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TEMPORARY IMPACTS OF DIFFERENT FERTILIZATION SYSTEMS ON SOIL HEALTH UNDER POTATO MONOCROPPING.

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ABSTRACT

Inapt agricultural intensification practices coupled with irresponsible use of organic and inorganic fertilizers has deteriorated soil health. Field and incubation experiments were conducted to determine temporary impacts of different fertilization systems on some labile soil biochemical and biological properties following potato monocropping under arid conditions. Application of different fertilization systems caused obvious significant temporal changes on SOC, DOC, DON, microbial biomass-C ($C_{-MIC.}$), -N ($N_{-MIC.}$), -P ($P_{-MIC.}$), bacterial and fungi counts and net N mineralization ($N_{-MIN.}$). Levels of SOC, DOC, $N_{-MIN.}$, microbial biomass-C ($C_{-MIC.}$), -P ($P_{-MIC.}$), bacterial and fungi counts and soil respiration (SR) were significantly increased under organic and integrated fertilization systems compared with inorganic nano or non-nano NPK fertilization system, while levels of microbial biomass-N ($N_{-MIC.}$) and DON were markedly increased under nano or non-nanofertilizers compared to organic or integrated (organic + inorganic) fertilizers. Several ratios of the studied biochemical and microbial indicators namely DOC: DON, $C_{-MIC.}$: SOC ($Q_{-MIC}\%.$) and $C_{-MIC.}$: $N_{-MIC.}$ followed an identical trend as relative chemical and biological properties being greatest in organic, integrated and minimal in nano or non-nano NPK chemical fertilizers. By contrast, higher values of metabolic quotient (qCO_2) were recorded in nano or non-nanofertilizer treatments suggesting that microbial biomass was less efficient under high maintenance of soil carbon.

Enzyme activities of dehydrogenase (DH), β-glucosidase (βG) and acid phosphatase (Ac-P) were in the order of organic > integrated > inorganic fertilization systems, while enzyme activity of urease (UR) was in the vice versa order. Results of this research induced significant temporal differences in clay soil biochemical and biological properties even in the short-term under potato monocropping. Integrated fertilization system of NPK non-nano or nanofertilizers with organic fertilizers recorded greater levels of SOC, DOC, $N_{\text{-MIN.}}$, microbial biomass-C ($C_{\text{-MIC.}}$), -P ($P_{\text{-MIC.}}$) and SR relative to sole inorganic fertilizers even though applied at lower rates. It is, therefore, important for clay soil under monocropping system to poise organic and inorganic fertilization system that enhances soil health and soil organic matter build-up.

Keywords: Fertilization system, Microbial biomass, Soil respiration, Nanofertilizers.

INTRODUCTION

Soil health and soil quality are considered synonyms and can be interchangeably used as the continued capacity of the soil to function as alive vital ecosystem that sustains plants, animals and humans (Suppan, 2017; Rinot *et al.,* 2019). Soil quality involves both dynamic and inherent soil properties, while soil health include only dynamic soil properties that transform as a result of soil land uses and management over time reflecting that soil is a lifelike ecosystem that needs to be wisely managed to preserve function capability. In contrast, inherent soil properties relevant to soil natural properties resulted from soil forming factors, such as the type of parent material, topography, organisms, climate, and time and cannot generally be influenced by anthropogenic activity (Bünemann *et al.,* 2018).

Monocropping of potato in Egypt is a common phenomenon in most governorates of the country being monocropped in fertile soils and endued with intensive fertilization. Consequently, soil health could have been deteriorated since potato productivity has been declining despite high rates of fertilizers applied and high yielding cultivars. Egypt is the largest African country producing potato, and ranks 14th in the world, therefore, authorities and farmers has the scope of increasing the intensification of crop production using intensive fertilization systems as the agricultural year is divided into three planting successive seasons; summer, *nili,* and winter. Intensive agricultural practices necessitate high fertilizers inputs to achieve high yields and hence improper agricultural intensification joined with careless use of fertilizers has deteriorated soil health. Thus, there is a rising cognizance on the use of eco-friendly sustainable fertilizers that place stress on soil health conservation on short and long-term bases (Rinot *et al.,* 2019). In addition, current methods of fertilization significantly contribute to greenhouse gas emissions from agricultural sectors therefore, nanoscience and nanotechnology are being exploited for producing nanofertilizers to ensure nutrients use efficiency even though enhancing crop yields (Reay et al. 2012; El-Ramady et al. 2018; Abdelsalam et al. 2019; and Eissa 2019).

Fertilizers are organic and inorganic products applied to soil ecosystems for compensating or satisfying the essential nutrients needs for plant growth and health. Inorganic fertilizers play an important role in achieving crop yield targets, yet latent inefficiencies in conventional fertilizer use management can lead to disastrous environmental and economic concerns. Much of the NPK fertilizers applied to farming systems are lost to water and air resulting in harmful environmental impacts such as leached nitrate and phosphates runoff into aquatic ecosystems causing eutrophication and release of N-oxides into the atmosphere (Schroder et al. 2011, El-Ramady *et al.,* 2018). Organic fertilizers for instance composts trigger continual nutrient availability, microbial activity and growth due to high content of labile carbon (C) and nitrogen (N) (Bai et al. 2015). Organic fertilizers are progressively decayed in soils providing a continual release of nutrients including C, P, S and N compared to fast release of nutrient when inorganic fertilisers are used (Fischer and Glaser 2012). Although compost application conveys various profits to soil, i.e. increasing soil conservation, improving water holding and soil structure (Celik et al. 2004), compost contributes significantly to greenhouse gas emissions (Jiang et al. 2011).

Intensive agriculture for food production and consequent fluctuations in soil health is a common phenomenon and hence there is worldwide interest in rating the shifts in soil health due to agricultural practices (Dick, 1992; El-Ramady et al. 2018; Abdelsalam et al. 2019). Enhancement of global agricultural production using innovative nanoscience technology to produce new types of nanofertilizers is crucial to meet the coming stresses of population growth. Soil health depends on a large number of physicochemical and biochemical soil properties considered as early indicators for nutrient cycles of N and C and highly sensitive to changes in agricultural management practices such as fertilization systems (Melero *et al.,* 2006; Marinari *et al.,* 2006, Zagal *et al.,* 2009). Soil biochemical properties reflect the size of microbial biomass activity (microbial biomass C, N and P, respiration etc.) and its related enzymatic activity involved in the C, N, S and P cycles in soil ecosystem and considered as highly significant for soil ecological functions (Monaco *et al.,* 2008). In addition, changes in soil microbial biomass and enzymatic activities due to changes in soil fertilization types and systems are more rapid and swift (Sparling, 1992; Truu *et al.,* 2008).

Organic carbon and carbon storage in agricultural soils are the major and most labile carbon pools on the earth's mantle ecosystem and CO_2 exchange between agricultural soils ecosystems and the atmosphere has a significant impact on the carbon cycle in soils (Tang *et al.,* 2010; Yang *et al.,* 2018; Song *et al.,* 2019). Among significant factors affecting net soil ecosystem CO_2 exchange and soil organic carbon (SOC) and storage is the fertilization type and method applied (Liu *et al.,* 2016; Yang *et al.,* 2018). Temporary responses of soil microbiological and biochemical properties to different organic and inorganic fertilization systems are considered to be sensitive indicators for detecting changes in soil health (Dinesh *et al.,* 2012; Dinesh *et al.,* 2013). However, data on biochemical and microbiological properties under field conditions of potato monocropping, in response to various organic and inorganic fertilizers compared to nanofertilizers is still of little research. Different potato fertilization systems in Egypt are followed either exclusively fertilized with chemical NPK fertilizers or applied with a combination of inorganic and organic inputs or it is supplied with only different organic fertilizer types under organic farming systems.

