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ARTICLE

Sustainable Management of Wind-Eroded Sand Dunes Using Organic Amendments for Enhanced *Zea mays* L. Growth in Basra Governorate

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ABSTRACT

Wind erosion is a major cause of soil degradation in the arid and semi-arid regions of southern Iraq, where sandy dune soils are characterized by poor structural stability, low fertility, and limited agricultural productivity. Study evaluated the potential of organic amendments consist of biogas technology and compost to improve soil physical and chemical properties and crop (*Zea mays* L.) growth in wind-eroded soils of Basra Governorate. Composite sandy dune soil samples were collected from three erosion-prone locations (Safwan, Burjasiya, and Hartha) and amended with liquid biogas (L), solid biogas (S), compost (C), a 1:1 mixture of solid phase and compost (S+C), while raw cattle (R) served as the conventional control. Pots experiment was conducted using a completely randomized design with three replications. Soil aggregate stability, expressed as mean weight diameter (MWD), total porosity, pH, (EC), organic matter (OM) and available (N) and (P) were determined. Crop was cultivated for two months under NPK fertilizer levels 0, 50%, and 100% of the recommended NPK. Results showed the highest MWD was 1.350 mm at $S+C_{1:1}$ compared 0.549 mm under raw cattle, results revealed to $S+C_{1:1}$ was superior across all fertilizer levels when increasing plant dry biomass, plant height, N and P concentrations to 7.599 gm plant^{-1}, 11.59cm, 81.50 g m kg^{-1} dry matter and 47.33 g m kg^{-1} dry matter by 81%, 61%, 87%, and 76%, respectively compared to control. In addition to the $S+C_{1:1}$ markedly enhanced post-harvest soil fertility by increasing available nitrogen and phosphorus to by 92% and 91%, respectively, so these findings demonstrate that combining solid biogas digestate with compost substantially improves soil aggregation, nutrient availability, and maize growth in wind-eroded sandy soils also integrated amendment represents a sustainable strategy for restoring degraded sand dune ecosystems, enhancing soil resistance to wind erosion, and reducing mineral fertilizers in arid agricultural systems.

