

The study was conducted with the aim to understand, the impact of organic fertilizers on soil fertility status and its contribution towards increasing the yield of malt barley. A comprehensive review of literature on the direct and indirect roles of organic and inorganic fertilizers to soil fertility was incorporated to the present study. The present investigation has been carried out on the farmers and farmers training centers at Arsi and West Arsi zones. Beer Bio-Sludge (BBS), Liquid Bio-Fertilizer (LBF), NP fertilizer (CHF) and Zero fertilizer (ZF) were used at standard desired qualities and quantities. The effects of these organic and inorganic fertilizers on plant phenology, growth and yield were studied. The important findings emerged out during present studies were summarized and concluded here under. In this study, Bio-fertilizer application *viz.*, beer bio-sludge showed good result on malt barley growth and yield components. However, no significant differences were observed on some of parameters like Plant Height (PH), Tiller Capacity (TC) and Spike Length (SL) with that of LBF treated soil. Despite this, significantly varied in some parameters such as Number of Seed Per Spike (NSPS), Thousand Kernel Weight (TKW), Straw Weight (STW) and Yield (YLD). Nevertheless, higher significant variation was observed in all parameters with that of CHF and Zero Fertilizer treated soil. Significantly more NSPS of (29.06), TKW of (51.63g per 1000 seeds), SWT (1145kg ha^{-1}) and YLD of (70.34 Q ha $-^{1}$) were recorded for BBS treated soil. BBS treated soil increased the yield by (2.2, 4.12 and 9.17%), respectively over LBF, CHF and Control. Organic fertilizers treated soil prolonged days to 50% heading and 90% physiological maturity, respectively by 14 and 6 days over the inorganic and zero applied soil. More time required for heading and maturity as the plant staid green for longer time as compared to inorganic fertilizer treated soil. One of the main objective of this study was to proof whether, these bio-fertilizers had a contribution towards accumulation of some

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heavy metals to the soil beside its contribution to soil fertility. Because, some heavy metals are very poisons for life organisms for instant heavy metals like, Cadmium and Cromium which are very hazardous and toxic at certain concentrations, and even on the top of this, it is toxic to humans and other living organisms especially when present in the soil at higher level. The source of cadmium in the sludge which might be attributed during painting materials or pigments used in coating the sludge tank as well as oils used in lubrication of the machine before or after production. The high levels of Pb in the sludge may due to emission from exhaust pipe of the generating plant used to power the machines during production but it is interesting to note that the values of these heavy metals are very low the soil analysis and showed under permissible level and these bio-organic materials specially, the brewery bio-sludge can be utilized as a source of cheap fertilizer and with no lead to pollution. It can thus be said that sludge is good for agricultural application. Result obtained from the grain analysis indicated that, little higher protein content percentage (12.00 & 14.80%) in grain harvested from sludge treated and untreated soil respectively.

Finally, the research indicated that, sludge from a breweries and liquid bio-fertilizer showed normal concentration for heavy metals, the levels obtained fell within the allowed permissible levels set by European Union and United States of America. Therefore, this study revealed that the sludge from this breweries is unpolluted and can be utilized as source of cheap fertilizer for soil. However, it needs further research to recommend to more areas and in environmentally friendly manner. Needs a big collaboration between different stakeholders namely; Research Centers, Environmental Authorities and Breweries for furthers utilization of these breweries wastes as one of the cheapest bio-fertilizer sources for the country like Ethiopia, where difficult for disposal .

Appendix 1: Mean values, standard deviations, minimum and maximum values for both dependent and independent values of barley as influenced by BBS (beer bio-sludge), LBF (liquid bio-fertilizer) and CHF (chemical fertilizer) at Arsi and West Arsi zones,

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Zn	32	1.500	0.51	48.00	1.00	2.00
Dst	32	4.500	2.33	144.00	1.00	8.00
Trt	32	2.500	1.14	80.00	1.00	4.00
DH	32	88.20	7.51	3250.00	79.00	98.00
DM	32	152.03	8.57	4865.00	131.00	168.00
PP	32	265.06	16.59	8482.00	238.00	290.00
TC	32	15.21	2.90	487.00	10.00	24.00
PH	32	78.93	10.99	2526.00	53.60	101.60
SL	32	8.46	1.01	270.90	6.80	10.50
NSPS	32	27.48	2.88	879.50	21.00	33.20