The scientific aim of this research therefore was to determine temporary impacts of different fertilization systems namely organic (compost), inorganic (NPK non-nanofertilizers or only NPK nanofertilizers) and integrated fertilization systems (organic + inorganic) on various labile microbial and biochemical soil properties and its interrelationships reflecting soil health of potato monocropping cultivation. It was hypothesized that all fertilization treatments would temporarily affect soil biochemical and biological variables and NPK non-nano or nanofertilizers can be effectively applied individually or integrated with organic fertilizers to deliver nutrients without harming the concocts of soil health.

MATERIALS AND METHODS

Experimental site details and soil characteristics

Field experiment was conducted at the experimental farm facilities (28º18'16"N latitude and 30º34'38"E longitude), Faculty of Agriculture, Minia University, Egypt, in order to study effects of different fertilization systems on biochemical and biological soil properties as sensitive indicators of soil health after monocropping cultivation of potato crop (*Solanum tuberosum* L.). Soil of the experimental site had a clay texture and classified as alluvial soil according to Abd El-Azeim *et al.,* (2016). Prior to the initiation of the field trial, clay soil detailed in Table 1 was collected, air dried, sieved to < 2.0 mm, and composite sub-samples were used to determine the basic soil physicochemical properties using standard methods derived from Jackson (1973), Black (1965), Avery and Bascomb (1982), Page *et al.,* (1982), and Bao (2005).

Table 1. Physicochemical properties of the soil investigated.

Soil Property			
Soil Chemical Properties		Soil Physical Properties	
pH (1:2.5 water)	7.7 (7.4)[a]	F.C %	42.45
$CaCO_3$ (g kg^{-1})	17.9	PWP %	13.78
CEC (cmol$_c$ kg^{-1})	37.87	WHC %	48.76
O.M (g kg^{-1})	28.61[b]	A.V (F.C – PWP) %	28.67
Total N (g kg^{-1})	1.29	A.V (WHC – PWP) %	34.98
Total C/N Ratio	22.18	Bulk Density (BD) g/cm^3	1.31
S.O.C g kg^{-1}	18.48	Particle Density (PD) g/cm^3	2.22
Organic N (g kg^{-1})	0.76	Clay (%)	56.45
Organic C/N Ratio	24.31	Sand (%)	17.76
Mineral N (mg kg^{-1})	58.46	Silt (%)	25.79
Total P (g kg^{-1})	0.56	Soil texture	Clay
Available P (mg kg^{-1})	13.11		
Total K (g kg^{-1})	4.37		
C-$_{mic}$ (mg kg^{-1})	112.89		
N-$_{mic}$ (mg kg^{-1})	22.45		
C-$_{mic}$: N$_{-mic}$	5.03		
EC (dS m^{-1} at 25°C)	1.35		

[a] Figures in parentheses are pH values obtained for soil by $CaCl_2$ extraction ratio of 1:2.5. [b] Organic matter determined by loss on ignition.

Experiment procedures and fertilization systems.

Soil plot area was 8 m^2, prepared manually after the experimental field was deeply turn over using Chesil plow and then levelled accurately to break soil clods and bring soil to desired tilth. Factorial design of nine treatments in a randomized complete block design was used with three replicates. Nile compost was added during soil preparation before ploughing as organic fertilizer at the rate of 40 m^3 ha^{-1}. Field plots were irrigated fifteen days prior to sowing then potato tubers sowing was done at 10 cm depth at the tuber rates of 1500 kg ha^{-1} by opening furrows in lines at a distance of 50 cm among rows and the distance between hills was 25 cm apart. Potato tubers; cv Cara were obtained from Mallawy Agricultural Research Centre (ARC), Ministry of Agriculture, Egypt. Tubers were divided into pieces, averaging approximately 35 g weight, then potato tuber pieces were sterilized with Kapetan 1% at the rate of 1.25 kg/ton for 5 min, then sterilized potato tuber pieces were sown 10 cm depth on summer season. Intercultural operations other than abovementioned treatments were followed as per schedule according to potato cultivation recommendations of Agricultural Research Centre in Egypt.

The fertilization systems employed were in accordance with the Agricultural Research Centre in Egypt on potato production and are being recommended to the farmers for adoption. Fertilization systems employed were organic where only compost was applied (control), synthetic fertilization system involved solely recommended levels (100%) of chemical NPK non-nanofertilizers or solely recommended (100%) of NPK nanofertilizers and integrated fertilization system involved a mixture of compost as an organic fertilizer plus solely recommended (100%) or lower levels (50%), (25%) of NPK nano or non-nanofertilizers. In this experiment, organic fertilization system using Nile compost was added during soil preparation before ploughing as organic fertilizer at the rate of 40-ton ha^{-1}. Nutrient composition and physicochemical properties of the Nile compost is presented in Table (2). Inorganic fertilization system applied were nitrate ammonium (33%N), triple super phosphate (15% P_2O_5) and potassium sulphate (48% K_2O) used as resources for NPK chemical fertilizers at the recommended levels for potato crop at rates of 350 nitrogen, 85 phosphorus, and 200 potassium kg ha^{-1} as recommended by the Egyptian Ministry of Agriculture, Egypt (Selim *et al.*, 2009).

Table 2. Nutrient composition and physicochemical properties for the investigated compost.

Compost property	Organic Nile compost
Moisture weight %	36.60 %
pH (1 - 2.5)	7.90
EC mS/cm at 25 ^{0}C	5.20
CEC (cmol$_+$ kg^{-1})	45.66
Dry solids %	63.40
Ash %	9.90
Total organic carbon (g kg^{-1}) (D.M)	265.0
Total N (g kg^{-1}) (D.M)	10.0
C/N Ratio	26.50
Total P (g kg^{-1}) (D.M)	5.0
N/P Ratio	2.00
Total K (g kg^{-1}) (D.M)	9.0
Total Ca (g kg^{-1}) (D.M)	26.3
Total Mg (g kg^{-1}) (D.M)	6.6

Individual nano-N, nano-P and nano-K fertilizers in liquid formulations were imported from India containing 19% of each nutrient of NPK. These fertilizers are eco-friendly made through biological process, and have been designed to match chemical fertilizers in terms of nutrient content and application rates. These revolutionary nutritional agricultural inputs of nano-N, nano-P and nano-K fertilizers are developed by private company (Pratishtha) in India in association with Indian Council of Agricultural Research as complete nutritional nanofertilizer of NPK for crops. The experimental treatments included therefore were as following:

1. (Control) = Compost as organic fertilizer at the rate of 40-ton ha^{-1}.
2. (FS$_1$) = 100% NPK non-nano fertilizers alone at recommended levels.
3. (FS$_2$) = 100% NPK nanofertilizers alone equal to recommended levels.
4. (FS$_3$) = 100% NPK non-nanofertilizers + compost at the rate of 40-ton ha^{-1}.
5. (FS$_4$) = 100% NPK nanofertilizers + compost at the rate of 40-ton ha^{-1}.
6. (FS$_5$) = 50% NPK non-nanofertilizers + compost at the rate of 40-ton ha^{-1}.
7. (FS$_6$) = 50% NPK nanofertilizers + compost at the rate of 40-ton ha^{-1}.
8. (FS$_7$) = 25% NPK non-nanofertilizers + compost at the rate of 40-ton ha^{-1}.
9. (FS$_8$) = 25% NPK nanofertilizers + compost at the rate of 40-ton ha^{-1}.

Soil sampling and incubation.

