

Impact of organic and bio-fertilizers on soil health and production of quinoa and soybean

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ABSTRACT

The objective of this work was to study the effects of four organic fertilizers consists of compost made of either soybean straw or maize straw mixed with either chicken manure or fungi on soil properties and production of quinoa and soybean. All compost combinations applied with the half recommended dose of mineral NPK. Yield, economic growth of a winter quinoa-summer soybean rotation and soil health. Three types of soil namely sandy, calcareous and clay were used. Lysimeter experiments were carried out in EL-Gemmieza Agriculture Research Station. Agricultural Research Center (ARC), El Gharbiah Governorate, Egypt (Middle Delta region 30° 43- latitude and 31° 47- longitude). Results showed that soybean straw mixed with chicken manure combined with half recommended dose of mineral NPK resulted in the highest growth parameters and yield of quinoa and soybean in all soils. The maximum grain and straw yields of quinoa reached 3.48 and 6.28 Mg ha⁻¹, respectively in clay soil, while in calcareous soil, they were 1.78 and 4.30 Mg ha⁻¹, respectively in comparison to just 1.16 and 2.72 Mg ha⁻¹, respectively in sandy soil. While, the maximum grain and straw yield of soybean were 3.06 and 5.15 Mg ha⁻¹, respectively in clay soil and 1.68 and 3.23 Mg ha⁻¹, respectively in calcareous soil and 1.29 and 2.40 Mg ha⁻¹, respectively in sandy soil. Also, results revealed that values of selective plant growth, physical, chemical and biochemical soil parameters were improved significantly by applied organic fertilizers in particular soybean straw plus chicken manure in all three type soils. It can be concluded that organic fertilizers application in particular soybean straw plus chicken manure combination with half recommended dose of mineral NPK can be an alternative for the best integrated soil fertility management and maintain sustainability over applying mineral fertilizers in all used three soils.

Keywords: compost, quinoa, soybean, sandy soil, calcareous soil, and clay soil

Introduction

Maintaining healthy soils is a key component of organic agriculture. Which it's leads to increase the sustainability of the cropping system. Incorporating organic matter into the soil is a fundamental approach to maintain soil health. Frequently, growers use compost applications. However, the excessive use of compost can increase P levels without adequate N for plant nutrition. (Jensen and Hauggaard-Nielsen., 2003). Measuring soil health frequently involves a number of complementary indicator tests. These indicator tests are typically chosen to assess the physical, chemical characteristics of the soil. Soil physical measurements provide information about the size and structure of soil particles and aggregates that help determine key qualities such as pore space, infiltration, and moisture holding capacity. One key measure of physical structure is bulk density which is a measure of how tightly packed soil aggregates are in a given volume of space (Tahat *et al.*, 2020). Soil chemical properties are frequently assessed to determining plant available nutrients. Soil extractable elements provide information on the availability of macro and micronutrients in the soil at a particular time that can be used as a guide to estimate the nutrient status of a system (Arrobas *et al.* 2012). Soil chemical properties, like extractable ammonium (NH₄⁺) or nitrate (NO₃⁻), show only a snapshot of the nutrients availability at sampling time. Extractable soil NO₃⁻ at 30 days after planting has been used for crops with a high N demand such as corn, and may be indicative of available N for quinoa Quantifying organic matter within the soil is also useful in evaluating the overall health of soil. Total N and organic carbon (C) are frequently used to measure the organic matter (OM) content of soils but these tests do not indicate if the OM is labile or recalcitrant.

The soil microbial biomass is the living part of the soil organic matter, formed by fungi, bacteria, protozoa, and algae, and represents an important source of nutrients that may supply plant demands due

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to its rapid cycling (Sicardi *et al.*, 2004), being one of the main biological attributes used in soil health studies. Biofertilizer is a component that contains living microorganisms that are given into the soil as inoculants to provide certain nutrients for plants. The interaction between manure and soil microorganisms could improve the aggregate and the soil structure. The results of decomposition by soil microorganisms such as extra polysaccharides have function as glue or adhesives between soil particles so as to increase the amount of soil pores and eventually become a suitable medium for plant growth because of the wider range of roots so that nutrient absorption is easier. As roots expand, fertilization efficiency, with increased access to and increase nutrients, is expected to increase, so that plants grow well (Widowati *et al.*, 2005).

Farmyard (FYM) and chicken manures are organic fertilizer applied traditionally as soil conditioners and fertilizers (Atta Allah and Mohamed, 2003). In addition to playing important role in improving the physical properties of soils, especially the sandy and calcareous ones, organic manures are valuable resources rich in P, N and micronutrients essential for plant growth, that are slowly released after degradation by microorganisms. Farmyard manure significantly improved dry weight of wheat plants grown on soils of different textures, but response of plants to the organic manure treatments was more pronounced in sandy and calcareous soils than in the clayey ones (Mostafa, 2004). Application of poultry manure at (0, 2.5, 5.0, 7.5 and 10 t ha⁻¹) significantly increased organic carbon, exchangeable bases and effective cation exchange capacity in the soils, concentrations of N, P and K in plant tissue. Application of poultry manure increased available nutrients, increased nutrient uptake and improved dry matter yield in soybean (Soremi *et al.*, 2017).

In many developing countries and in newly reclaimed areas, where manures are not available in adequate quantities, other forms of organic matter like filter mud and vinasse of sugar-cane industry (Yassen *et al.*, 2002), composted plant residues and town wastes (Morsy, 2002) are frequently used as soil amendments and fertilizers for supplementing major plant nutrients. In the absence of farmyard manure, crop residue incorporation should be considered as a viable alternative for sustaining soil organic carbon content and promoting soil biological properties. However, particular attention should be paid to the correct estimation of their contribution in the PK fertilization in order to maximize their beneficial effect on crop yields (Blanchet *et al.*, 2016).

Soybean (*Glycine max* L. Merrill) is the world's leading source of oil and protein. It has the highest protein content of all food crops and is second only to groundnut in terms of oil content among food legumes (Raghuveer and JA Hosmath, 2017). Economically, soybean is an important leguminous crop worldwide. Soybean being a legume crop is capable of fixing atmospheric nitrogen through symbiosis but the symbiotic nitrogen fixation alone is not enough to meet the high nitrogen requirement of this crop.

Quinoa (*Chenopodium quinoa* Willd.) is a staple crop that has been cultivated for thousands of years in the Andes of South America. In recent years, there has been an increasing interest and demand of quinoa around the world (Krivonos 2013 and Bazile *et al.*, 2015). The recent awareness of quinoa lies, among others, in its protein content higher than cereals like rice, barley and maize and good balance of essential amino acids, like lysine (Wu, 2015). Little information is currently available on quinoa crop production, little scientific literature is available about its cultivation, and there is a need for recording data of farming practices, yield, nitrogen (N) efficiency, fertilizer. The soil is not inverted and mixed with the crop residues and this seems to profoundly impact many soil properties particularly in the upper soil layer (D'Haene *et al.*, 2008). This study may also provide useful information in relation to promote plant growth and soil health by efficient solubilization and utilization of soil nutrients.

The objective of this study was to study the effects of four organic fertilizers consist of compost made of either soybean straw or maize straw mixed with either chicken manure or fungi, with the half recommended dose of mineral NPK on quinoa and soybean yields, economic growth and soil health.

Materials and Methods

1. Soils used and physiochemical analyses

Three types of soils namely sandy (location of EL-Bostan- Bahira Governorate), calcareous (location of Nubaria –Bahira Governorate) and clay (location of EL-Gemmieza Agriculture Research Station of the Agricultural Research Center) were used in this experiment. Prior to use in the lysimeter experiment, soils were air-dried, passed through 2-mm sieve to remove stones, and to be homogenized.