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SC	32	3.54	0.71	113.50	3.00	6.00
NB	32	3.82	1.05	122.50	2.00	7.00
TKW	32	49.22	8.10	1575.00	36.00	73.00
STW	32	1001.00	266.20	32027.00	499.00	1480.00
YLD	32	60.93	11.83	1950.00	40.100	84.20

Zn= zone, Dst = districts, Ttr = Treatments, Std Dev = standard deviation, DH= days to heading, DM = Days to Maturity, PP = Plant population, TLC = Triller capacity, SL = spike length, NSPS = number of seed per spike, SC = scald, NB = net blotch, TKW = thousand kernel weight, STW
= straw weight and YLD = yield

Appendix 2: Mean value of soil analysis after and before treatments application and actual beer sludge analysis result, 2017 cropping season

Parameters	**Symbols**	**Unit**	**Beer Sludge**	**sludge treated**	**Liquid Bio-Fert**	**Chemical fert**	**Soil with zero Fert**	**Standards**
Acidity	PH-H2O		7.27	5.45	5.26	5.31	4.92	5.50-7.00
Phosphorus	P	mg/kg (ppm)	2,964.79	17.11	11.99	11.11	15.52	20-30
Potassium	K+	mg/kg (ppm)	2,459.31	553.22	537.69	525.26	670.56	90-190
Calcium	Ca2+	mg/kg (ppm)	4,131.99	2,499.01	2,169.02	2,261.93	2,223.94	1000-2000
Magnesium	Mg2+	mg/kg (ppm)	1,655.54	277.33	212.5	219	223.14	120-360
Sulphur	S	mg/kg (ppm)	1,281.43	16.93	16.69	14.63	25.03	20-80
Iron	Fe	mg/kg (ppm)	354.32	344.04	346.39	340.76	327.28	80-300
Manganese	Mn	mg/kg (ppm)	106.19	201.83	224.64	211.35	264.38	>110
Zinc	Zn	mg/kg (ppm)	112.29	5.07	4.79	5.14	5.85	1.5-10
Boron	B	mg/kg (ppm)	14.73	0.5	0.55	0.51	0.54	0.8-2.0
Copper	Cu	mg/kg (ppm)	9.47	4.04	3.73	3.85	3.74	3.0-7.0
Molybdenum	Mo	mg/kg (ppm)	0.45	0.36	0.38	0.37	0.36	0.05-1.0
Sodium	Na+	mg/kg (ppm)	4482.31	43.62	17.03	17.99	21.50	69-161
Silicon	Si	mg/kg (ppm)	404.76	309.15	277.08	248	280.79	

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Nickel	Ni	mg/kg (ppm)	2.44	3.99	4.31	4.25	4.03	
Arsenic	As	mg/kg (ppm)	1.17	0.65	0.74	0.7	0.69	
Tin	Sn	mg/kg (ppm)	4.07	2.9	3.26	3.1	2.95	
Cadmiu m	Cd	mg/kg (ppm)	0.22	0.21	0.22	0.22	0.22	
Chromiu m	Cr	mg/kg (ppm)	0.55	0.18	0.18	0.17	0.17	
Lead	Pb	mg/kg (ppm)	4.48	1.45	1.42	1.43	1.48	
Mercury	Hg	mg/kg (ppm)	0.41	0.3	0.3	0.28	0.30	
Organ.C arbon	OC	%	20.7 1	4.42	4	3.8	4.09	1.00-3.00
T/Nitrog en	N	%	3.92	0.32	0.31	0.3	0.32	0.12-0.25
C:N	C/N		5.28	14.03	12.96	12.75	12.88	
CEC		Meq/10 0gsoil	42.9 5	32.01	28.2	12.75	30.45	15-25
Sand		%		20	20	20	18	
Clay		%		42	40	40	42	
Silt		%		38	40	40	40	
Textural Class				Clay	silt clay	silt clay	silt clay	

Mg = mill gram, ppm = parts per meter

Appendix 3: Internationally Acceptable Methodologies Used for the Soil Analysis

Acidity	**PH-H2O**	**ESISO10390:2014(1:2.5)**
Soil texture		Bouyoucos Hydrometer Methods
Organic Carbon	OC	Walkely And Black
Total Nitrogen	TN	ES ISO 11261:2015 (Kjeldahl Methods)
Ava. Phosphorus	P	ES ISO 11263:2015 (Olsens Methods)
CEC	CEC	Ammonium Actate Methods
Ca,K, Mg, Na, S, P, Mo, B, Cu, Fe, Mn , Zn, As, Pb, Co, Cr, Cd, Ni, Hg, & Sn		Mehlich -3

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