At harvest stage, dated after 115 days from planting, a sample of one-kilogram soil was taken from each experimental plot for incubation under controlled conditions to determine changes in soil biochemical and biological properties. Soil samples were taken directly before tubers harvest from the inner of each plot, cleared of all root debris and transferred for soil laboratory. Once in the laboratory, the soils were sieved (< 2mm) and then incubated for 10 days at 30^0 C under 65% of soil field capacity.

Analyses of soil biochemical properties.

After incubation, soil samples for the determination of soil biochemical properties were sieved to pass a 0.5 mm mesh and reported means were calculated on soil oven dried bases (105^{0}C). For determination of net N mineralization (N$_{\text{-MIN}}$), before and after incubation, 10 g soil was extracted with 50 mL of 2 M KCl for 30 min, and by steam distillation using N analyser (Kjeltech 2100, Foss), NH_4^+-N and total inorganic N (NH_4^+-N and NO_3^--N) were determined (Mulvaney, 1996). Soil mineralization capacity was demarcated by differences between values found before and after incubation. Walkley and Black method was used to determine soil organic C (SOC) (Nelson and Sommers, 1996), steam distillation method using N analyser (Kjeltech 2100, Foss) for mineral N (Mulvaney, 1996). Dissolved organic nitrogen (DON) and dissolved organic carbon (DOC) were determined by the method described by Smolander and Kitunen (2002) using multi N/C Analyzer (Jena, Germany).

After aerobic incubation, the chloroform fumigation-extraction method of 25 gm of moist soil (Brookes *et al.*, 1982; Wu *et al.*, 1990; Dinesh *et al.*, 2013) was used to determine soil microbial biomass carbon (C$_{\text{-MIC}}$), microbial biomass nitrogen (N$_{\text{-MIC}}$) using (multi N/C 2100, analyzer Jena), and microbial biomass phosphorus (P$_{\text{-MIC}}$) using k_{EC} of 0.45, k_{EN} of 0.54 and k_{EP} of 0.40, respectively. Soil basal respiration (SR) was measured as the cumulative amounts of CO_2 evolved from moist soil, adjusted to 65% water field capacity, and incubated for ten days at 30^{0}C in the dark. The CO_2 accumulated amount was then measured using NaOH vials trap and titrated with HCl or the CO_2 accumulated was analysed using gas chromatography technique described by Liu *et al.,* (2012). Metabolic quotient ($q\text{CO}_2$) was calculated as the ratio of basal respiration (SR) to microbial biomass carbon unit ($\text{C}_{\text{-MIC}}$) according to Plaza *et al.,* (2016).

Analyses of soil enzyme activities.

As described by Tabatabai (1994), dehydrogenase (DH) activity was estimated using 2,3,5-triphenyltetrazolium chloride (TTC) as the substrate, urease (UR) using urea as the substrate (Kandeler and Gerber, 1988), acid phosphatase (Ac-P) using *p*-nitrophenyl phosphate as the substrate (Chen *et al.,* 2013), β-glucosidase (βG) using *p*-nitrophenyl-β-d-glucopyranoside as the substrate (Eivazi and Tabatabai, 1988; Chen *et al.,* 2013). The amount of *p*-nitrophenol released in all these cases was estimated spectrophotometrically and all enzyme activities were expressed as products per unit of dry soil mass and incubation time.

Soil resistance index (SRI) and total bacteria and fungi.

Plate count technique in accordance with Alef (1995) was used to determine total counts of bacteria and fungi in soil samples after potato monocropping cultivation. On nutrient agar, colony forming units (CFU) of total bacteria was counted, while colony forming units (CFU) of total fungi was counted on potato dextrose agar media. The soil resistance index (SRI) was determined as the counts of bacteria or fungi withstand each fertilizer type using the equation developed by (Orwin and Wardle, 2004).

$$\text{RS}\,(t_0) \quad = \quad \frac{1 - 2\,[D_0]}{(C_0 + [D_0])}$$

The index proposed for resistance index (SRI) was calculated as (D_0) is the difference between undisturbed control (C_0) (organic fertilized soil) and the disturbed soil (F_0) (inorganic fertilized soil) at the end of the disturbance time (fertilization) (t_0), (i.e time $_0$ or t_0 at the end of the experiment). This index is symmetrical with the control, as this takes into account differences in the amount of change in soil microbial biomass that a disturbance could cause considering fertilizer type is a disturbance factor. This index of resistance is confined between +1 and -1, indicating +1 treatment had no disturbance effect (greatest resistance), and inferior data show stronger effects (low resistance).

Statistical analyses.

Experimental treatment means were statistically subjected to variance analysis and presented as mean values. Significance of the differences was estimated and compared using Duncan test at 5% level of probability ($p < 0.05$). Interrelationships between soil parameters was measured using Pearson's correlations and all the statistical analyses were carried out using "SAS" computer software package (2013).

RESULTS AND DISCUSSIONS

Soil biochemical properties

The soil biochemical properties studied were soil pH, O.M, CEC, net N mineralization ($\text{N}_{\text{-MIN.}}$), dissolved organic-N (DON), dissolved organic-

C (DOC) and soil total organic carbon (SOC) (Table 3). Soil O.M, CEC, mineral N, SOC and DOC were significantly influenced by different fertilization systems and varied markedly between organic (compost), integrated fertilization system (organic + inorganic), and inorganic (NPK nano or non-nanofertilizers). All these soil parameters were significantly greater in organic (control) and integrated fertilization systems compared to inorganic fertilization system except for DON and mineral N where these values were greater in inorganic treatments (NPK nano or non-nanofertilizers) than organic treatment. However, soil pH values were not significantly affected by different fertilization systems. Generally, a perusal of data represented in Table (3), a significant use impact of organic and integrated fertilization systems (nano or non-nanofertilizers + organic compost) was observed on soil biochemical quality parameters compared to inorganic fertilization system. Soil biochemical characteristics of the investigated soil after potato monocropping cultivation exposed obvious improvements at all organic or integrated fertilization treatments. The experimental results showed among different fertilization treatments, treatment FS_8 (25% NPK nanofertilizers + compost at the rate of 40-ton ha^{-1}) resulted in higher increases in most soil parameters compared to other treatments though statistically was at par with treatments FS_6, FS_5 (50% NPK nano or non-nanofertilizers + compost at the rate of 40-ton ha^{-1}) and control. Founded on this research, it is preferable to integrate organic compost plus NPK nanofertilizers on non-nanofertilizers due to the priority of lower rates of nanofertilizers on a full dose of NPK non-nanofertilizers (El-Sharkawy *et al.*, 2017; Sohair EED *et al.,* 2018; Burhan and Hassan, 2019).

Specifically, soil concentrations of organic carbon (SOC) and labile organic fractions such as dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) were significantly influenced by the application of different fertilization systems (Table 3). Means of SOC ranged from 18.49 to 23.40 g kg^{-1} across different fertilization systems, where SOC levels were significantly greater in organic (control, 23.4 g kg^{-1}) followed by integrated (FS_7, 22.49 g kg^{-1}), and inorganic treatments of NPK non-nanofertilizers (FS_1, 18.49) or nanofertilizer (FS_2, 20.07 g kg^{-1}). Whereas, means of dissolved organic carbon (DOC) ranged from 194.98 to 293.44 mg kg^{-1}, recording obvious significant increase in compost organic treatment (control) over integrated and inorganic treatments. In contrast, inorganic NPK fertilization system either nano or non-nano and integrated fertilization system were positively affected dissolved organic nitrogen (DON) levels compared to organic fertilization treatments. A significant use effect of nano and non-nano fertilizers alone or integrated with organic compost was observed on the DON at all application rates except for FS_1 (100% of NPK non-nanofertilizers).

Table 3. Soil biochemical properties as impacted by different fertilization systems.