Selected Physical and chemical characteristics of the studied soil were determined according to Page *et al.*, (1982). Soil samples at the depth of 0-30 cm representing all the treatments were taken before and after harvesting quinoa and soybean yield then air dried, sieved through a 2 mm and stored for analysis. Soil chemical parameters including pH were determined in a 1:2.5 ratio (soil/water), the total soluble salts (EC) were determined using electrical conductivity meter at 25°C in soil paste extract as dS m⁻¹, Cation Exchange Capacity (CEC) were determined by using ammonium acetate method, organic Matter (OM) were determined by using Walkley and Black method, available N(NH₄⁺ and NO₃⁻), P and K of the used soil were extracted by KCl (2M), NaHCO₃ (0.5 M) and CH₃COONH₄ (1M) respectively, Soil available Fe, Zn, Cu and Mn were extracted using Ammonium bicarbonate (NH₄HCO₃) + Diethylene Triamine Penta-Acetic acid (DTPA) pH 7.6 as described by Soltanpour and Schwab (1977), total Calcium Carbonate was determined by using calcimeter, Particle size distribution was carried out by the pipette method with analyses for natural minerals were evaluated according the procedures described by Cottenie *et al.*, (1982). At the same time, undisturbed soil samples were taken to determine the bulk density according to Blake and Hartge, (1986) The total porosity was estimated using values of bulk density and particle density (2.65 g cm⁻³) and was calculated according to the formula: soil porosity = 1- (bulk density/particle density) x100, hydraulic conductivity was measured by auger hole method according to Rowel, (1994). Dehydrogenase activity can be empirically measured using artificial electron acceptors like tetrazolium salt. Thus, DHA is a good indicator of total microbial activity. In the current work, we quantified microbial activity by measuring the DHA in the soil according to the method of Chander and Brookes, (1991). Soil microbial biomass carbon was estimated employing fumigation and extraction procedure as described by Vance *et al.*, (1987). The main chemical and physical properties of the soils are presented in Table (1).

Table 1: Some selected properties of studied soils

Parameters	pH (1:2.5)	EC ds m ⁻¹ soil paste	CEC (cmol/kg)	ESP %	Bd gm/cm ³	HC cm/hr	Tp (%)	
Soil type								
Sandy	8.19	2.18	7.05	19.2	1.62	17.2	37.7	
Calcareous	8.15	1.91	18.25	17.3	1.51	9.2	45.3	
Clayey	8.09	3.12	44.25	24.9	1.22	1.1	50.2	
Parameters	Total carbonate (%)	OM (%)	Clay (%)	Silt (%)	Coarse sandy (%)	Fine sand (%)	Texture	
Soil type								
Sandy	3.98	0.33	4.66	4.56	52.08	38.7	Sandy	
Calcareous	25.85	0.45	25.84	28.70	22.06	23.4	Sandy loam	
Clayey	3.65	0.78	48.41	33.90	5.29	12.4	Clay	
Soil type	Available macronutrients (mg kg ⁻¹)				Available micronutrients (mg kg ⁻¹)			
	N _{NH4}	N _{NO3}	P	K	Fe	Zn	Mn	Cu
Sandy	12.15	6.29	0.70	55.20	1.65	0.85	1.13	0.28
calcareous	13.08	7.68	2.20	69.70	2.55	1.75	1.39	0.42
Clayey	22.00	15.78	4.15	265.00	4.03	2.25	3.02	0.89

OM= Organic matter CEC= Cation Exchange Capacity ESP= Exchangeable Sodium Percentage HC= hydraulic conductivity Tp= total porosity Bd= bulk density.

2. Compost preparation

Compost was prepared using straw of both soybean and maize in a local manufactured Composter for thirty day. Oven dried were ground to 2 mm size using plant materials an electrical crusher, then transferred to a composting unit consisting of a vessel (500 kg capacity) having controlled temperature and aeration (shaking at 50 rev min⁻¹). During composting process, the moisture level of 40% (v/w) was maintained via addition of water. The temperature in the composting vessel rose from 35 to 70 °C during the 2nd and 3rd day of composting process and later, gradually reduced to 35 °C after the 4th day. Various physicochemical properties of compost components are illustrated in Table (2).

Table 2: Physicochemical properties of organic components

Properties	pH (1:10)	EC (1:10) dS m ⁻¹	Bd (g cm ⁻³)	Total N (%)	Total P (%)	Total K (%)	OC (%)	OM (%)	C/N ratio
Chicken manure	6.91	1.91	0.70	3.32	1.15	1.90	33.85	58.36	10.20
Soybean straw	-----	-----	0.41	1.02	0.42	1.85	31.25	53.87	30.64
Maize straw	-----	-----	0.30	0.65	0.32	1.55	25.55	44.05	39.31

3. Lysimeter experiment set up and design:

Lysimeter experiments were conducted at EL-Gemmieza Agriculture Research Station, Agricultural Research Center (ARC), El Gharbiah Governorate, Egypt (Middle Delta region 30° 43' latitude and 31° 47' longitude) where quinoa (*Chenopodium quinoa* Willd.) (Miser 1) was planted on Nov 2018 (winter season) followed by soybean (*Glycine max* (L.) Merrill) (Giza 111) on May 2019 (summer season). Forty five lysimeters 2 meter in length, 1 meter in width and 2 meter in depth were used in this study. Lysimeters divided into three groups, each group were filled one soil type. Split-plot with three replicates was used. The main plots were occupied by three soils and the sub plots were occupied by four compost types. Treatments were thoroughly mixed with the surface soil layer (0-30 cm) of the concerned plots before planting crops. The recommended dose from mineral fertilizers for quinoa was 214 Kg N /ha as ammonium sulphur (20.6%N), 120 kg (P₂O₅)/ha as superphosphate (15.5% P₂O₅) and 120 kg(K₂O)/ha as potassium sulphate (48% K₂O), while in soybean, it was 145 Kg N /ha as ammonium sulphur (20.6%N), 180 kg(P₂O₅)/ha as superphosphate (15.5% P₂O₅) and 120 kg (K₂O) as potassium sulphate (48% K₂O). At harvesting stage, quinoa plants harvest in May 2019, soybean were harvest in September 2019. After harvesting either quinoa or soybean, soil samples of each experimental unit were taken and analyzed for soil physical and chemical properties.

Treatments used in experiment

T₁: Control that consisted of full recommended dose of mineral fertilizer

T₂: Soybean straw 5 Mg/ha + chicken manure 5 Mg/ha plus half of the recommended dose of mineral fertilizers.

T₃: Maize straw 5 Mg/ha + chicken manure 5 Mg/ha plus half of the recommended dose of mineral fertilizers.

T₄: Soybean straw 5 Mg/ha + Fungi (Trichoderma Verdi + Trichoderma harzianum 10 liter/ha) plus half of the recommended dose of mineral fertilizers.

T₅: Maize straw 5 Mg/ha + Fungi (Trichoderma Verdi + Trichoderma harzianum 10 liter/ha) plus half of the recommended dose of mineral fertilizers

All treatments were applied in all soil types used.

4. Plant analyses:

At harvesting, a sample of plants from each plot was randomly chosen to calculate grain, straw and biological yields that were recorded on plot basis, and then, they were estimated as Mg ha⁻¹. Grain and straw samples of quinoa and soybean were taken for chemical analysis to determine N, P and K percentages in grains and straw and their uptakes were calculated. Grain and straw were wet digested by a mixture of HClO₄ and H₂SO₄ acids according to Sommers and Nelson (1972). The digestion was then exposed to determine N, P and K as described by A.O.A.C (1990). Plant uptake of Macronutrients was obtained by multiplying the element % by the plant dry matter weight (grains and straw)/100. Moreover, crude protein was calculated by multiplying total N value by conversion factor of 6.25. Moisture percentage and ash content were determined according to the methods described in AOAC (1995). Chlorophyll content was measured on the fresh fifth mature leaf from top using Minolta chlorophyll meter Spad-501 according to the method of Goodwine, (1965).

5. Statistical analyses

Statistical analysis was assessed using the Statistical Analysis Software System for Windows (SAS, 2010). The significant difference between the mean values were determined by using the analysis of variance (ANOVA) and Duncan's multiple range test was conducted at a significance level of p<0.05. All samples were analyzed in triplicates.