Keywords: *M.W.D.; Zea mays L; Compost; Organic Fertilizer Technology.*

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INTRODUCTION

Since ancient times, the flourishing of agriculture has coincided with the essential application of organic waste, especially animal waste for important reasons, most notably that the decomposition of these residues by various soil microorganisms in the rhizosphere region directly supports plant growth and supplies it with essential nutrients, or indirectly improves the chemical-physical in addition to biological properties of fragile, fragmented groups soil, especially in the arid and semi-arid regions of Basra, Iraq, which is faced to wind erosion for most of the year seasons, particularly its central and southern regions characterized by average annual rainfall of no more than 100 mm in the south and up to 400 mm in the central regions, along with high temperatures (Sadiq *et al*., 2013; Arnose, 2022). Furthermore, harmful human practices have led to severe degradation of natural vegetation cover, making it highly susceptible to wind erosion for most of the year led to known sand dunes (Abd alhamid *et al*., 2022; Arnose and Hasan, 2021; Jørgensen and Jensen, 2009). Wind erosion is a global problem with a significant impact on the ecosystem in general and the agricultural system in particular. Its severity has increased in recent decades due to soil, climate, and vegetation cover (Wu, *et al*., 2022). In a field experiment conducted in southern Basra governorate to determine the amount of soil lost through wind erosion and the particle size distribution of transported soil particles (Shah, *et al*., 2014; Wu *et al.*, 2022) found that the Enrichment Ratio (ER) for macronutrients (NPK) and organic matter in wind-eroded soils yielded a value greater than 1. This indicates that the eroded soil, wind erosion affects agricultural production through topsoil loss, thereby affecting soil properties by transporting small soil particles (silt and clay) and nutrients essential for plant growth, as well as organic matter, resulting in reduced soil fertility and decreased agricultural productivity. In addition, Wu *et al*. (2022) cautioned that wind erosion affects agricultural production through topsoil loss, thereby affecting soil properties by transporting small soil particles (silt and clay) and nutrients essential for plant growth, as well as organic matter, resulting in reduced soil fertility and decreased agricultural productivity. Moreover as Izadi *et al*. (2022) and Naseh *et al*. (2023) who noted that several techniques are used to stabilize sand dune soils and improve their physical, chemical, and fertility properties one of the most important of these technologies is known of amendments particularly organic from agricultural and animal residues which have proven a significant impact on reducing soil losses due to wind erosion ,this is achieved by improving the soil's physical properties enhancing its water-holding capacity and fertility increasing its water retention capacity then increased nutrient availability, Compost is one such organic amendment prepared using the traditional fermentation method where animal residues exposed to an aerobic fermentation process organic residues have been decomposed by soil microorganisms to make organic fertilizer Provides a number of nutrients, most importantly carbon, hydrogen, nitrogen, phosphorus, and sulfur (Shah *et al*., 2014). The type of compost produced varies depending on the type of residue, which determines its characteristics and components, thus affecting the quality of the compost and improving the physical-chemical and biological properties of the soil, the mechanism of reaction for sand dune amendments in reducing the amount of soil lost by wind erosion is similar to the action of clay and organic matter at humus stage as bind to the surfaces of soil particles through bridges, bonds also van-der-walls forces to give stable soil aggregates these amendments are added to the soil in different ways including spraying on the soil surface mixing them into the soil or adding them to the prepared planting practice. The susceptibility of soil to wind erosion then formation of sand dunes are an integrated effect of the process of lifting and transporting dry, loose particles unprotected by vegetation cover by the wind, the intensity of wind erosion varies according to the variation in the size of the susceptible particles and the speed of the wind (Pedersen *et.al*., 2020; Al-hamdawi, 2021). There are also technologies such as the anaerobic fermentation of animal residues known as biogas technology, in which animal residues are subjected to a biochemical process by obligate anaerobic microorganisms in a completely closed system and in the complete absence of oxygen (Al-afasi *et al*., 2010). With the rapid development of modern agriculture, the anaerobic fermentation of organic residues using what is known as the anaerobic digester has been employed which is a source of clean renewable energy. Produced organic fertilizer is one of the main outputs of anaerobic digestion technology, with high-quality specifications differing in its properties from conventional fertilizer (Naseh *et al.,* 2023 and Pedersen, *et al.,* 2020). So, the study aimed to (i) show that organic amendments would improve soil aggregation and reduce the susceptibility of sandy dune soils to wind erosion; (ii) show that combined application of solid phase and compost would outperform individual amendments because of complementary effects on organic carbon stabilization and nutrient release; and (iii) improved soil quality would enhance maize growth while reducing the requirement for mineral NPK fertilizers.

MATERIALS AND METHODS

Study Sites soils and Timeline

After conducting several field and exploratory tours, three different sites in Basra governorate were selected from February 2025 to April 2026, as locally confirmed sources that site faced wind erosion for most seasons, included Safwan site an arid region located at south of Basra in an arid region that is an extension of the alluvial plain, located at latitude and longitude 38°25'30"North and 12°41'47" East, soil texture classified as loamy sand, hyperthermic, and typical torripsamments (Al-uttabi, 2008) and second site is Burjasiya site located in Al-Zubair city, south of Basra from the center of Basra governorate ,located at longitudes 46°36'30" North and latitudes 52°65'47" East with soil texture classified as loamy sand under classification: sandy, mixed, active calcareous, hyperthermic, typical torripsamments (Al-uttabi, 2008), third region is Haritha which located northeast of Basra city at 22 km from the center of Basra governorate, is an arid region that situated at longitudes 30°65'91" North and latitude 47°72'72" East and classified as hyperthermic, typic torrifluvents fine mixed, active calcareous (Al-uttabi, 2008).