		Soil biochemical property							
Treatment		pH (1:2.5 water)	O.M (g kg^{-1})	CEC (cmol$_c$ kg^{-1})	N$_{-MIN}$ (mg kg^{-1})	SOC (g kg^{-1})	DOC (mg kg^{-1})	DON (mg kg^{-1})	DOC: DON
Control		7.79	35.38^{a}	40.11^{bc}	78.36^{f}	23.40^{a}	293.44^{a}	68.71^{bc}	4.30^{a}
Inorganic	FS$_1$	7.76	28.21^{b}	36.44^{e}	112.70^{de}	18.49^{e}	233.38^{e}	64.68^{c}	3.67^{b}
	FS$_2$	7.77	28.10^{b}	37.39^{de}	119.99^{cd}	20.07^{cde}	196.74^{f}	73.77^{abc}	2.67^{de}
Integrated	FS$_3$	7.80	34.14^{a}	39.08^{cd}	107.48^{d}	21.41^{bc}	194.98^{f}	76.21^{abc}	2.57^{e}
	FS$_4$	7.78	34.48^{a}	39.13^{cd}	117.46^{de}	21.56^{bc}	252.45^{cd}	85.11^{a}	2.97^{cde}
	FS$_5$	7.79	33.64^{a}	38.82^{cd}	129.47^{bc}	19.69^{de}	263.44^{b}	83.78^{a}	3.15^{bcd}
	FS$_6$	7.75	35.37^{a}	41.44^{ab}	134.75^{ab}	20.99^{bcd}	260.46^{bc}	81.17^{a}	3.26^{bc}
	FS$_7$	7.75	35.23^{a}	40.03^{bc}	140.44^{a}	22.49^{ab}	246.31^{d}	77.01^{ab}	3.20^{bcd}
	FS$_8$	7.80	35.70^{a}	41.88^{a}	139.08^{ab}	22.37^{ab}	257.60^{bc}	81.75^{a}	3.16^{bcd}
L.S.D $_{0.05}$		0.092	2.41	1.4648	10.322	1.6699	10.433	11.81	0.5663

Dissolved organic nitrogen (DON) ranged from 64.68 to 85.11 mg kg^{-1} across treatments, and among treatments FS_4 treatment however at par with FS_5 and FS_6 resulted in significantly higher DON (85.11 mg kg^{-1}) than other treatments in comparisons. Among treatments, the inorganic NPK non-nano treatments (FS_1) recorded minimum levels of SOC and DON, while the integrated treatment of FS_3 recorded the lowest level (194.98 mg kg^{-1}) of dissolved organic carbon (DOC). In general, the ratio of dissolved organic carbon to dissolved organic nitrogen (DOC: DON) was balanced with DOC across all fertilization systems and ranged from 2.57 for FS_3 treatment to 4.30 for control (organic treatment). Different fertilization systems obviously affected dissolved soil organic substrates (DOC and DON) and soil levels of SOC, though at varying degrees according to each fertilizer type. A fertilizer type and rate effect upon soil biochemical properties is well established in the literature by many researchers (Wang *et al.*, 2008; Fang *et al.*, 2009; Rifai *et al.*, 2010; Dinesh *et al.*, 2013; Jian *et al.*, 2016; song *et al.*, 2019).

Organic compost supplied readily metabolizable carbon via SOC and DOC, this in turn provide energy for microbial biomass carbon and phosphorus reflecting soil value increases in C_{-MIC} and P_{-MIC}. Positive strong intercorrelation ($p < 0.05$; n = 24**)** were figured between C_{-MIC} in relation to soil biochemical properties such as SOC ($r = 0.69$), and DOC ($r = 0.64$) (figure 1). Also, intercorrelations were found between P_{-MIC} and SOC ($r = 0.38$) and DOC ($r = 0.33$). In contrast, this study revealed that, soil microbial biomass nitrogen (N_{-MIC}) values were identical and not significantly correlated with soil properties of SOC ($r = 0.01$) or DOC ($r = 0.01$) indicating lower microbial and enzyme activities. On the contrary to DOC, inorganic fertilization system enhanced DON levels in the soil under investigation reflected by positive correlation between N_{-MIC} and DON ($r = 0.57$) and these positive effects has been demonstrated in many literature (Dinesh *et al.*, 2013; Jian *et al.*, 2016; Song *et al.*, 2019). Dissolved organic nitrogen (DON) is used as a measure of labile substrate N for soil microorganisms nutrition exactly as labile C as measured by dissolved organic carbon (DOC), even though weak correlation was observed between DOC and DON ($r = 0.1$; $p<0.05$; n= 20).

Also, in this research, the availability of labile C was evaluated by Q_{-MIC} as the percentage of microbial biomass carbon (C_{-MIC}) to soil organic carbon (SOC) (Anderson and Domsch, 2010; Dinesh *et al.*, 2012; Jian *et al.*, 2016). Results of this research indicated that soil levels of Q_{-MIC} ranged from 1.187 to 2.057% across different fertilization systems and being higher in the organic fertilization system due to high soil dissolved organic carbon (DOC) content which conducted more efficient microbial biomass and enzymatic activities.

Soil biological and microbial biomass properties.

Soil biological properties studied were microbial biomass-C ($C_{-MIC.}$), microbial biomass-N ($N_{-MIC.}$) and microbial biomass-P (P_{-MIC}), soil respiration (SR), metabolic quotient (qCO_2), soil microbial population (bacterial and fungi counts) and enzyme activities of dehydrogenase (DH), urease (UR), β-glucosidase (βG) and acid phosphatase (Ac-P). Microbial biomass carbon (C_{-MIC}) means ranged from 227.76 to 479.46 mg kg^{-1}, microbial biomass nitrogen (N_{-MIC}) ranged from 31.04 to 55.23 mg kg^{-1}, and microbial biomass phosphorus (P_{-MIC}) ranged from 16.44 to 35.48 mg kg^{-1}, reflecting obvious improvements in between different fertilization systems (Table 4). The greatest levels of C_{-MIC} were recorded in the control treatment (organic compost), while the greatest levels of P_{-MIC} were in integrated treatment (FS_5), and N_{-MIC} was in integrated fertilizer treatment (FS_7). Individual usage of nano or non-nano fertilizers (inorganic fertilization system) resulted in a significant drop in C_{-MIC}, represented by an average 52.5% and 41,76% compared to organic and integrated treatments, respectively. Organic fertilization system (control) recorded highest significant value of C_{-MIC} over both full recommended dose of inorganic treatments (nano and non-nano) and all six integrated treatments in comparison (organic + inorganic), even though, C_{-MIC} levels in all integrated treatments were highly significant compared to individual inorganic treatments.

By complete contrast, inorganic fertilization (nano and non-nano NPK fertilizers) significantly increased N_{-MIC} levels compared to organic treatment, while integrated treatments N_{-MIC} levels were significantly higher than both organic and inorganic treatments and it was almost identical among integrated treatments. Similarly, P_{-MIC} followed the same trend of C_{-MIC}, where P_{-MIC} levels in inorganic treatments were lower by 24.41 to 53.66% compared to organic and integrated fertilization systems as it was almost identical and insignificant in between these integrated treatments. Both ratios of C_{-MIC}: N_{-MIC} and C_{-MIC}: SOC (Q_{-MIC}%) ranged from 5.96 to 15.45 and from 1.187 to 2.057%, respectively, across treatments, being lower in inorganic treatments whether NPK nano or non-nanofertilizers compared to organic and integrated treatments. However, higher and significant C_{-MIC}: N_{-MIC} and C_{-MIC}: SOC ratios were recorded by organic treatment (control) compared to both integrated and inorganic fertilization treatments. In contrast to microbial biomass carbon (C_{-MIC}) and microbial biomass phosphorus (P_{-MIC}), microbial biomass nitrogen ($N_{-MIC)}$ levels were obviously cumulated at greater rates in all inorganic fertilization treatments. Evidently, after artificial NPK non-nano or nanofertilizers, availability of nitrogen increased encouraging soil microbes to immobilize N leading to N_{-MIC} increases. This was in agreement with the results of Wang *et al.*, (2008) and in disagreement with Omari *et al.*, (2017), they stated that the privilege of inorganic fertilization system, though applied at lower rates was evident on soil biochemical properties relative to the reference sites where organic and integrated soil improvement approaches were applied