Results and Discussion

1. Effect of organic fertilizer on soil health

1.1. Soil pH

Results in Table (3) showed that no significant effect on soil pH between different treatments of compost with all soils types. The lowest values 8.07, 7.87 and 7.85 of the soil pH were found for the soil treated with soybean straw plus chicken manure combination with half recommended dose of mineral fertilizer (T₂), it was decreased by 1.63% in calcareous soil, 1.65 % in clay soil, but slightly decrease 0.62 % in sandy soil after quinoa growing season. Relative to sandy soil, these slightly decrease in soil pH may be due to the lower clay and organic matter content in the sandy soil could explain its lower buffering capacity and, as a consequence, the lower resistance to changes in soil pH. While after soybean growing season, was a decrease of 2.5 % in sandy soil, 1.64% in calcareous soil and 2.79 % in clay soil. The decrease in soil pH induced by the addition of compost treatments can be attributed to the acidic effect of decomposable products of organic materials. The obtained results confirm finding Walker *et al.*, (2003) that addition of compost to soil led to decrease soil pH. Smiciklas *et al.*, (2002), also observed a decrease in soil pH after the use of organic materials. The production of organic acids (amino acid, glycine, cystein and humic acid) during mineralization (amminization and ammonification) of organic materials by heterotrophs and nitrification by autotrophs would have caused this decrease in soil pH. Also, addition of compost from manure has been reported to increase or decrease soil pH and have the ability to buffer soil pH (Johnson *et al.*, 2006).

1.2. Soil organic matter (OM)

Organic matter content in soil is a good indicator for soil fertility. Results showed that application of soybean straw plus chicken manure combination with half recommended dose of mineral fertilizer (T₂) led to a significant increase in OM content, compared to other treatments and control (Table 3). It was increased by 51.43 % in sandy soil, 58.93% in calcareous soil and 37.17% in clay soil, compared to the control, after quinoa growing season, while, after soybean growing season, it was increased by 53.66 % in sandy soil, 67.74% in calcareous soil and 60.33% in clay soil, compared with other treatments and the control treatment. The obtained results confirm finding by Chang *et al.* (2014) who suggested that organic amendment improved soil organic carbon. Panwar *et al.* (2010) reported higher soil organic carbon in the treatments receiving organic nutrients over a long term period. In a sandy silt loam soil, Albiach *et al.* (2001) found significant increase in soil organic matter after four years of organic amendment application to a horticultural soil.

1.3. Cation Exchange Capacity (CEC)

Application of soybean straw plus chicken manure combination with half recommended dose of mineral fertilizer (T₂) increased cation exchange capacity of soil after quinoa and soybean growing seasons significantly as compared to control as well as mineral fertilizer (Table 3), after quinoa growing season, data showed that application T₂ increased the CEC value, it was increased by 77.31 % in sandy soil, 23.94% in calcareous soil and 9.32% in clay soil, over the control, whereas after soybean growing season increased by 88.26 % in sandy soil, 26.74% in calcareous soil and 11.81% in clay soil, over its the control. The increase in CEC of soil, as the result of organic material addition, comparing the types of soils, sandy soil had a high response to organic fertilizers addition on CEC over control. The increase of CEC under sandy soil was related to the OM content in soil, since OM accounts for a major part of the variable negative charges, resulting in the increase of soil CEC, which agreement with the results obtained by Vieira *et al.*, (2007), who found positive correlations between CEC and the carbon management index in another long-term experiment on the same kind of soil. The CEC of the soils was closely related to their organic C contents (Czarnecki and Düring, 2015).

1.4. Dehydrogenase activity

Dehydrogenase activity was significantly higher in soils receiving organic fertilizers (Table 3) than those under recommended dose of mineral fertilizer treatment. However, there was no significant difference among treatments as far as dehydrogenase activity is concerned (Table 3). Results showed that all soils types, T₂ increased the dehydrogenase activity compared to control. Dehydrogenase

activity was increased by 81.35% in sandy soil, 39.15% in calcareous soil and 77.29% in clay soil, compared with its control treatments, after quinoa growing season.

Table 3: Effect of some crops residue on soil chemical and biological properties after quinoa and soybean yields.

Soils	Treatments	After quinoa of harvesting				
		pH (1:2.5)	OM (%)	CEC (cmol kg ⁻¹)	D A µgTPF/gdry soil	(MBC) µg C/g soil
Sandy soil	T1	8.12	0.35	5.95	6.22	85.23
	T2	8.07	0.53	10.55	11.28	132.40
	T3	8.08	0.47	9.32	11.07	127.85
	T4	8.08	0.44	9.18	9.84	121.20
	T5	8.09	0.46	8.85	10.59	120.16
	Mean		8.09	0.45	8.77	9.80
Calcareous soil	T1	8.00	0.56	21.14	20.00	130.72
	T2	7.87	0.89	26.20	27.83	182.57
	T3	7.92	0.78	24.75	26.61	175.61
	T4	7.93	0.79	23.20	25.51	162.05
	T5	7.94	0.71	23.46	23.68	162.48
	Mean		7.93	0.75	23.75	24.73
Clay soil	T1	7.98	1.13	43.15	35.22	270.42
	T2	7.85	1.55	47.17	62.46	345.32
	T3	7.88	1.48	46.67	60.37	326.53
	T4	7.87	1.43	45.30	54.08	302.76
	T5	7.91	1.38	44.38	56.99	309.52
	Mean		7.90	1.39	45.33	53.82
LSD _{0.05}	A	0.03	0.07	0.78	0.39	6.56
	B	0.04	0.06	0.50	1.03	9.10
	A*B	Ns	0.03	Ns	0.78	4.72
After soybean of harvesting						
Sandy soil	T1	8.03	0.41	6.39	6.94	92.92
	T2	7.83	0.63	12.03	13.38	148.71
	T3	7.86	0.57	11.37	12.96	140.55
	T4	7.89	0.53	9.78	11.95	134.25
	T5	7.92	0.51	9.35	11.43	129.00
	Mean		7.91	0.53	9.78	11.33
Calcareous soil	T1	7.90	0.62	22.25	21.93	152.13
	T2	7.77	1.04	28.20	31.17	209.38
	T3	7.81	0.91	27.80	29.16	210.52
	T4	7.84	0.85	26.41	27.16	195.20
	T5	7.87	0.81	26.81	25.63	202.05
	Mean		7.84	0.85	26.29	27.01
Clay soil	T1	7.89	1.21	43.02	37.13	285.00
	T2	7.67	1.94	48.10	74.05	399.82
	T3	7.74	1.78	47.82	71.39	415.05
	T4	7.84	1.78	46.80	66.67	401.27
	T5	7.87	1.73	45.90	64.48	378.30
	Mean		7.80	1.69	46.33	62.74
LSD _{0.05}	A	0.03	0.04	0.64	0.77	12.08
	B	0.03	0.03	0.70	0.96	17.59
	A*B	ns	0.057	ns	0.74	12.50

CEC=cation exchange capacity, DH=Dehydrogenase activity, MBC= Microbial biomass carbon, A= Soil, B=Treatments

Whereas, after soybean growing season, was observed with an increase 92.8% in sandy soil, 42.13% in calcareous soil and 99.43% in clay soil. Applying chemical fertilizers to sandy soil significantly decreased urease activity, whereas adding organic manure to all soils type resulted in an increase in its

activity. This may be due to the produce of some organic acids and CO₂ in soil results from the oxidation of soil organic matter by heterotrophic microorganisms and from root respiration. Dehydrogenase activity exists as an essential part of soil microbial life (Włodarczyk *et al.*, 2002). It is worth noting that organic fertilizers are more favorable to the overall biological activity of the soil compared with mineral fertilizers which can exert a negative effect on the activity of the enzyme. These results may be due to N fertilizer treatments were most likely because of crop residue, as higher yields, and hence greater organic matter, thus improved CO₂, DHA and SMBC (Heidari *et al.*, 2016).

1.5. Microbial biomass carbon (MBC)

MBC is the living component of the soil which, links soil nutrients to energy dynamics that is considered a sensitive indicator that responds to short term nutritional and environmental changes in soil. There was a significant effect on MBC detected in the soil across two seasons representing growth features of quinoa and soybean crops (Table 3). Application of soybean straw plus chicken manure (T2) significantly increased MBC concentration compared to the control and other treatments in the three soils with the smallest increases in recorded (27.69%) in the clay soil and the greatest (55.34%) in the sandy soil, after quinoa growing season. Whereas after soybean growing season was observed with the smallest increases was observed (38.38%) in calcareous soil and the greatest attributed (60.04%) in the sandy soil, compared to the control. The increase in MBC concentration in sandy soil may be due to the negative relation between MBC and clay content that physically protect SOC from attack by microbes. (Malik *et al.*, 2013) showed that application of organic amendments (farmyard manure, poultry litter and biogenic waste compost were applied at the rate of 10 g kg⁻¹ soil) significantly increased soil microbial biomass C, N and P concentrations compared to the unamended soil in both soils (sandy loam and silt loam). Thus microbes can be considered as slow release fertilizers that store nutrients (mainly N and P) when nutrient concentrations are high and then release them (Docampo *et al.*, 2010). SOC in association with the small pore sizes related to clay minerals could become shielded from microorganisms.