Before planting, the soil samples were collected from three various regions to determine the mean. Weighted diameter was estimated using dry sieving analysis according to the method of Van Bavel, (1949) and Youker and McGuinness, (1956) as described in Al-Wali, (2006), then was calculated from MWD= ∑xi wi--------when, xi: diameter mean for any size range of palm-separated clusters and wi :the weight of the aggregates within that range. The percentage of the total dry weight of the sample was estimated using soil bulk density (ρb) using the metal cylinder method (core sample) for the depth of the studied soil, as reported in Black, (1965). The particle density (ρs) was estimated using the pycnometer method as described in Al-Wali, (2006). The total porosity (f) was calculated mathematically from the bulk density and particle density values reported Black, (1965) as: %f = (1-pb/ps)×100. In addition to Soil moisture content was determined gravimetrically by taking soil samples using a metal core sampler of known weight and volume. The wet weight of each sample was then recorded, and the samples were placed in an electric oven at 105 °C until the weight stabilized. Soil moisture content was calculated using the following formula Black, (1965)**;** Mw/Ms×100. PH degree soil: water (1:1) suspension as Jackson (1958) and E.C. referred to electrical conductivity (1:1) soil filtrate was measured using an EC-Meter according to the method described in Page *et al.* (1982). In addition to soil moisture content was determined gravimetrically by taking soil samples using a metal core sampler of known weight and volume. The wet weight of each sample was then recorded, and the samples were placed in an electric oven at 105 °C until the weight stabilized, soil moisture content was calculated using the following formula: (Mw/Ms)×100. PH degree soil:water (1:1) suspension as Jackson (1958). Organic matter was estimated using the Black and Walkley method described in Black, (1965). The percentage of organic matter was calculated by multiplying the organic carbon content by a conversion factor was 1.72. So, prepared organic amendment included: Raw cattle residue (R), Liquid phase bioreactor fertilizer (L), solid phase bioreactor fertilizer (S) and compost and the solid phase of the bioreactor (1:1) as $(S+C)_{(1:1)}$.

Pots experiment was conducted in plastic pots when were filled with dried sieved (4mm mesh) soil composite sample weighed 3kg from various three studied regions with using a completely randomized design randomized (R.C.D.) according to the fertilizer recommendation to NPK (100:100:100) fertilizer of *Zea mays* crop was added as levels were NPK0, NPK half and NPK full dose that mixed the solid organic residues from the compost and the solid phase of the bioreactor (1:1) solid organic amendments as compost or solid phase treatments mixed with the soil to a depth of 20 cm ,but liquid phase of the bioreactor was added with the irrigation water. The climate data was obtained from the Basra meteorological department from 1/1/2025 until 1/2/2026. The monthly averages of the climate data were taken as shown in the Table (1). Results of the agricultural experiment were digested and determined nitrogen and phosphate according to Bremner, (1970). Statistically analyzed using software Genstat to demonstrate the statistical significance of the differences between treatments the R.L.S.D. test was used to differentiate between the means at a significance level of $P<0.05$ (AL-Rawi and Khalaf, 1980). The prepared organic fertilizers raw dung cattle, compost and di-products of produced solid and liquid phases from bioreactor technique all of these were analyzed to determined physical and chemical characteristics according to Black, (1965). Composite soil samples were collected from the three studied sites to a depth of 0-30 cm and passed through a sieve with openings of 2 mm in order to estimate some of the physical and chemical properties of the soil as shown in table (3). Plastic pots weighing 3 kg were prepared and treated with the required treatments as: raw (R), compost (C), Bioreactor fertilizer, (L) Bioreactor fertilizer (S) and mixed (C) + (S) $_{1:1}$ with three replicates.

Table (1) climate data for Basra governorate for the period from January 2025 to February 2026

Months	Evaporation (mm)	Temperature C^0	Wind velocity ($msec^{-1}$)	Rain (mm)
Jan/ 2025	54.354.3	11.43	2.29	86.9
Feb/ 2025	94	13.66	2.53	4.4
Mar/ 2025	152.1	20.45	2.84	36.3
Apr/ 2025	200.3	24.61	2.68	16.9
May/ 2025	253.5	30.90	2.78	0
Jun/ 2025	7..368	36.99	4.25	0
Jul/ 2025	265	39.28	3.52	0
Aug/ 2025	307	38.87	2.90	0
Sep/ 2025	250	35.64	2.78	0
Oct/ 2025	174	28.84	2.07	0.3
Nov/ /2025	98	19.94	1.96	21.3
Des/ 2025	85	16.29	2.34	18.45
Jan / 2026	52	15.23	2.42	7.7
Feb/ /2026	80	15.28	2.38	26.1
Mar / 2026	149	18.87	2.70	37.9
Apr/ 2026	189	26.77	2.58	7.9