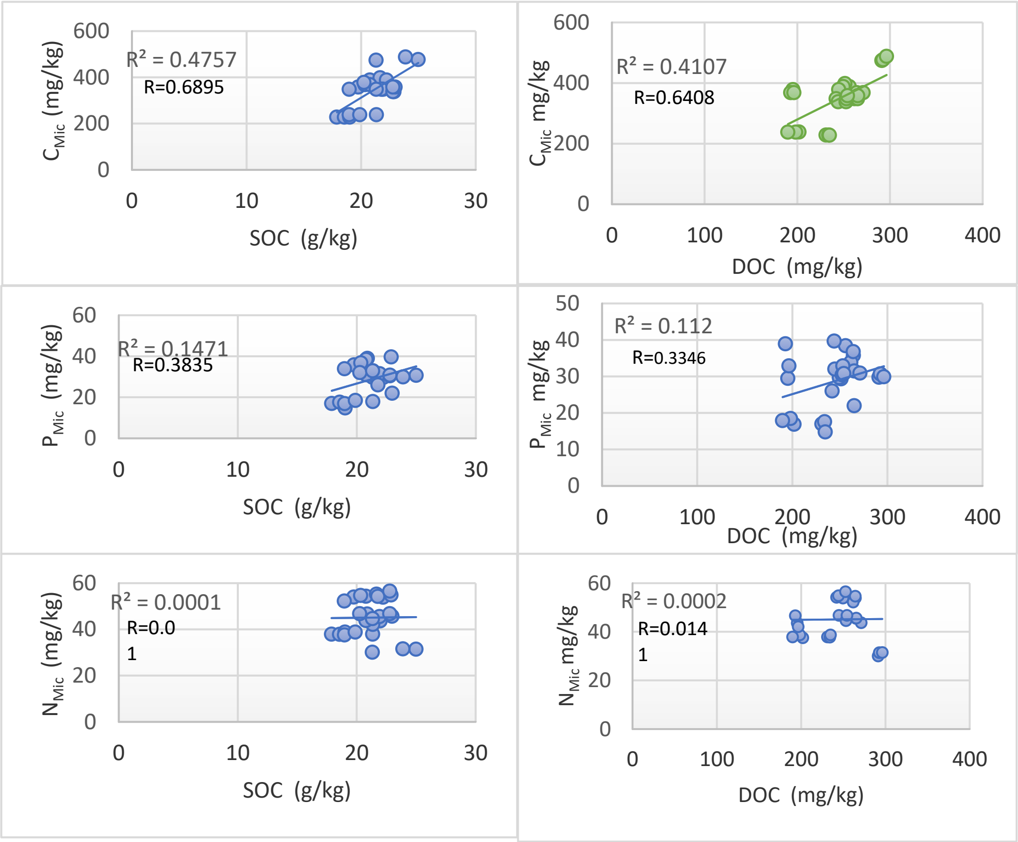

Figure1: Temporal changes in soil microbial biomass carbon (C-Mic), phosphorus (P-$_{\text{Mic}}$) and nitrogen (N-$_{\text{Mic}}$) as affected by (SOC) and (DOC).

Soil respiration (SR) indicating CO_2 influx ranged from 22.70 to 40.44 µg CO_2-C $g^{-1}day^{-1}$ across all treatments being significantly greatest in organic and integrated treatments compared to inorganic treatments. The lowest SR values were recorded by inorganic non-nanofertilizer treatment (FS_1, 22.7, µg CO_2-C $g^{-1}day^{-1}$) and nano treatment (FS_2, 23.32, µg CO_2-C $g^{-1}day^{-1}$). The integrated treatment (FS_7) registered the highest SR (40.44, µg CO_2-C $g^{-1}day^{-1}$) among all treatments followed by the organic treatment (38.36, µg CO_2-C $g^{-1}day^{-1}$). In this research, soil respiration (SR) rates in organic and inorganic treatments were significantly higher than those in the inorganic fertilizer treatments due to inorganic fertilization (Bowden *et al.*, 2004; Melero *et al.*, 2006; Dinesh *et al.*, 2010) or due to higher soil microbial biomass activities as reflected by positive high correlation (figure 2) between SR and C_{-MIC} (r = -0.64; P< 0.22; n= 24) (Melero *et al.*, 2006; Dinesh *et al.*, 2010). Lower rates of soil respiration ratios under inorganic fertilization system and across treatments might have resulted from decreased microbial biomass activity as the availability of dissolved and labile organic carbon fractions decreased (Lee and Jose, 2003; Wang et al. 2003; Ding *et al.*, 2010). By contrast, under organic and integrated fertilization systems, availability of carbon substrates increased as the carbon pool and microbial biomass activity increased.

By contrast to soil respiration ratio (SR) and microbial biomass carbon (C_{-MIC}), the qCO_2 levels trend amongst treatments were in the order of inorganic > integrated > organic fertilization systems. Means of qCO_2 were significantly higher in treatments with inorganic (FS_1 and FS_2) compared to organic (control) and integrated fertilization treatments (FS_3, FS_4, FS_5, FS_6, FS_7 and FS_8). Higher qCO_2 values recorded by inorganic fertilization system treatments indicated decreased organic substrates use efficiency as conversion of total soil organic carbon (SOC) into microbial biomass carbon (C_{-MIC}) is less effectual (Anderson and Domsch, 1990). Lower qCO_2 values under organic fertilization system detected in this research reflected by negative correlation between qCO_2 and C_{-MIC} (r = -0.33; P< 0.22; n= 24) is in regular with the remarks of several researchers (Melero *et al.*, 2006; Ding *et al.*, 2010; Dinesh *et al.*, 2013). Metabolic quotient (qCO_2) as CO_2 flux per unit of microbial biomass carbon (C_{-MIC}) ranged from 80.01 to 118.86 mg CO_2-C (g biomass C)$^{-1}$ day^{-1} (Table, 4). The metabolic quotient (qCO_2) supplies the energy requirements for soil microorganisms, where values above 2 g C-CO_2 h^{-1} kg $C_{MIC}{}^{-1}$, being the critical threshold for active performance of soil microorganisms (Anderson, 2003). Anderson and Domsch (2010), reported that high qCO_2 values reflected soil system disability to restock carbon lost by respiration resulting in microbial population decline.

Across all treatments, after incubation the total inorganic nitrogen mineralized ($N_{\text{-MIN}}$) ranged between 118.49 and 146.36 (mg N kg^{-1} per 10 days) and was greatest in integrated fertilization treatment (FS_5, 146.36 mg N kg^{-1} per 10 days) followed by organic treatment (control, 143.40 mg N kg^{-1} per 10 days). Means of $N_{\text{-MIN}}$ varied little and insignificantly in between organic (control) and integrated treatments (FS_3, FS_4, FS_5, FS_6, FS_7 and FS_8), while they were significantly higher compared to inorganic treatments (FS_1 and FS_2) (Table 4).