1.6. Macronutrient contents (N, P and K):

All treatments used were effective on availability of N, P, and K concentration in all type of soils compared to the control treatments (Table 4).

Table 4: Effect of some crops residues on soil available macronutrients after quinoa and soybean yields.

Soils	Treatments	After quinoa of harvesting				After soybean of harvesting			
		available macronutrients (mg kg ⁻¹)				available macronutrients (mg kg ⁻¹)			
		NH ₄	NO ₃	P	K	NH ₄	NO ₃	P	K
Sandy soil	T1	12.40	7.73	1.29	54.90	14.33	9.12	2.59	52.20
	T2	18.45	13.33	3.80	76.98	21.40	16.25	5.26	92.74
	T3	16.80	11.62	3.30	73.64	19.83	14.53	4.33	82.88
	T4	15.57	10.78	2.94	71.37	19.10	13.56	4.18	78.93
	T5	14.20	9.62	2.18	65.67	18.95	11.98	3.63	75.85
	Mean		15.48	10.62	2.70	68.51	18.72	13.09	4.00
Calcareous soil	T1	14.57	9.62	2.50	68.51	16.87	10.30	3.44	109.60
	T2	21.33	17.08	6.77	138.62	26.50	20.65	9.80	167.27
	T3	19.90	16.05	5.88	133.30	24.70	18.07	9.69	160.10
	T4	18.48	13.23	4.86	123.35	23.57	16.57	8.19	156.03
	T5	17.22	12.03	4.18	122.63	22.80	14.70	6.87	140.60
	Mean		18.30	13.60	4.84	117.28	22.89	16.06	7.60
Clay soil	T1	22.67	16.47	4.22	262.87	24.47	18.00	4.91	266.67
	T2	33.80	23.64	8.67	320.65	37.77	28.26	12.23	414.38
	T3	30.67	21.05	7.90	312.32	35.97	27.03	10.35	391.60
	T4	27.55	21.33	7.18	298.63	31.33	24.60	9.72	360.52
	T5	25.90	20.52	6.58	290.68	29.55	21.88	8.46	334.52
	Mean		28.12	20.60	6.91	297.03	31.82	23.95	9.13
LSD _{0.05}	A	0.84	0.07	0.60	5.57	0.65	0.35	0.73	3.04
	B	0.98	0.06	0.38	6.74	1.08	0.81	0.60	10.58
	A*B	0.62	0.03	0.30	3.70	0.71	0.47	0.44	7.82

Results showed that available N, P and K in the soils treated by T₂ after quinoa growing season, with an increased by 57.87, 194.57 and 40.22 %, respectively, in sandy soil, (58.78, 170.8 and 102.33 %), respectively, in calcareous soil, (46.75, 105.45 and 21.98 %), respectively, in the clay soil, the over control. While after soybean growing season, available N, P and K in soils, increased by (60.55, 103.08 and 77.66 %), respectively, in the sandy soil, (73.53, 184.88 and 52.62 %), respectively, in the calcareous soil, (55.47, 149.08 and 55.39 %), respectively, in the clay soil, over the control. High response to organic fertilizer addition in calcareous soil may be due to adequate levels of plant essential nutrients.

The effect of all treatments rates on N, P and K content in soil were high, this may be due to pH reduction as a result of adding compost to the soil, which is responsible for nutrients availability in soils. Several research investigations showed that the application of FYM along with mineral fertilizers increased the availability of N, P and K in the soil after harvest of maize El-Maaz *et al.* (2014) found that a general increase in nutrient supplying capacity of soils with addition of compost. These results are in agreement with those obtained by Abd El-Mouty *et al.*, (2001) and EL-Etr *et al.*, (2004) by substituting 25% of the recommended level of nitrogenous fertilizer with vermicompost. Application of FYM along with lime and half the dose of NPK to Rape seed and black gram cropping system in an acid inceptisols increased the soil organic carbon and available N, P, K, S and exchangeable Ca and Mg (Basumatary, 2018). Plant residues were weighed and added into the jars at a rate equivalent to 200 mg N kg⁻¹ led to increase the content of N in soil (Abbasi *et al.*, 2015).the incorporation of soybeans with maize resulted in a different dynamic of C and N mineralization compared with maize or soybean sole crops. This may be caused by the translocation of N, the limiting nutrient, from the nutrient-rich residue of the soybeans to the nutrient-poor residue of the maize (Vachon and Oelbermann, 2011)

1.7. Micronutrient contents (Fe, Zn, Mn and Cu):

After quinoa growing season, available micronutrient cations were significantly influenced by treatments (Table 5).

Table 5: Effect of some crops residue on soil available micronutrients after quinoa and soybean yields.

Soils	Treatments	After quinoa of harvesting				After soybean of harvesting			
		Available micronutrients (mg kg ⁻¹)				Available micronutrients (mg kg ⁻¹)			
		Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu
Sandy soil	T1	1.64	0.86	1.03	0.32	1.54	0.84	1.08	0.23
	T2	2.71	2.10	2.52	0.65	3.88	2.24	3.45	0.81
	T3	2.65	2.03	2.37	0.61	3.29	2.30	2.82	0.85
	T4	2.55	1.73	2.21	0.55	3.08	2.16	2.52	0.70
	T5	2.39	1.54	1.99	0.46	2.62	2.09	2.70	0.61
	Mean		2.39	1.65	2.02	0.52	2.88	1.93	2.51
Calcareous soil	T1	2.52	1.12	1.30	0.41	2.88	1.54	1.53	0.37
	T2	6.06	2.95	3.48	0.89	7.39	4.80	5.90	1.11
	T3	5.75	2.73	3.14	0.80	7.70	4.33	5.45	0.96
	T4	5.55	2.42	2.75	0.73	7.05	4.11	5.06	0.80
	T5	5.16	2.35	2.57	0.63	7.27	3.64	4.55	0.90
	Mean		5.01	2.31	2.65	0.69	6.46	3.68	4.50
Clay soil	T1	3.80	2.46	2.94	0.80	3.87	2.50	2.80	0.73
	T2	8.17	4.18	6.16	1.96	9.19	6.90	7.53	2.28
	T3	7.38	4.29	6.13	2.03	8.69	6.27	7.07	2.04
	T4	6.86	3.36	6.03	1.86	8.19	6.08	6.31	1.93
	T5	6.05	3.33	6.19	1.62	7.35	5.72	6.49	1.76
	Mean		6.45	3.52	5.49	1.65	7.46	5.49	6.04
LSD _{0.05}	A	0.18	0.18	0.24	0.03	0.47	0.09	0.35	0.15
	B	0.29	0.18	0.34	0.10	0.45	0.38	0.22	0.16
	A*B	0.32	0.15	0.13	0.06	0.44	0.20	0.25	0.08

Data showed that the available concentration Fe was increased by 65.24% in the sandy soil, 140.47% in the calcareous soil and 115 % in clay soil, over their control treatments. Available Zn was

significantly higher under T2 in the sandy and calcareous soils, while it was significantly higher under T3 in clay soil. It was increased by 144.19% in sandy soil, 163.39% in the calcareous soil and 74.39% in the clay soil, over control treatment. A similar trend in available Cu was observed increases by 103.13% in the sandy soil, 117.07% in calcareous soil and 150% in clay soil compared to the control treatment). Like Fe, Zn and Cu, concentration of Mn in soil significantly influenced by different treatments, the highest concentration of Mn was recorded for (2.52 and 3.48 mg kg⁻¹) under T2 in sandy and calcareous, while in clay soil, the highest concentration of Mn was recorded 6.19 mg/kg under T5 compared to the control. It was increased by 144.66% in sandy soil, 167.69% in calcareous soil and 109.52 % in clay soil compared to the control.