Table (2) Physical and chemical characteristics of prepared fertilizers before planting

Characteristics	Value	Raw (R)	Compost (C)	Bioreactor fertilizer solid (S)	Bioreactor fertilizer Liquid (L)
PH	–	7.02	7.00	7.50	5.30
E.C.(1:1)	ds m^{-1}	15.00	12.00	13.24	8.05
Organic carbon	g kg^{-1}	269.99	179.80	260.00	180.00
Total -N		39.00	29.01	26.60	21.40
Total -P		9.00	7.76	22.27	12.33
Total-K		38.44	5.66	18.12	12.55

C/N	–	14.31	16.46	10.77	11.41
C/P	–	30.00	16.52	10.23	11.59

Table (3) some physical and chemical properties of three studied regions

Properties	Unite	Safwan,	Burjasiya,	Hartha
PH $_{(1:1)}$	-	7.0	7.2	8.2
E.C.$_{(1:1)}$	dsm^{-1}	1.24	1.32	2.44
C.E.C.	C mole kg^{-1}	14	21	24
organic matter	g m kg^{-1}	0.12	0.34	2.32
available- N	g m kg^{-1}	0.04	0.12	0.67
total –P	mg kg^{-1}	0.04	0.04	0.25
available -K	g m kg^{-1}	0.12	0.32	1.23
pw	%	2.0	1.78	3.22
total porosity	%	33	25	32
Soil texture		Sandy loam	Loamy sand	Clay loamy
Sand		801	788	307
Silt	gm kg^{-1}	102	233	200
Clay		24	34	506

Table (4) some physical and chemical properties of composite treated studied soil

Properties	Unite	Value
PH $_{(1:1)}$	-	7.6
E.C.$_{(1:1)}$	dsm^{-1}	1.54
C.E.C.	C mole kg^{-1}	25
organic matter	g m kg^{-1}	1.45
available- N	g m kg^{-1}	1.02
total –P	mg kg^{-1}	2.33
available -K	g m kg^{-1}	2.02
pw	%	8.12
total porosity	%	40.32
Soil texture	gm kg^{-1}	707
Sand		201
Silt		65
Clay		Sandy loam

RESULTS AND DISCUSSION

Treated soil parameters

1-Soils Mean weight diameter

Results conducted at table (5) a significant effect of various prepared or produced organic fertilizers from cattle dung manure by various fermentations ways as composting or bioreactors either solid or liquid phases before planting when mean weight diameter increased from 0.549 mm at raw cattle dung residues (control) to 0.660, 0.735, 0.510, 0. 501 mm for L, S, C and modified S+C $_{(1:1)}$ treatment respectively that's agreed with Al-Jammas *et al.* (2018) and Al-delfi (2020). When referred to positive role of mixed compost with other material recorded 65.78% increase compared to the control (only compost) this is attributed to the fact that adding mixed compost increased the cohesion of the primary soil particles leading to the formation of small aggregates small aggregates then bonded together then bonding resulted in the formation of larger aggregates, thus increasing soil mean weight diameter.in addition to results showed that when there was significant interaction effect between amendments and regions when the lowest soils mean weight diameter was 0.222 mm at raw amendments (R) and Safwan and the highest was 1.778 mm at Safwan treated with compost and solid S+ C $_{(1:1)}$ as, Safwan region was sandy loam texture more faced windy erosion so when applied with modified treatment (S+ C $_{(1:1)}$) this aligns finding that compost serves as a source of nutrients and energy for revitalizing the soil microstructure enabling it to perform its biological functions through decomposition products, it improves soil structure and contributes to increased aggregate stability modifier also plays a significant role in improving soil structure and increasing weighted average diameter by forming water-stable aggregates that bind soil particles together (Tian *et al*., 2019). So, the reason for this is attributed to the increased activity of microorganisms and their secretions as a result of the spread of plant roots, which led to an improvement in soil structure and an increase in the stability of its aggregates Al-Hadi and Yahya, (2014).

