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Anaerobic fermentation of cow dung and its effect on the growth and nitrogen and phosphorus content of (*Zea mays* L.) grown in sandy soil under Basra governorate conditions

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I. Abstract

Agricultural residual (especially animal) accumulates in enormous quantities, leading to pollution of soil, water, and air negatively impacting the environment and human health. Since this animal residual is often rich in essential nutrients for crop growth and soil productivity that are either already poor or depleted due to a lack of scientific management, this study aimed to conduct anaerobic fermentation of the daily accumulated cow dung at a cattle farm station to produce liquid organic fertilizer. This was achieved by storing the cow dung in a locally designed, fixed tank-type anaerobic digester(as bioreactor). The results showed that the cumulative production of liquid organic fertilizer during the 28-day period of anaerobic fermentation reached its peak so, this 28-day period represents the time required for the complete anaerobic decomposition of cow dung in the digester, main chemical features of this fertilizer pH, EC, organic-C and organic matter were measured after anaerobic fermentation in anaerobic digester these features were 3.60,13.44 dSm^{-1}, 544.42gkg^{-1} dry matter of cow dung and 893.78gm kg^{-1} dry matter respectively additionally the content of the two essential nutrients ,total nitrogen and phosphate were determined 26.88gm N kg^{-1} and 14.34 gm P/kg^{-1} dry matter cow dung respectively. An agricultural experiment was conducted in plastic pots containing an air dried sandy soil obtained from the Al-burjasiya region studied soil was treated with either half or full chemical doses as traditional recommendation (NPK fertilizer) or the produced organic fertilizer from anaerobic digester, then planted with local variety corn(*Zea mays* L.) seeds . Experimental treatments were designed as C.R.B.D and statistical analysis was performed using analysis of variables (ANOVA) with the SPSS ,the datas were compared using t-test at a significance $p \leq 0.05$ to show differences among average treatments. The results showed that treatment full chemical dose (NPK) was superior when have supported with produced organic fertilizer led to in a significantly($p \leq 0.05$) increase at main most of the plants parameters growth as plant height of shoot and root dry weight and the amount of nitrogen and phosphorus uptake were 111cm $plant^{-1}$,10 gm $plant^{-1}$, 6.25 gm $plant^{-1}$,140 mg kg^{-1} and 33.11mg kg^{-1} as compared to half dose were 55cm $plant^{-1}$, 5 gm $plant^{-1}$, 2.3 gm $plant^{-1}$, 20.32 mg kg^{-1} and 1.32mg kg^{-} for parameters growth respectively as well as studied soil sustainability indicators based on the soil's content of N and P-available A sustainable parameters soil after planting which were99.86 mg kg^{-1} soil and 59.86 mg kg^{-1} soil compared elements (N and P)60 in soil after 60 days planting ,so encouragment soil protection and sustainability from nutrient depletion in future then maintaining soil fertility as a resource for agricultural purposes.