Meanwhile, after soybean growing season, higher available concentration of Fe was observed with T2, 151.94% in sandy soil, 156.59% in calcareous soil and 137.46 % in clay soil, over control treatment. Also, the data showed that the available Zn was significantly higher under T2, reaching 144.19% in sandy soil, 163.39% in calcareous soil and 74.39% in clay soil over control treatment. A similar trend in available Cu was observed that increased by 103.13% in sandy soil, 117.07% in calcareous soil and 150% in clay soil, compared to control. Like Fe, Zn and Cu, concentration of Mn in soil significantly influenced by different treatments, the concentration of Mn was increased by 219.44% in sandy soil, 285.63% in calcareous soil and 168.93% in clay soil compared to control. The high amount of organic matter in compost, its oxidation and degradation and neutral pH increase micronutrients availability such as Fe, Mn, Zn and Cu in soil. Fertilization could surely affect microbial growth and competitiveness as different groups of microorganisms could vary in their ability to process the various nutrient forms found in soil Heidari *et al.* (2016). Similar findings have been reported by Antoniadis and Alloway, (2003).

1.8. Soil physical parameters.

Bulk density (Bd), total porosity (Tp), field capacity (Fc) and water holding capacity (Whc), these parameters are considered as a good indicator for the improvement of the main soil physical properties. Data in Table 6 show that application of treatments used had a significant increase in all parameters except for (Bd), which declined. This pattern happened in all soils under investigation as a response to organic fertilizers treatments.

Table 6: Effect of some crops residue on soil physical properties after quinoa and soybean yields.

Soils	Treatments	After quinoa of harvesting				After soybean of harvesting			
		Bd (gm cm ⁻³)	Tp (%)	Fc (%)	Whc (%)	Bd (gm cm ⁻³)	Tp (%)	Fc (%)	Whc (%)
Sandy soil	T1	1.59	40.00	15.20	24.35	1.58	40.37	15.08	23.95
	T2	1.47	44.40	18.43	27.58	1.46	45.03	20.48	28.70
	T3	1.46	44.78	20.40	29.43	1.44	45.53	21.28	31.23
	T4	1.49	43.65	17.97	26.05	1.48	44.27	19.25	27.40
	T5	1.49	43.65	18.25	27.83	1.49	43.90	20.28	28.13
	Mean	1.50	43.30	18.05	27.05	1.49	43.82	19.27	27.88
Calcareous soil	T1	1.46	44.78	20.07	27.74	1.46	44.78	20.83	28.25
	T2	1.43	46.17	23.10	33.73	1.40	47.04	25.41	35.42
	T3	1.41	46.92	24.87	34.82	1.38	47.80	27.37	37.66
	T4	1.44	45.79	23.74	32.28	1.42	46.54	24.19	34.87
	T5	1.42	46.29	23.78	33.08	1.39	47.55	25.19	34.96
	Mean	1.43	45.99	23.11	32.33	1.41	46.74	24.60	34.23
Clay soil	T1	1.24	53.33	38.22	46.98	1.21	54.21	37.72	47.57
	T2	1.17	55.85	41.17	48.80	1.13	57.23	43.30	49.68
	T3	1.12	57.61	43.19	50.80	1.07	59.62	44.87	52.40
	T4	1.19	55.09	39.76	48.02	1.15	56.48	42.35	49.19
	T5	1.17	55.72	40.40	48.98	1.15	56.73	43.43	49.78
	Mean	1.18	55.52	40.55	48.72	1.14	56.85	42.33	49.72
LSD _{0.05}	A	0.01	0.36	1.11	0.46	0.09	0.33	0.57	0.24
	B	0.01	0.44	0.73	0.73	0.01	0.38	0.59	0.26
	A*B	0.01	0.40	ns	0.56	0.01	0.34	ns	0.43

Bd=bulk density, Tp= Total porosity, Fc= Field capacity, Whc=Water holding capacity

The application of soybean straw plus Fungi compilation half recommended dose of mineral fertilizers caused the most considerable significant effect almost under all studied soils for both crops after harvesting. Soil Bd (g m^{-3}) values decreased by 1.46 in sandy soil, 1.43 in calcareous soil, and 1.17 gm cm^{-3} in clay soil, after quinoa growing season, while Bd values decreased to 1.46 in sandy soil, 1.38 in calcareous soil and 1.07 Mg.m^{-3} in clay soil, as compared with control after soybean growing season. A good soil bulk density depended on the content and nature of the organic matter added. This decrease in soil bulk density may be due to increases soil organic matter lead to soil aeration increases. These findings are very close to that obtained by Omran *et al.* (2002). Also results indicated that the values of soil moisture content (Fc, Tp and Whc) increased gradually by increasing the rate added of organic wastes in all treatments. Soybean straw plus Fungi with half recommended dose of mineral fertilizers (T3) caused the most considerable significant effect almost under all studied soils for both crops after harvesting. The higher content in TP, FC, and WHC was 44.78, 20.40 and 29.43 %, respectively for sandy soil, 46.92, 24.87 and 34.82 for calcareous soil, and 57.61, 43.19 and 50.62% for clay soil. However, the rest of treatments had a slight variation among them. The interaction between treatments and soil type for FC in both crops was no significant. Tejada *et al.* (2009) who reported that compost had a positive effect on soil physical (structural stability increased 10.5% and bulk density decreased 13.5%) in respect to the control.

2. Effect of organic fertilizers on plant health

2.1. Productivity of quinoa and soybean

2.1.1. Yield

Five types of organic fertilizers and three types of soils showed significantly increase of yields in two crops over the two-season study. As shown in (Fig 1), soybean straw plus chicken manure combination with half recommended dose of mineral fertilizers (T₂) had much greater yield than the other treatment and control.

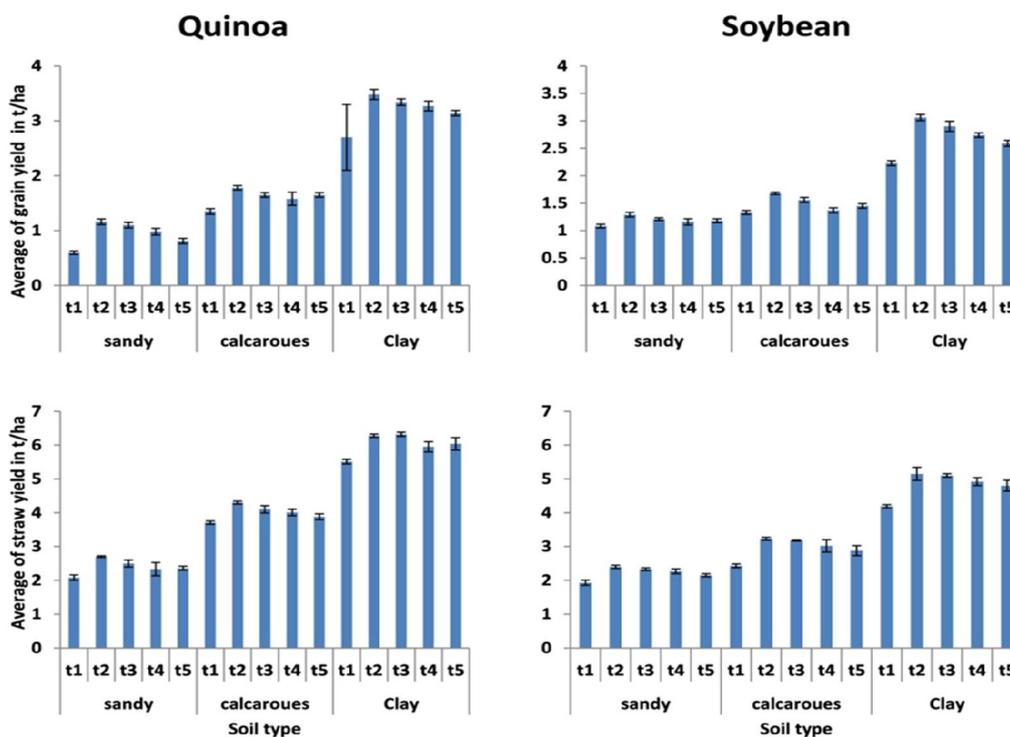


Fig. 1: Effect of residual crop on grain and straw of quinoa and soybean.