Ratios of $Q_{\text{-MIC}}$ in soils significantly differentiated in the order of organic > integrated > inorganic. Ratios of $Q_{\text{-MIC}}$ in the soil treated with integrated or inorganic fertilization systems at all application rates were in general below 2% indicating that soil microorganisms were under an environmental stress due to labile carbon deficiency. Under inorganic fertilization system, treatments of FS_1 and FS_2 recorded the lowest $Q_{\text{-MIC}}$ values of 1.233% and 1.187%, respectively, indicating the lowest labile organic substrates availability but an abundance of labile nitrogen causing luxurious consumption of N beyond their current metabolic requirements (Dinesh *et al.,* 2010).

Evident effects of different fertilization systems on net $N_{\text{-MIN}}$ levels indicating increases in soil microbial population pool (Denish *et al.,* 2013; Jian *et al.,* 2016; Song *et al.,* 2019). Greater levels of $N_{\text{-MIN}}$ in organic and integrated treatments indicted that more nutrient and organic carbon availability imparted favorable conditions for soil microorganisms reflexed on increases in the counts of bacteria and fungi and fast nutrient turnover (Rivest *et al.,* 2010; Jian *et al.,* 2016). In the case of integrated fertilization system at all application rates, elevated availability of N in the presence of organic carbon can modify the form and decomposition of soil organic carbon (SOC) and finally soil C turnover due to indispensable spousing of C and N in the soil ecosystem (Galloway *et al.,* 2008; Jian *et al.,* 2016).

Soil microbial biomass and resistance index.

Different fertilization systems impact on soil microbial biomass counting of bacteria and fungi at different application rates are presented in Table (5). The levels trend in the counts of bacteria and fungi among treatments were in the order of organic > integrated > inorganic fertilization systems. Means of bacteria or fungi counts were significantly higher in treatments with organic (control) compared to inorganic (FS_1 and FS_2) and integrated fertilization treatments (FS_3, FS_4, FS_5, FS_6, FS_7 and FS_8). After soil incubation, significant differences were observed between organic and inorganic fertilization systems in the counts of bacteria or fungi reflecting that soil microbial biomass (SMB) activities were temporarily facilitated or inhibited by each fertilization system.

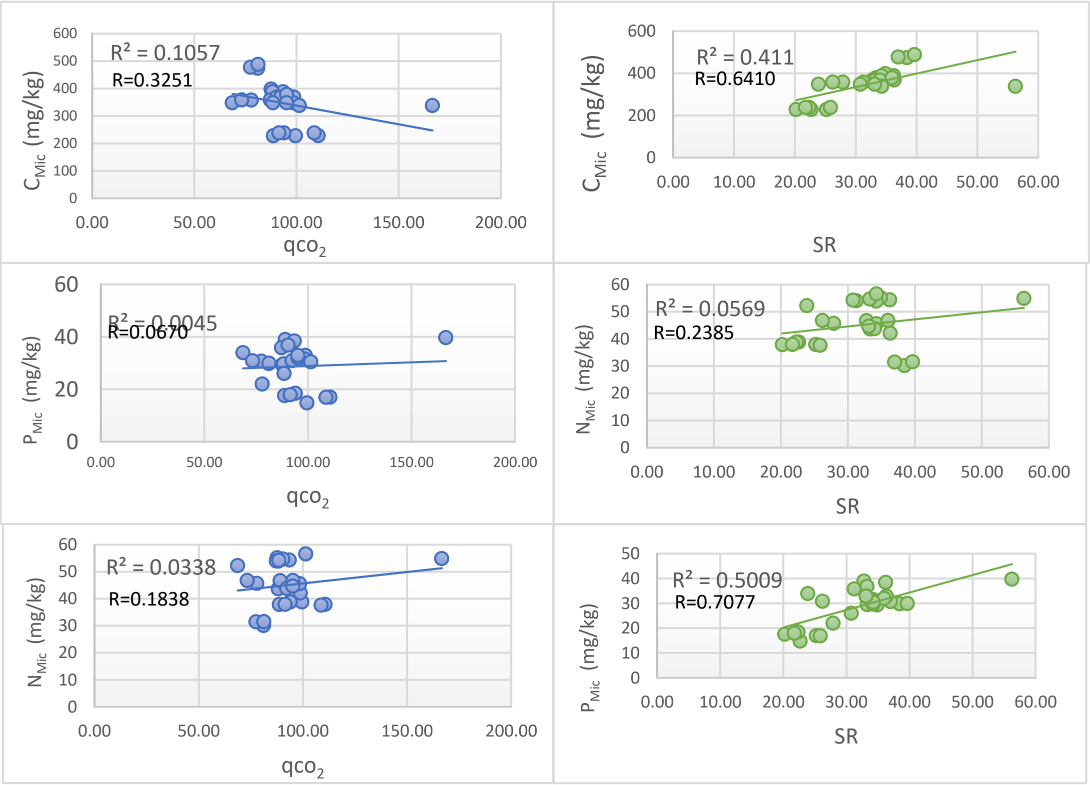

Figure 2: Temporal changes in soil microbial biomass carbon (C_{-Mic}), nitrogen (N_{-Mic}) and phosphorus (P_{-Mic}) as affected by (qco_2) and (SR).

Table 4. Soil biological properties as impacted by different fertilization systems.

Treatment		Soil biological property							
		C_{-MIC} (mg kg^{-1})	N_{-MIC} (mg kg^{-1})	P_{-MIC} (mg kg^{-1})	SR (µg CO_2-C g^{-1}day^{-1})	N_{-MIN} (mg N kg^{-1} per 10 days)	qCO_2 (mg CO_2-C (g biomass C)$^{-1}$ day^{-1})	C_{-mic}/ N_{-mic}	Q_{-mic}%
Control (organic)		479.46^{a}	31.04^{d}	30.11^{d}	38.36^{ab}	143.40^{a}	80.01^{b}	15.45^{a}	2.057^{a}
Inorgani	FS_1	227.76^{f}	38.21^{c}	16.44^{c}	22.70^{d}	118.49^{c}	99.68^{ab}	5.96^{f}	1.233^{d}
	FS_2	237.77^{f}	38.10^{c}	17.74^{c}	23.32^{d}	120.07^{c}	98.09^{ab}	6.24^{f}	1.187^{d}
Integrated	FS_3	371.14^{c}	44.14^{b}	33.75^{b}	34.15^{abc}	138.08^{ab}	92.04^{ab}	8.42^{b}	1.734^{b}
	FS_4	391.11^{b}	54.48^{a}	32.46^{a}	35.13^{abc}	138.23^{ab}	89.84^{b}	7.18^{d}	1.815^{b}
	FS_5	357.79^{d}	53.64^{a}	35.48^{a}	29.47^{bcd}	146.36^{a}	82.16^{b}	6.67^{e}	1.817^{b}
	FS_6	364.41^{cd}	45.37^{b}	31.44^{b}	34.75^{abc}	127.66^{bc}	95.41^{ab}	8.04^{bc}	1.740^{b}
	FS_7	341.08^{e}	55.23^{a}	32.03^{a}	40.44^{a}	129.15^{bc}	118.86^{a}	6.18^{f}	1.518^{c}
	FS_8	354.47^{d}	45.70^{b}	28.55^{b}	29.08^{cd}	122.37^{c}	82.15^{b}	7.76^{c}	1.586^{c}
L.S.D $_{0.05}$		13.017	2.098	6.691	8.989	10.821	27.362	0.4157	0.1425

Soil resistance index (SRI) is effective measure of soil microbial biomass responses to a soil disturbance factor (environmental stress) (Orwin and Wardle 2004). In the present study, a significant effect of different types and rates of fertilizers on the total counts of bacteria and fungi was demonstrated and verified by increasing or decreasing values of the SRI compared to control (organic treatment). The values of resistance index (SRI) for soil bacteria and fungi were positive throughout the experiment, but differed according to the fertilizer dose and type applied (Table 5). Across all treatments, soil resistance index (SRI) ranged between 0.448 to 1.00 for bacteria and from 0.214 to 1.00 for fungi and was greatest in organic fertilization treatment followed by integrated treatments.