Table (5): Effect of organic amendments on mean weight diameter (mm) of studied soils before planting

Organic amendments	Safwan	Burjisiya	Hhartha	average
R	50.00	50.00	50.11	50.03
L	50.33	50.22	50.12	50.22
S	50.16	50.13	50.15	50.41
C	50.44	50.33	50.04	50.27
$C_{(1:1)}$+ S	50.69	50.45	50.13	50.43
Average	50.32	50.23	50.11	
$RLSD_{0.05}$				
amendments	0.12			
regions	0.03			
regions * amendments	0.33			

2-Soil moisture content (%)

Results conducted at table (6) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid phase on soil moisture content (%) when increase from 51.79% at raw cattle dung residues (as control) to 52.16, 62.71, 59.35 and 81.06% that's agreed with Al-buraih and Hasan (2023) who referred to positive role of fermentation ways of organic residues moreover results conducted to significant effect interaction between regions and amendments when increase moisture content from 45.13% at Safwan with raw to 87.33% at Burjisiya with S+$C_{(1:1)}$ that's agree with Al- buraih (2023) when curtained of split as pathway to encourage soil moisture content.

Table (6) effect of organic amendments on moisture content (%) of sandy soils

Organic amendments	Sefwan	Burjisiya	Hartha	average
R	45.13	60.12	50.12	51.79
L	50.44	55.76	50.15	52.16
S	55.98	67.77	64.55	62.71
C	50.83	60.12	67.12	59.35
S+$C_{(1:1)}$	85.76	87.33	70.11	81.06
Average	57.63	66.22	60.41	
$RLSD_{0.05}$				
amendments	NS			
regions	1.79			
regions * amendments	4.55			

3-pH degree and E.C. soil

Results conducted at table (7) no significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways. PH in table (8) composting or bioreactors either solid or liquid pH as on pH degree when pH degrees were 7.272, 7.330, 7, 407, 178 and 7.05 for organic amendments respectively that is curtained by AL-mousawi *et al*. (2017). However significant of interaction between regions and amendments when reduce PH degree from 6.909 to 7.66 agreed with Ali *et al*. (2014).

Table (7) effect of organic amendments on pH degree of soil

Organic amendments	Sefwan	Burjisiya	Hartha	average
R	7.00	7.409	7.409	7.272
L	7.66	7.111	7.55	7.330
S	7.55	7.00	7..66	7,40
C	7.00	7.411	7.123	7,178
S+$C_{(1:1)}$	7.119	6.909	7.123	7.05
average	7.26	7.172	7.839	
RLSD0.05 **amendments regions** **regions* amendments**	NS	NS	0.123	

Table (8) Effect of organic amendments on E.C. (ds m $^{-1}$) of soils

Organic amendments	Sefwan	Burjisiya	Hartha	average
R	9.611	11.59	12.40	10.409
L	6.621	7.599	8.411	7.810
S	11.613	13.599	15.021	10.894
C	8.631	5.599	14.026	8.609
S+$C_{(1:1)}$	13.611	13.599	12.00	11.599
average	7.122	8.123	10.34	
RLSD0.05				
amendments	4.34			
regions	2.41			
regions* amendments	NS			

4-Soils organic matter %

Results conducted at table (9) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid phase on soil organic matter (%) when increase from 2.41 % at raw cattle dung residues (as control) to 1.81 2.894, 2.609 and 3.599 % that's agreed with Al-delfi, (2020) who referred to positive role of fermentation ways of organic residues on organic matter of sandy soils in Burjasiya region ,results (Table 9) showed that significant role to various regions and organic amendments interaction on organic matter when lowest was 1.00% at Burjasiya and raw residues and highest was 4.599% at either Burjasiya or Hartha treated with S+$C_{(1:1)}$ that referred to importance treated organic amendments to improve their properties as organic matter %.