The maximum grain and straw yield of quinoa in winter season 3.48 and 6.28 Mg ha⁻¹, respectively was noted in clay soil and they were 1.78 and 4.30 Mg ha⁻¹, respectively was in calcareous soil and they were 1.16 and 2.72 Mg ha⁻¹, respectively, in sandy soil. The rank order of the grain and straw yield in the three soil types was clay > calcareous > sandy soil. Similar trend was also recorded for soybean crop, data showed that the application of T₂ had significant positive effects on the yields of grain and straw of soybean.

The total yields grain and straw of soybean grown on three soils, with a rank order of clay > calcareous > sandy soil with grain and straw yield values of 3.06 and 5.15 Mg ha⁻¹ in clay soil, 1.68 and 3.23 Mg ha⁻¹ in calcareous soil, 1.29 and 2.40 Mg ha⁻¹, respectively, compared to control. High response to compost addition in sandy textured soil may be attributed to adequate levels of plant essential nutrients. The main effect shows that application T₂ significantly increased yield of quinoa grain in sandy soil, although the increase was very slight in soybean yield in both grain and straw. This significant increase in grain and straw yield of quinoa and soybean in both three soils was possible due to the availability of better nutrients and improved development of the plants, along with greater proliferation of roots and tillers due to the favorable effects of compost on soil physical characteristics.

The variation in growth characters at different locations could be due to the variation of growing conditions like soil texture and its chemical properties, air temperature, humidity, (Prado *et al.*, 2014 and Präger *et al.*, 2018). Yamika and Ikawati, (2012) found that the combination of inorganic with organic fertilizers (0, 0.5 and 1.0 Mg ha⁻¹) increased the seed yield up to 3.5 Mg ha⁻¹. Data from other studies showed the positive impact of the organic fertilization on dry matter yield in quinoa reaching 8.65 kg ha⁻¹ and 8.80 kg ha⁻¹ for compost and cow manure, respectively. Kakabouet *et al.*, (2018) found that 100 (N₁) and 200 kg N ha⁻¹ (N₂) and sheep manure were slightly higher in quinoa yield and N uptake.

2.2.2. 1000-seed weight of quinoa, 100-seed weight of soybean, plant height of quinoa and number of soybean pods.

Data in Table (7) the main effect shows that treated quinoa and soybean caused a significant increase especially T₂. The average increase in terms of percent in 1000-seed weight of quinoa utilizing T₂ was 59.56, 56.88 and 37.19 % in sandy soil, calcareous soil and clay soil, respectively compared to control. Meanwhile, using the same treatment with soybean, the average increase in 100-seed weight was 66.7, 74.14 and 68.57% in sandy, calcareous, and clay soil, respectively. Interestingly, quinoa height measured in treated plots via T₂ was much taller than the control which received only mineral fertilizers; the percentage recorded for the increase are 44.89, 33.47 and 39.68 % in sandy, calcareous and clay soil, respectively. The interaction between treatments and soils type for both crops had no significant. The increase in plant height, in response to application of organic and chemical fertilizers is probably due to enhanced availability of nutrients. This significant increase in plant height and 1000-seed weight of quinoa growing in clay soil compared to calcareous and sandy soil may be due to the increase in the percentage of organic matter and to the clay texture, which is reflected in a several other positive properties of clay soil (e.g., cation exchange capacity and water holding capacity). The increase in biological and grain yield could be due to the increase in yield attributes (plant height, number of productive tillers/hill, panicle weight and 1000-grain weight) consequently (Ebaid and El-Refae, 2007).

Salem (2006) reported that application of FYM along with nitrogen fertilizer significantly increased number of panicles per square meter, panicle length, panicle weight, number of filled grains/panicle, 1000 -grain weight and grain yield in rice. (Muhammad *et al.*, (2012). reported that application of 50 % organic and 50 % inorganic N significantly enhanced spike length and thousand grain weight. Regarding the number of soybean pods/plant which reached the maximum with T₂ which resulted in significant increase averaged 20.84, 29.72 and 29.69% in sandy, calcareous and clay soil, respectively. This an indicator for exploiting potential leguminous yield recovery which could be attributed to a continuous supply of nitrogen, phosphorus, potassium to the crop at the early stages and through organic manure at later stages of crop growth, as slow release nutrients. The increase in the number of pods per unit area can be attributed to the increased number of nodes and reduced abortion of flower and pods. The results agree with those obtained by Mandal *et al.*, (2009) who reported significantly higher number of pods per plant in soybean plots treated with NPK+ farmyard manure than in control plots. Liu *et al.*, (2008) also reported that combined application of organic and inorganic

fertilizers as a total basal dressing is beneficial to the balanced release of nutrients; hence this could have probably contributed to the increase in pod number.

Table 7: Effect of some crops residue on some properties of quinoa and soybean yields.

Soils	Treatments	Quinoa yield					
		Ch a	Ch b	Ch a+b	Protein (%)	Plant height (cm)	Weight 1000 seed (gm)
Sandy soil	T1	2.57	0.80	3.37	9.19	42.33	1.83
	T2	2.84	0.89	3.73	15.75	61.33	2.92
	T3	2.81	0.88	3.69	15.19	54.00	2.77
	T4	2.72	0.86	3.58	13.69	49.67	2.48
	T5	2.70	0.85	3.55	13.31	48.33	2.46
	Mean		2.73	0.86	3.58	13.43	51.13
Calcareous soil	T1	2.81	0.83	3.64	10.31	73.67	2.25
	T2	3.02	0.91	3.93	17.19	98.33	3.52
	T3	2.95	0.90	3.85	16.38	97.00	3.45
	T4	2.86	0.87	3.73	15.13	89.67	3.33
	T5	2.82	0.86	3.68	14.88	87.67	3.30
	Mean		2.89	0.87	3.77	14.78	89.27
Clay soil	T1	2.85	0.84	3.69	11.56	82.33	2.85
	T2	3.20	0.92	4.12	18.13	115.00	3.91
	T3	3.15	0.91	4.06	16.94	105.00	3.80
	T4	2.94	0.88	3.82	15.94	95.00	3.75
	T5	2.92	0.88	3.80	15.69	94.33	3.75
	Mean		3.01	0.89	3.90	15.65	98.33
LSD _{0.05}	A	0.021	0.006	0.027	0.48	2.67	2.55
	B	0.042	0.010	0.046	0.33	4.54	2.37
	A*B	0.062	ns	0.065	ns	5.94	2.68
		Soybean yield					
Sandy soil	T1	2.69	0.83	3.52	33.75	80.00	10.12
	T2	3.08	0.94	4.02	39.06	96.67	16.87
	T3	2.96	0.92	3.88	37.81	92.67	15.47
	T4	2.87	0.89	3.76	36.94	88.67	13.73
	T5	2.81	0.88	3.69	36.69	85.33	12.53
	Mean		2.88	0.89	3.77	36.85	88.67
Calcareous soil	T1	2.88	0.86	3.74	35.31	83.00	11.10
	T2	3.33	1.00	4.33	41.81	107.67	19.33
	T3	3.20	0.95	4.15	39.94	101.67	17.65
	T4	3.08	0.93	4.01	37.81	95.67	15.03
	T5	2.94	0.92	3.86	36.94	92.33	14.65
	Mean		3.09	0.93	4.02	38.36	96.07
Clay soil	T1	2.92	0.90	3.82	35.88	88.67	12.28
	T2	3.55	1.19	4.74	43.31	115.00	20.70
	T3	3.32	1.08	4.40	40.69	111.67	18.73
	T4	3.14	0.98	4.12	39.06	98.33	16.74
	T5	3.02	0.96	3.98	37.50	95.00	15.53
	Mean		3.19	1.02	4.21	39.29	101.73
LSD _{0.05}	A	0.046	0.015	0.059	0.40	2.04	0.43
	B	0.058	0.010	0.061	0.29	3.74	0.79
	A*B	0.066	0.03	0.071	0.86	4.87	ns

ch=chlorophyll

2.2. Plant chemical composition

2.2.1. Protein % in seeds:

The most pronounced significant increase effect occurred in soybean which received with T₂; moreover, both T₂ and T₃ were similarly effective in quinoa, giving the highest protein % (Table 7). Protein % in seeds of quinoa and soybean plants and recorded the highest value (15.75 and 39.06%) in

sandy soil, (17.19 and 41.81%) in calcareous soil and (18.13 and 43.31%) in clay soil, respectively. It was increased by (71.38 and 15.73%) in sandy soil, (66.73 and 18.42%) in calcareous soil, and (56.83 and 20.71%) in clay soil, respectively compared to other treatments and control. This could be due to better availability of desired and required nutrients in the crop root zone resulting from its solubilisation caused by the organic acids produced from the decaying organic matter and also the increased uptake by quinoa and soybean root due to increased availability of nutrients in root zone. The results agree with those obtained by Maheshbabu *et al.* (2008) attributed higher protein content in soybean seeds following application of organic manures to availability of required nutrients in the root zone as a result of their solubilization caused by the organic acids produced from the decomposition of organic manures applied.