Key words : *Agriculture sustainable , recycling , organic manure technology*

II. Introduction

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Major nutrients such as nitrogen and phosphorus are exposed to many problems in the soil, which negatively affect their availability to plants, especially if they are added in their chemical form therefore, the use of liquid organic fertilizer has been a supplement or alternative to chemical fertilizers, especially in agricultural experiments, which adds burdens on farmers and pollutes the environment. Organic matter is defined (as a term) as having carbon specifically as the largest part of its structural content **(Tang et.al.,2021)**, while mineral matter has the mineral elements only, excluding carbon, as the largest content of its structure. Therefore, the use of fertilizer in the form organic matter is considered a highly sustainable source of carbon supply to the soil, which makes it highly receptive to essential nutrients and improves the properties and structure of soil particles from the seed germination stage until production and fruiting, this was confirmed by a series of ongoing field or greenhouse studies as**(Cavali et. al. ,2022 and Ahmed et. al., 2024)** . studies have confirmed a significant increase in nitrogen and phosphorus content 83.2 mg/kg and 27.4 mg/kg respectively in soil treated with liquid organic fertilizer produced from the anaerobic digester in the bioreactor this improves the soil's physical and chemical properties and makes it rich in nitrogen and phosphorus **(Xiaohu et.al., 2007 , Wilkinson 2011,)** almost researches recycling waste indicated that liquid organic fertilizer produced through anaerobic digestion in designed bioreactor under the climatic conditions like Basra governorate in June or July and August yielded a liquid organic fertilizer with superior quality characteristics in terms of its nitrogen, phosphorus, and potassium content(**Arnoos,2022 and Baria and Hasan ,2024)** resulted in improved productivity for barley and corn compared to the recommended chemical added despite the soil suffering from severe nutrient deficiencies and consistently high salinity levels.so study aimed to conduct the role of produced liquid fertilizer fermented from bioreactor to reduce or support traditional recommendation and improve growth crop in poor sandy soil and its role to maintain soil health and prevent an environmental pollution .

III. Methods and materials

The study was conducted at the cattle farm belonging to the college of agriculture, university of Basra, Karma Ali site on July 22, 2025, cow dung was collected then mixed well and dried in the oven at a temperature of $65C^0$, a sample was digested by using the wet method **(Cresser and Parson 1979)** to determine main features before and after anaerobic digestion after 28 days fermentation as pH, electrical conductivity, moisture content, organic carbon, organic matter, etc. characteristics as shown in table (1) , fresh cow dung was placed in local manufactured designed fixed- dome model of bioreactor device (photo 1) with continuous monitoring of the water quantity and homogeneity of the fermented manure over time. The pots experiment with three replicates per treatments included traditional as half and full doses of NPK (10:10:10) and unfermented or fermented manure that arranged randomly according to CRBD designed to agriculture experiment plants harvested after 60 days planting then collected and weighed shoot and root then digested determined nitrogen and phosphate both in plant parts and studied soil as according to **Black, C. A. (1965)** .

Table (1):The main characteristics of cow dung before anaerobic digestion

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unite	value	characteristics
-	4.89	**(5:1)pH**
dsm^{-1}	11.22	**(5:1)EC**
gm kg^{-1}	46.88	**total -N**
	17.34	**total -P**
	19.19	**total-K**
	893.78	**Organic matter**
	544.42	**organic carbon**
% w/w	75	**Moisture content**
-	19.65	**C/N**
-	31.47	**C/P**
%	32	**Total solid**

Table(2): The main some characteristics of cow dung after anaerobic digestion

unite	value	characteristics
-	3.60	**(5:1)pH**
dsm-1	13.44	**(5:1)EC**
gm kg^{-1}	26.88	**total -N**
	14.34	**total -P**
	26.19	**total-K**
	693.78	**organic matter**
	344.42	**organic carbon**
% w/w	55	**Moisture content**
-	12.35	**C/N**
-	34.98	**C/P**
%	32	**Total solid**

Table(3): Physical and chemical properties of sandy studied soil

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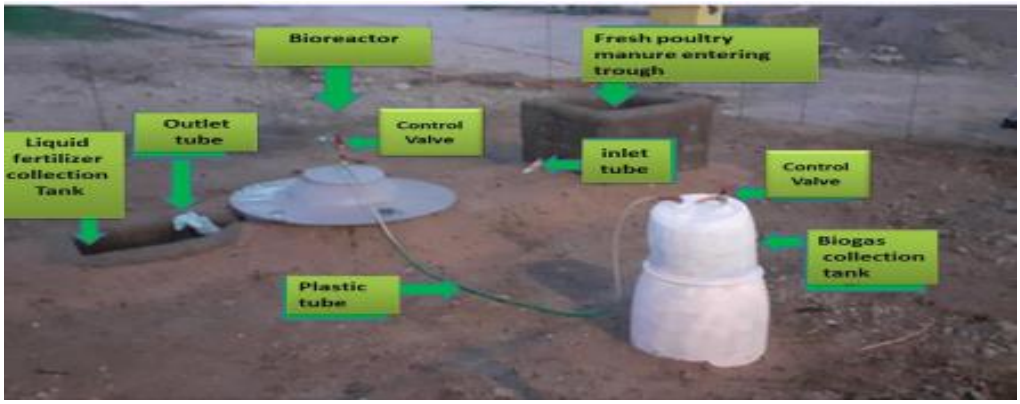
parameters	Value	Unit
pH	7. 57	-
EC	3. 65	dsm^{-1}
organic matter **total -N**	1.34 1.2	% mg kg^{-1}
P	0.22	$mgkg^{-1}$
K	80.12	$mgkg^{-1}$
sand	497	gkg^{-1}
silt	280	gkg^{-1}
clay	103	gkg^{-1}
soil texture	sandy silt	