Table (9) effect of organic amendments on organic matter % of studied soils

Organic amendments	Sefwan	Burjisiya	Hartha	average
R	1.599	1.00	2.599	2.41
L	3.599	2.599	2.599	1.810
S	2.599	3.599	2.599	2.894
C	2.599	1.44	3.599	2.609
S+$C_{(1:1)}$	3.599	4.599	4.599	3.599
average	2.55	1.57	2.44	
RLSD$_{0.05}$				
amendments	0.14			
regions	NS			
regions* amendments	0.174			

Plants parameters

1-Dry weight

Results conducted at table (10) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid pH as on dry weight *Zea mays* L. plants under various levels of NPK as recommendation doses when increased dry weight from1.41 g m pot^{-1} at raw cattle dung residues (as control) to 5.81, 8.89, 5.60 and 7.599 g m pot-1 with increase perc. were 75.9, 85, 75 and 81 % as compared to control for organic amendments respectively moreover, significant effect for interaction when increased from 1.11 gm pot^{-1} to 9.67 gm pot^{-1} at S +C$_{(1:1)}$ and NPK0 that curtained fermentation ways on raw residues to improve its characteristics then reflected on soil properties and plants growth as (AL-mousawi *et al.,* 2017 and Al-delfi, 2020).

Table (10) effect of organic amendments on dry weight (gm pot^{-1}) of *Zea mays* L. plants under NPK levels

Organic Amendments	NPK_0	NPK_{half}	$NP\ K_{full}$	average
R	1.11	2.21	3.14	1.409
L	6.16	4.55	5.00	5.810
S	5.99	5.66	6.19	8.894
C	4.99	6.33	5.13	5.609
S+C$_{(1:1)}$	9.67	8.19	4.89	7.599
Average	6.44	5.76	5.76	
$RLSD_{0.05}$				
amendments	1.23			
NPK levels NPK levels*	0.145			
amendments	2.33			

2-Height plants

Results as table (11) referred to the same results on height (cm plant) of *Zea mays* L. plants that's agreed with Arthur *et al*., (2012) and Al- buraih, (2023) who referred to positive role of fermentation ways of poultry residues on crops growth

Table (11) Effect of organic amendments on height (cm plant) of *Zea mays* L. plants under NPK levels

Organic Amendments	NPK_0	NPK_{half}	$NP\ K_{full}$	average
R	3.33	6.22	4.54	4.49
L	4.33	7.76	5.65	8.810
S	12.00	8.88	10.10	10.894
C	6.81	5.45	7.77	6.609
S+C$_{(1:1)}$	12.67	11.34	8.16	11.599
average	5.66	6.78	7.12	
$RLSD_{0.05}$	1.21			
amendments	NS			
NPK	1.87			
NPK* amendments				

3-Nitrogen content (g m kg-1 dry matter)

Results conducted at table (12) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid phase on nitrogen content g m kg^{-1} dry matter plants under various levels of NPK when increase from10.44 gm kg^{-1} at raw cattle dung residues (as control) to 30.81, 44.89, 36.61and 81.59 gm kg^{-1} that's agreed with (3) results also revealed to significant for interaction effect between NPK levels and amendments on N – content when increased from lowest 11.55 gm kg^{-1} dry matter at raw NPK_0 to highest 88.45 g m kg^{-1} dry matter at S + $C_{(1:1)}$ and NPK $_{half\ dose}$, may be that encourage roles of organic amendments to reduced recommendation of chemical fertilizers to prevent losses of these fertilizer then environment pollution to protect soil health.