2.2.2. Chlorophyll content (mg/g fresh leaves):

Results in Table (7) showed all treatments induced chlorophyll in both crops. The most pronounced significant increase effect occurred in soybean which received T₂. The average increase in terms of percent in chlorophyll of quinoa utilizing T₂ were 3.73, 3.93, and 4.12 mg/g fresh leaves in sandy soil, calcareous soil and clay soil, respectively compared to control. Meanwhile, using the same treatment with soybean, the average increase in chlorophyll were 4.02, 4.33 and 4.74 mg/g fresh leaves in sandy, calcareous, and clay soil, respectively. The total leaf chlorophyll concentration significantly increased with T₂, as compared with recommended dose of mineral fertilizers application resulted in greater amount of chlorophyll content, while lowest content was noted with 100% N alone (control). Similar finding has also been reported by Alam *et al.*, (2010), that lower chlorophyll content would limit the photosynthetic potential, lead to a decrease in biomass, and yield.

2.2.3. N, P and K concentration and uptake in grain and straw

Results in Table (8) and Fig. (2 and 3) shown that nutrients concentration and uptake by quinoa and soybean significant increased by organic and bio-fertilizer application than control. The application of chicken manure and straw soybean give the highest values of that nutrients concentration and uptake by quinoa and soybean than other treatments. The results show that T₂ boosted N, P, K quinoa grain uptake by about 231.41, 372.22 and 485% for N, P and K, respectively in sandy soil, 119.7, 269.72, and 250.55% in calcareous soil, 102.04, 203.83 and 163.01%, respectively, in clay soil, over control. Quinoa straw N, P and K uptake was significantly affected by the different treatments. The highest values of N, P and K straw uptake were 83.16, 260 and 179.41% in sandy soil, 70.27, 290.91, and 162.79% in calcareous soil, and 61.41, 243.75, and 93.55% in clay soil, respectively. While the increases due to application T₂, on soybean were 38.25, 270.37 and 258.33% for N, P, and K uptake in sandy soil, 49.55, 238.97 and 208.38 %, respectively, in calcareous soil, 65.67, 192.87 and 194.02%, respectively, in clay soil, over control. The highest values of N, P, and K straw of soybean were 48.29, 271.43, and 237.86 %, respectively, in sandy soil, 61.96, 287.27 and 163.21%, respectively in calcareous soil, 51.99, 192.09, and 141.54%, respectively, in clay soil, over control. Quinoa grain N, P and K uptake in control plots that received only mineral fertilizers in both calcareous and clay soil was almost the same which also was about four to five times greater than those in sandy soil. However, the plant N, P, K uptake response to compost treatment addition led to a significant augmentation that reached the double using T₂. The ranking of soils treatments in respect of total N, P, K % uptake was increased by the order sandy soil > calcareous soil > clay soil, with grain of quinoa, while, total N and K % uptake was increased by the order clay soil > calcareous soil > sandy soil, with grain of soybean, while, total P uptake was increased by the order sandy soil > calcareous soil > clay soil.

These results were in agreement with those of Verma *et al.*, (2006) also found a significantly higher NPK uptake by maize-wheat cropping system by the application of 100% NPK + FYM 10 Mg ha⁻¹. The uptake of N, P, K and Mg by rice plant was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al.*, 1997). Yadav *et al.*, (2005) also reported that the maximum P uptake was noted when 25% N was substituted by green leaf (sesbania) manure. Recommended NPK + FYM 10 Mg ha⁻¹ followed by 50% recommended NPK + FYM 10 Mg ha⁻¹ resulted in higher nutrient uptake compare to the recommended rate of NPK alone (Chaturvedi and Chandel, 2005). Poultry manure (0, 2.5, 5.0, 7.5 and 10 t ha⁻¹) with 100 kg ha⁻¹ NPK mineral fertilizer significantly improved soil nutrient status as shown in increases in organic C, available P. it brought about increases in plant tissue concentrations of N, P and K, plant height, and soybean dry matter yields (Soremi *et al.* 2017).

Table 8: Effect of crop residue on nutrients concentration of quinoa and soybean yield.

Soils	Treatments	Nutrients concentration of quinoa					
		NPK concentration (%) of grain			NPK content(%) of straw		
		N	P	K	N	P	K
Sandy soil	T1	1.47	0.18	0.40	0.95	0.10	0.34
	T2	2.52	0.44	1.21	1.74	0.36	0.95
	T3	2.43	0.41	1.08	1.65	0.31	0.82
	T4	2.19	0.32	0.98	1.56	0.28	0.78
	T5	2.13	0.29	0.96	1.52	0.25	0.72
	Mean	2.15	0.33	0.93	1.48	0.26	0.72
Calcareous soil	T1	1.65	0.21	0.53	1.11	0.11	0.43
	T2	2.75	0.59	1.41	1.89	0.43	1.13
	T3	2.62	0.51	1.29	1.83	0.41	0.99
	T4	2.42	0.40	1.12	1.74	0.35	0.88
	T5	2.38	0.36	1.03	1.66	0.32	0.83
	Mean	2.36	0.41	1.08	1.65	0.32	0.85
Clay soil	T1	1.85	0.28	0.74	1.27	0.16	0.62
	T2	2.90	0.66	1.51	2.05	0.55	1.20
	T3	2.71	0.53	1.43	1.93	0.47	1.08
	T4	2.55	0.43	1.35	1.85	0.37	0.98
	T5	2.51	0.40	1.26	1.80	0.34	0.94
	Mean	2.50	0.46	1.26	1.78	0.38	0.96
LSD _{0.05}	A	0.077	0.011	0.044	0.043	0.017	0.035
	B	0.053	0.017	0.034	0.031	0.019	0.016
	A*B	ns	0.038	0.059	ns	0.022	0.036
Nutrients concentration of soybean							
Sandy soil	T1	5.40	0.10	0.40	1.09	0.09	0.32
	T2	6.25	0.31	1.20	1.30	0.26	0.87
	T3	6.05	0.28	1.10	1.23	0.27	0.80
	T4	5.91	0.30	0.94	1.17	0.23	0.74
	T5	5.87	0.27	0.95	1.24	0.21	0.71
	Mean	5.90	0.25	0.92	1.21	0.21	0.69
Calcareous soil	T1	5.65	0.16	0.52	1.19	0.11	0.48
	T2	6.69	0.43	1.27	1.45	0.32	0.95
	T3	6.39	0.36	1.20	1.35	0.29	0.86
	T4	6.05	0.34	1.14	1.31	0.27	0.84
	T5	5.91	0.28	1.04	1.27	0.26	0.82
	Mean	6.14	0.31	1.03	1.31	0.25	0.79
Clay soil	T1	5.74	0.22	0.63	1.31	0.16	0.57
	T2	6.93	0.47	1.35	1.62	0.38	1.12
	T3	6.51	0.41	1.25	1.52	0.36	1.00
	T4	6.25	0.38	1.21	1.43	0.31	0.98
	T5	6.00	0.34	1.15	1.39	0.30	0.96
	Mean	6.29	0.36	1.12	1.45	0.30	0.93
LSD _{0.05}	A	0.064	0.029	0.019	0.033	0.014	0.028
	B	0.047	0.042	0.024	0.047	0.023	0.017
	A*B	0.14	ns	0.052	0.065	0.018	0.037