Photo 1: Local manufactured designed fixed- dome model of bioreactor device



IV. Results and Discussion

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plant height

As shown inTable (4), the unfermented and fermented manure of cow dung treatments effect on plant growth parameters after 60days planting treatments Were significant effect ($p<0.05$) on *Zea mays* height after 60 days planting were 77 and 110 cm plant^{-1} respectively as compared to control(no added manure) was 66 cm plant^{-1} at increase 30 , 40 % while traditional recommendation doses (NPK $_{\text{half dose}}$ and NPK $_{\text{full dose}}$), height plants were 77 and 92.3 cm plant^{-1} at increase 16% for NPK $_{\text{half dose}}$ NPK $_{\text{full dose}}$ respectively , in addition to results showed at Table (4) that significant effect of interaction between $_{\text{NPK doses}}$ and manure when increase height from 55cm at control to 111 cm plant^{-1} at fermented manure with NPK $_{\text{full dose}}$ at increase 50% , that agreed with researches when curtained on insignificant role of fermentation process to improve growth plant parameters along growth stages from seedling to especially flag leave stage (maximum shoot parts growth) (Arnos,2022)

Table (4):The effect of unfermented and fermented manure on height plants (cm plant^{-1}) under NPK doses

Treatments	NPK $_{\text{half dose}}$	NPK $_{\text{full dose}}$	average
Control	55	78	66
unfermented	67	88	77
fermented	109	111	110
average	77[a]	92.30[b]	84.65
RLSD$_{0.05}$ manure= NPK doses* manure=	3.45 5.56	.	

Dry weight shoot (gm plant $^{-1}$)

As shown in Table (5), the unfermented and fermented manure of waste cow treatments affected significantly ($p<0.05$) on *Zea mays* dry weight shoot (gm plant $^{-1}$) under half and full NPK doses after 60 days planting were 8.3 and 9.55 gm plant $^{-1}$ respectively as compared to control(no added) was 6.43 gm plant $^{-1}$ at increase 22 , 32 % while traditional recommendation levels shoot dry weight plants were7.7 and 9.23 gm plant $^{-1}$ at increase 16% for NPK $_{\text{half dose}}$ NPK $_{\text{full dose}}$ respectively, in addition to results showed at Table (5) that significant effect of interaction between $_{\text{NPK doses}}$ and manure when increase dry weight from 5.0 at control to10.11 gm plant $^{-1}$at fermented with NPK $_{\text{full dose}}$ together at 50%, that agreed with researches when curtained on insignificant role of fermentation process to improve growth plant parameters along stages from seedling to maximum shoot parts growth(**Zhao, et.al ., 2016)**

Table (5):The effect of unfermented and fermented manure on shoot dry weight plant (gm plant $^{-1}$) under NPK levels

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Treatments	NPK half dose	NPK full dose	average
Control	5.0	7.85	6.43
unfermented	7.6	8.8	8.3
fermented	9.10	10.11	9.55
average	7.7[a]	9.23[b]	8.08
RLSD0.05 manure = 1.11 NPK doses* manure= 1.98		.	