Means of SRI were significantly higher in treatments with organic (control) compared to integrated fertilization treatments (FS_3, FS_4, FS_5, FS_6, FS_7 and FS_8) and inorganic (FS_1 and FS_2). Lower values indicate inhibited influence of fertilization system on the microbial biomass activity and assimilation balance (lower microbial activity). Higher SRI values of bacteria and fungi were prominent in organic (higher microbial activity) than other fertilization systems. The SRI for bacteria and fungi in inorganic fertilization system whether non-nano or nano decreased to a minimal extent and caused stronger disturbances for soil microorganisms than integrated or organic systems. Temporal effects of different fertilization systems were more prominent upon the counts of fungi than the counts of bacteria for all treatments and as indicated by the soil microbial biomass resistance index (SRI). The counts of bacteria and fungi were also, more prominent in organic than integrated at all application rates. Results of this study suggest that the temporal growth of soil microbial biomass may either be partially inhibited or completely facilitated following a fertilization system, depending on fertilizer type and application rate (Anderson and Domasch, 2010; Iqbal *et al.,* 2010; Jian *et al.,* 2016; Song *et al.,* 2019).

Enzyme activities

Soil microorganisms' enzymatic activities were studied as dehydrogenase (DH), urease (UR), β-glucosidase (βG) and acid phosphatase (Ac-P) (Table 6). Dehydrogenase (DH) as an important oxi-reductase enzyme, and hydrolytic enzymes participated in carbon (β-glucosidase, βG), nitrogen (urease, UR) and phosphorus (acid-phosphatase Ac-P) soil cycles, were activated to different degrees according to each fertilizer system (table 6). In general, Enzyme activities of dehydrogenase (DH), acid-phosphatase (Ac-P) and β-glucosidase (βG) were significantly differentiated in accordance with each fertilizer type in the order of organic > integrated > inorganic except for FS_6 which registered low value of enzyme activity in the case of βG (3.78, μmol *p*-nitrophenol g^{-1} h^{-1}) and FS_3 low value of enzyme activity in the case of Ac-P (6.81, μmol *p*-

nitrophenol g^{-1} h^{-1}). The lowest values ever were recorded by the inorganic treatments of (FS_1 and FS_2) regarding Enzyme activities of dehydrogenase (DH), acid-phosphatase (Ac-P) and β-glucosidase (βG). Whereas, the activity of urease (UR) significantly differentiated in the order of inorganic > integrated > organic, where the control (organic) treatment recorded the lowest enzyme activity value of 4.36 (μmol NH_3-N g^{-1} h^{-1}).

Inorganic fertilization system boosted urease (UR) activity reflecting the positive effects of this fertilization system on this particular enzyme activity (Allison at al., 2006). On the contrary, organic and integrated treatments showed stronger effects upon dehydrogenase (DH), acid-phosphatase (Ac-P) and β-glucosidase (βG), suggested the availability of a higher quantity of biodegradable substrates and thus, improvements in soil bimass and enzyme activities (Anderson and Domasch, 2010; Dinesh *et al.*, 2013). In general, soil biochemical properties were markedly enhanced under integrated fertilization system in comparison to inorganic system due to higher SOC soil contents. This suggests that organic compost application in combination with inorganic NPK nano or non-nanofertilizers even at lower rates. Also, integrated fertilization system enhanced $N_{\text{-MIN}}$ and DON levels in the soil under investigation reflected by positive correlation between $N_{\text{-MIC}}$ and $N_{\text{-MIN}}$ (r = 0.63; P< 0.22; n= 24) and this positive effect has been demonstrated in literature by many researchers (Dinesh *et al.*, 2013; Song *et al.*, 2019). These significant and positive correlations attributed to the role played by extracellular enzymes (dehydrogenase (DH), urease (UR), β-glucosidase (βG) and acid phosphatase (Ac-P)) as the nitrogen fertilization affects the rate of soil organic carbon (SOC) decomposition and the depolymerization of N-containing compounds by regulating extracellular enzyme activities (Dinesh *et al.*, 2013; Jian *et al.*, 2016).

Obvious and significant observations were detected in the soil counts of bacteria and fungi, soil resistance index (SRI) and enzyme activities due to different fertilization systems. The increases in these soil biological parameters provided further evidence of healthier conditions for soil microbial biomass in organic and integrated treatments (Dinesh *et al.*, 2012; Jian *et al.*, 2016) compared to solitary inorganic treatments. The poor influences of inorganic fertilization system on soil microbial and biological properties in comparison to organic or integrated systems might be attributed to rapid inorganic fertilizers diffusion and dispersion causing quick plant uptake, soil particles adsorption and/or leaching into water bodies without inducing temporal changes in soil biochemical properties (Shen *et al.*, 2010; Dinesh *et al.*, 2012; Jian *et al.*, 2016) and this was reflected upon crop yield.

Table 5. Soil resistance index (SRI) and microbial biomass counts of bacteria and fungi as impacted by different fertilization systems.

Soil resistance index (SRI) and soil microbial biomass					
Treatment		Total counts of Bacteria ($\times 10^{6}$ cfu g^{-1})	SRI	Total counts of Fungi ($\times 10^{4}$ cfu g^{-1})	SRI
Control (organic)		62.63^{a}	1.00	46.30^{a}	1.00
Inorganic	FS_1	44.60^{cd}	0.553	26.23^{d}	0.395
	FS_2	38.77^{e}	0.448	16.33^{e}	0.214
Integrated	FS_3	62.17^{a}	0.985	44.73^{ab}	0.935
	FS_4	55.23^{b}	0.789	40.03^{abc}	0.762
	FS_5	47.23^{c}	0.605	38.77^{bc}	0.720
	FS_6	46.33^{c}	0.587	33.97^{c}	0.579
	FS_7	45.97^{cd}	0.580	37.67^{c}	0.686
	FS_8	40.70^{de}	0.481	19.83^{de}	0.273
L.S.D $_{0.05}$		7.265		7.0119	

Table 6. Soil microbial enzyme activities in soils as impacted by different fertilization systems.

	Soil Microbial Enzyme Activities				
	Treatment	Dehydrogenase (nmol TPF g^{-1}soil h^{-1})	Acid phosphatase (μmol *p*-nitrophenol g^{-1} h^{-1})	ß-glucosidase (μmol *p*-nitrophenol g^{-1} h^{-1})	Urease (μmol NH$_3$-N g^{-1} h^{-1})
	control	216.12^{a}	16.71^{a}	10.45^{a}	4.36^{d}
Inorganic	FS$_1$	127.76^{f}	10.54^{bc}	3.77^{d}	10.37^{a}
	FS$_2$	117.77^{f}	7.10^{de}	4.41^{cd}	9.66^{a}
Integrated	FS$_3$	171.14^{c}	6.81^{e}	7.75^{ab}	7.48^{b}
	FS$_4$	191.11^{b}	11.81^{b}	6.79^{bc}	7.13^{bc}
	FS$_5$	157.79^{d}	8.64^{cde}	5.48^{bcd}	6.80^{bc}
	FS$_6$	164.41^{cd}	9.71^{bcd}	3.78^{d}	7.08^{bc}
	FS$_7$	141.08^{e}	11.89^{b}	6.37^{bcd}	6.77^{bc}
	FS$_8$	154.47^{d}	12.37^{b}	5.55^{bcd}	5.41^{cd}
	L.S.D $_{0.05}$	12.374	2.858	2.726	1.964

Results of this research revealed that C$_{\text{-MIC}}$, P$_{\text{-MIC}}$, DOC, soil bacterial and fungi counts and SRI values were relatively lower in inorganic fertilization system compared to organic and integrated. One plausible reason to explain why inorganic fertilizers produces marked reductions in most biochemical and microbial properties except for DON and N$_{\text{-MIC}}$. Solitary application of inorganic fertilizers triggered the negative effects of inorganic fertilization by diminishing soil organic carbon (SOC) and dissolved organic carbon (DOC), resulting in reduction of readily metabolizable carbon needed by soil microorganisms to activate soil microbial and enzyme activities and confidently vice versa was happened in the organic and integrated treatments (Hallin *et al.*, 2009; Dinesh *et al.,* 2012; Dinesh *et al.*, 2013; Jian *et al.*, 2016; Liu *et al.,* 2016; Yang *et al.,* 2018).