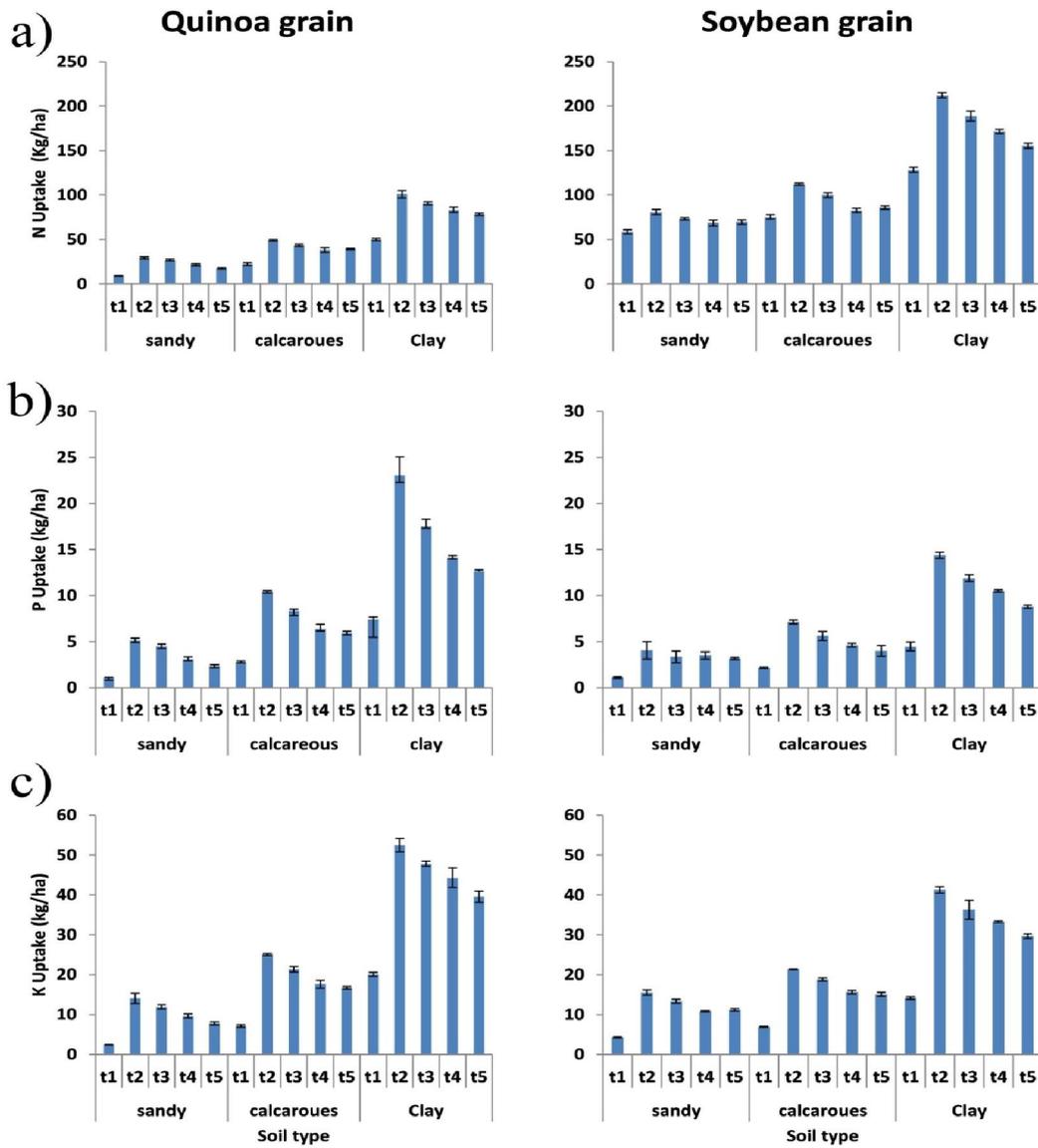


Fig. 2: Effect of residual crop on grain nutrients uptake of quinoa and soybean.

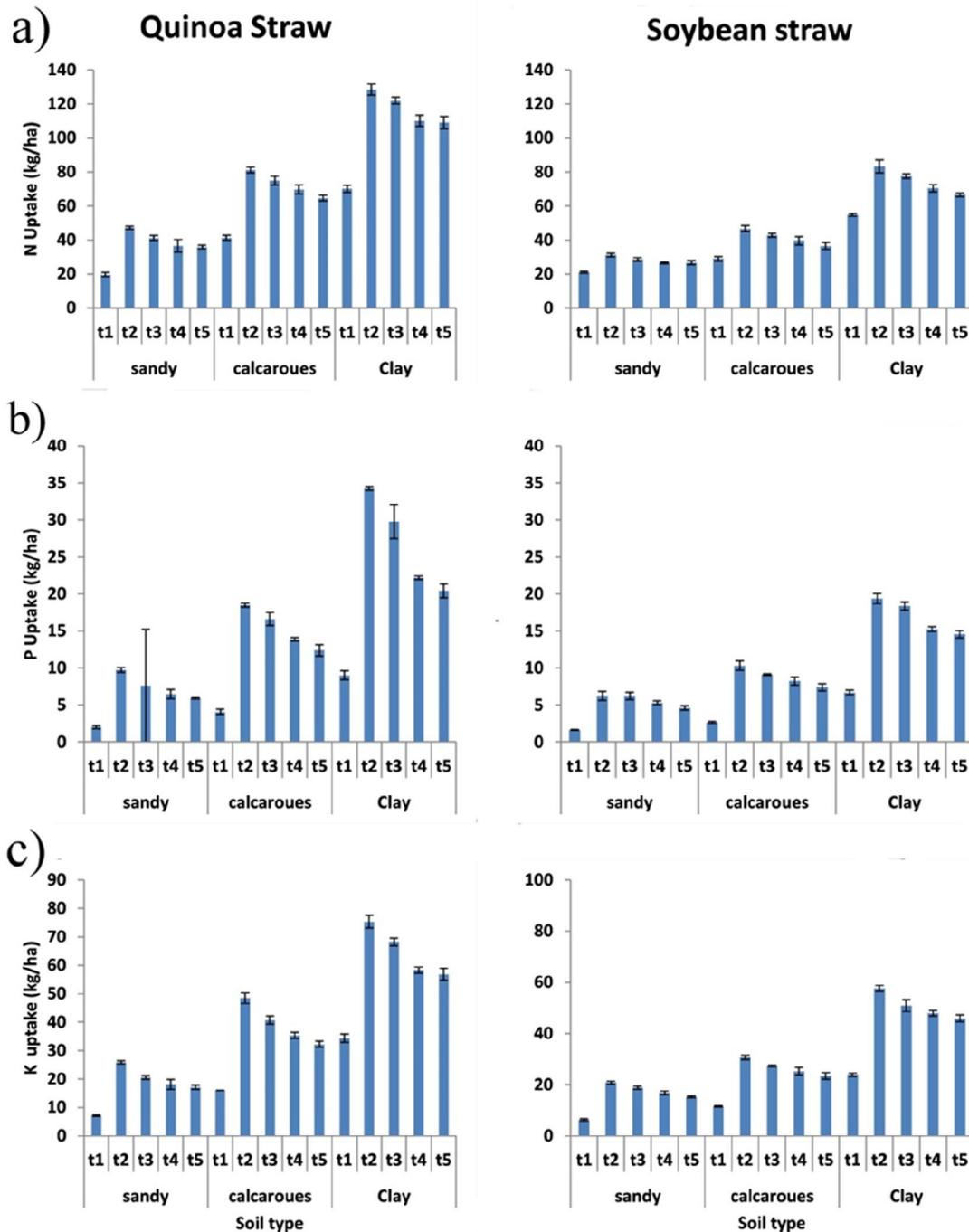


Fig. 3: Effect of residual crop on straw nutrients uptake of quinoa and soybean.

Conclusion

From the present study, it has been observed that the application of (T₂) soybean straw plus chicken manure combination of half recommended dose of mineral fertilizer resulted in be the best nutrient management practice among the five different treatments followed, not only producing the highest growth, yield and yield attributes but also improving the nutrient uptake and the availability of soil nutrient status after harvest of quinoa and soybean. This practice considerably improved soil physiochemical properties after the quinoa growing season of treatment onwards, and significant differences were found even after soybean growing season of application. Studying the various soil

types, and their responds to compost in addition to their influence on quinoa and soybean growth, it is concluded that quinoa is responsive to compost as organic fertilizer that was highest effective when applied on sandy soil for high growth performance, soil fertility improvement.

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