Table (12) Effect of organic amendments on nitrogen content (g m kg^{-1} dry matter) of *Zea mays* L. plants under

Organic Amendments	NPK_0	NPK $_{half}$	NP K $_{full}$	average
R	11.55	15.57	14.7	10.44
L	40.12	20.13	33.11	30.81
S	60.00	54.78	49.00	44.89
C	37.33	50.55	42.0	36.61
S+$C_{(1:1)}$	100.0	88.45	66.45	81.59
average	85.98	56.33	46.00	
$RLSD_{0.05}$				
amendments	2.67			
NPK levels	NS			
NPK levels * amendments	6.43			

4-Phosphate content (mg kg-1 dry matter)

Results conducted at table (13) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid phase on phosphate content mg kg^{-1} dry matter plants under NPK levels when increase from13.11 mg kg^{-1} at raw cattle dung residues (as control) to 26.32,34.43,33.11 and 47.33 mg kg^{-1} that's agreed with (Al-delfi, 2020) results also revealed to significant for interaction effect between NPK levels and amendments on P content when increased from lowest 13.12 mg kg^{-1} dry matter at raw with NPK_0 to highest 56.34 mg kg^{-1} dry matter at S + $C_{(1:1)}$ and NPK $_{half\ dose}$ as (AL-mousawi *et al*., 2017).

Table (13) Effect of organic amendments on phosphate content (mg kg $^{/-}$ dry matter) of *Zea mays* L. plants under NPK levels

Organic Amendments	NPK_0	NPK $_{half}$	NP K $_{full}$	average
R	13.12	11.00	15.11	13.11
L	11.43	25.05	30.00	26.32
S	32.00	23.22	12.12	34.43
C	31.55	33.00	32.00	33.11
S+$C_{(1:1)}$	32.74	45.04	56.34	47.33
average	33.33	39.54	36.21	
$RLSD_{0.05}$				
amendments	4.44			
NPK levels	2.12			
NPK levels * amendments	6.56			

Agricultural Sustainable of studied soil

1-An available nitrogen (g kg soil)

Results conducted at table (14) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid phase on available nitrogen when increase from 7.40g kg^{-1} soil at raw cattle dung residues (as control) to 20.81,48.89,45.60 and 86.59 g kg^{-1} soil that's agreed with Bath and Ramert (2000).

Table (14) Effect of organic amendments on available nitrogen (g kg^{-1} soil) under NPK levels

Organic Amendments	NPK_0	NPK_{half}	$NP\ K_{full}$	average
R	7.43	6.45	8.21	7.40
L	21.82	32.86	26.76	20.81
S	43.66	54.77	55.89	48.89
C	54.33	37.66	56.55	45.60
$S+C_{(1:1)}$	65.11	65.50	78.54	86.59
average	40.32	54.67	77.98	
$RLSD_{0.05}$ amendments	7.76			
NPK levels	2.22			
NPK levels * amendments	21.32			

2-An available phosphate (mg kg soil)

Results conducted at table (15) significant effect of various prepared or produced organic fertilizers from cattle dung manure by fermentations ways as composting or bioreactors either solid or liquid pH as on an available phosphate under NPK levels when increase from3.44 mg kg^{-1} soil at raw cattle dung residues (as control) to 20.55, 56.89, 44.60 and 38.56 mg kg^{-1} soil that's agreed with Al-hamdawi (2021) and Al-delfi, (2020) who referred to positive role of fermentation ways of organic residues, results revealed to significant effect of interaction between NPK levels and amendments on both of available nitrogen and phosphate of composite soil after planting, so the additions fermented organic amendments with either half dose or full dose will encourage agricultural sustainable then soil health in future.

Table (15) Effect of organic amendments on available phosphate under NPK levels

Organic Amendments	NPK_0	NPK_{half}	$NP\ K_{full}$	average
R	0.12	0.43	11.65	3.44
L	32.22	4.12	18.33	20.55
S	54.11	34.66	64.22	56.89
C	32.55	45.11	33.22	44.60
$S+C_{(1:1)}$	43.11	45.70	32.54	38.56
average	12.44	20.65	30.67	
$RLSD_{0.05}$ amendments	3.22			
NPK levels	4.55			
NPK levels * amendments	12.32			

CONCLUSIONS

The combined application of solid phase and compost would outperform individual amendments because of complementary effects on organic carbon stabilization and nutrient release and improved soil quality would enhance maize growth while reducing the requirement for mineral NPK fertilizers, wind-eroded sandy soils also integrated amendment represents a sustainable strategy for restoring degraded sand dune ecosystems, enhancing soil resistance to wind erosion.

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