This demonstrates that the most influential factors affecting soil microbial biomass activities in soils are the availability of dissolved organic substrates (SOC and DOC) as reflected by strong intercorrelations between microbial biomass-C and -P with dissolved organic substrates in soils (Tejada *et al.*, 2006; Dinesh *et al.*, 2012). Integration of different rates of inorganic and organic fertilizers increased soil biochemical and biological properties levels in the integrated treatments (FS$_3$, FS$_4$, FS$_5$, FS$_6$, FS$_7$ and FS$_8$) even though involved inorganic fertilizers, reflecting that different microbial responses were due to variations in the fertilizer type and application rates (Dinesh *et al.*, 2012; 2013; Jian et al, 2016). Interestingly, integration of inorganic fertilizers whether non-nano or nano at lower rates (FS_5, FS_6 at 50% and FS_7, FS_8 at 25%) with organic compost enhanced all soil biological parameters than recommended levels of NPK inorganic fertilizers applied alone or integrated with organic compost. This might be attributed to that organic compost was able to offset and alleviate the negative effects of inorganic fertilizers on C_{-MIC}, N_{-MIC} and P_{-MIC} at lower rates compared to full dose. Liu *et al.*, (2009) revealed that organic amendments with lower rates of chemical fertilizers heightened C_{-MIC}, N_{-MIC} and P_{-MIC} than recommended levels of chemical fertilizers.

Finally, organic compost or integrated fertilization system recorded significantly higher rates of C_{-MIC}, P_{-MIC}, soil respiration ratio (SR), N_{-MIN} and microbial biomass activity (bacterial and fungal counts), soil resistance index (SRI) and activities of DH, Ac-P and βG owing to the additive impacts of organic compost. On the contrary, inorganic fertilization system whether using nano or non-nano fertilizers recorded lower rates of C_{-MIC}, P_{-MIC}, SR, N_{-MIN}, DOC, bacterial and fungal counts, SRI, DH, Ac-P and βG activities but boosted the levels of N_{-MIC}, DON, UR activity and qCO_2. Integrated application of organic and inorganic fertilization systems might espouse the positive effects of both effects on microbial activity as evidenced by the paralleled levels of soil biochemical and microbial biomass properties in both fertilization systems. This indicated that fertilizer type and rate affected these soils properties in different ways probably due to changes in soil dissolved organic substrates and soil microorganism's growth environment under potato monocropping cultivation.

CONCLUSIONS

Monocropping is an agricultural method of farming where fields are often replanted year after year with one type of crop, such as potato. In monocropping farms, soils become depleted of certain nutrients used by the same crop. As a result, farmers have to add large quantities and different types of fertilizers to replenish lost nutrients which might result in soil health deterioration. Temporal changes in soil microbial biomass, enzyme activities and dissolved organic carbon under potato monocropping exposed that different fertilization systems impact effects are influential and critical. This study delivers clear evidence displaying that different fertilization systems significantly induced temporal improvement changes in soil biochemical and biological properties and finally the resultant soil health of the agricultural lands. In general, the privileges of organic and integrated fertilization systems even though applied at lower rates of recommended levels, were evident on soil biochemical and biological properties relative to the conventional inorganic fertilization systems whether using nano or non-nanofertilizers at the recommended levels. Grounded on this research, it is preferable to integrate organic compost plus NPK nanofertilizers on non-nanofertilizers due to the priority of lower rates of nanofertilizers on a full dose of NPK non-nanofertilizers. However, using organic compost as single fertilizer resource input in the organic farming system of potato induced low soil productivity. Therefore, it is imperative to assemble a poise between organic and inorganic sources of fertilizers to optimize a fertilization regime that espouse improvements in soil properties and conservation of soil health under potato monocropping cultivation.

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التأثيرات المؤقتة لبعض الأنظمة السمادية المختلفة على صحة التربة تحت الزراعة الأحادية للبطاطس

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أدت ممارسات التكثيف الزراعي إلى جانب الاستخدام غير المسؤول للأسمدة العضوية وغير العضوية إلى تدهور صحة التربة. تم إجراء تجارب حقلية وتجربة تحضين معملية لتحديد التأثيرات المؤقتة لنظم التسميد المختلفة على بعض الخصائص البيوكيميائية والحيوية للتربة بعد الزراعة الاحادية لمحصول البطاطس تحت الظروف الجافة.

اظهرت النتائج ان استخدام انظمة مختلفة من التسميد احدثت تغييرات مؤقتة ذات معنوية واضحة علي كربون التربة العضوي SOC والذائب DOC ونيتروجين التربة الذائب DON والكتلة الميكروبية للكربون(C-MIC) والنتروجين (N-MIC)والفوسفور (P-MIC) واعداد البكتريا والفطريات والنتروجين المعدني (N-MIN).

ادت مستويات التسميد العضوي والمتكامل الي زيادة SOC، DOC، N-MIN ، C (MIC.) (P-MIC، ، تعداد البكتيريا والفطريات وتنفس التربة (SR) بشكل ملحوظ بالمقارنة باستخدام الاسمدة غير العضوية للنانو أو التقليدية وعلي العكس من ذلك الكتلة الميكروبية للنتروجين (N-MIC.) و

DON كانت زيادة بشكل ملحوظ تحت نظام التسميد بالاسمدة المعدنية الأسمدة النانومترية أو التقليدية مقارنة بالأسمدة العضوية أو المتكاملة (العضوية + غير العضوية).

تم دراسة العديد من المؤشرات البيوكيميائية والميكروبية للتربة مثل DOC: DON ، C-MIC: SOC(Q-MIC%) و C-MIC: N-MIC. حيث اخذت كل هذه النسب اتجاها متطابقا حيث كانت جميعها اعلي في نظام التسميد العضوي متبوعا بالنظام المتكامل عند التسميد باسمدة النانو او المعدنية على العكس من ذلك ، تم تسجيل قيم أعلى من حاصل الأيض الميكروبي (qCO2) تحت نظام التسميد المعدني مما بدل علي ان الكتلة الحيوية الميكروبية كانت أقل كفاءة في وجود نسب مرتفعة من الكربون.

النشاط الانزيمي لكل من إنزيم ديهيدروجينيز (DH)،–بيتا–جلوكوسيديز (βG) والفوسفاتيز (Ac-P) كانت كما يلي نظام التسميد العضوي> المتكامل> المعدني ، بينما كان النشاط الانزيمي لليوريز (UR) كان عكس ذلك. في صفات التربة الطينية البيوكيميائية والحيوية حتي علي المدي القصير تحت نظام الزراعة الاحادية للبطاطس.

واتضح من النتائج انه من الاهمية في زراعة الاراضي الطينية ان يحدث تكامل ما بين انظمة التسميد العضوي والمعدني والتي تشجع علي الحفاظ علي صحة التلربة وبناء المادة العضوية.

الكلمات المفتاحية: انظمة التسميد، الكتلة الحيوية الميكروبية، التنفس الحيوي، الأسمدة النانومترية.