Dry weight root (gm plant -1)

As shown in Table (6) the unfermented and fermented manure of cow treatments Were significant effect ($p<0.05$) on *Zea mays* dry weight root (gm plant -1) under half and full NPK doses after 60 days planting were 4.15 and 6.67 gm plant -1 respectively as compared to control(no added) was 3.58 gm plant -1 at increase 13 , 46 % respectively while traditional recommendation levels root dry weight plants were3.4 and 6.25 gm plant -1 for NPK half dose NPK full dose respectively at increase 45 % , in addition to results showed at Table (6) that significant effect of interaction between NPK doses and manure when increase dry weight from 2.3 at control to 6.11 gm plant -1at increase 62% that agreed with **Mohammed (2013**) when curtained on positive role of fermentation process to improve growth plant parameters .

Table (6):The effect of unfermented and fermented manure on dry weight root plants(gm plant -1) under NPK doses

Treatments	NPK half dose	NPK full dose	average
Control	2.3	4.85	3.58
unfermented	4.5	7.8	4.15
fermented	3.4	6.11	6.67
average	3.4[a]	6.25[b]	4.8
RLSD0.05 manure= 1.11 NPK doses* manure= 2.04		.	

N- uptake (mg kg -1)

As shown in Table (7) the unfermented and fermented manure of waste cow treatments Were significant($p<0.05$) effect on N- uptake (mg kg plant-1) under half and full NPK doses after 60 days planting were 100.65 and 126.25 mg N kg plant-1 respectively as compared to control(no added) was 40.43 mg kg plant-1 at increase perc. 59 , 67 % respectively while traditional recommendation doses N- uptake were 74.4and 97.25 mg kg plant-1 at increase 45 % for NPK half dose NPK full dose respectively , in addition to results showed at Table (7) that significant effect of interaction between NPK doses and manure when increase N- uptake from 2.3 at control to 6.11 gm plant -1at fermented manure with NPK full dose together, that agreed with researches when curtained on insignificant role of fermentation process to improve growth plant parameters when high N- availability along stages from seedling to flag leave stage (maximum shoot parts growth) (**Zhai, et.al., 2015and Svoboda, 2013)**

Table (7):The effect of unfermented and fermented manure on N- uptake (mg N kg -1) under NPK doses

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Treatments	NPK half dose	NPK full dose	average
Control	20.32	40.85	40.43
unfermented	90.5	110.8	100.65
fermented	112.4	140.11	126.25
average	74.40[a]	97.25[b]	89.10
RLSD0.05 manure NPK doses* manure=	3.77 6.05	.	

P-uptake (mg P kg $^{-1}$)

As shown in Table (8) the unfermented and fermented manure of waste cow treatments Were significant ($p<0.05$) effect on P- uptake (mg P kg plant-1) under half and full NPK doses after 60 days planting were 10.65 and 25.25 mg P kg plant-1 respectively as compared to control(no added) was 3.08 mg P kg plant-1 at increase perc. 71 , 87 % respectively while traditional recommendation doses P- uptake were 9.40 and 16.58 mg P kg plant-1 at increase 43 % for NPK half dose NPK full dose respectively , in addition to results showed at table (8) that significant effect of interaction between NPK doses* manure when increase P- uptake from 1.32 at control to 33.11 mg P kg -1 at increase perc. 96%, significant role of fermentation process to improve cow properties after fermentation process when an essential nutrients released as an available phosphate then encourage soil fertility to improve plants growth (**Svoboda, 2013 and Aday et. a.,l 2017**).

Table (8):The effect of unfermented and fermented manure on P- uptake (mg P kg $^{-1}$) under NPK doses

treatments	NPK half dose	NPK full dose	average
control	1.32	4.85	3.08
unfermented	9.5	11.8	10.65
fermented	17.4	33.11	25.25
average	9.40[a]	16.58[b]	12.99
RLSD0.05 manure= NPK doses* manure=	1.044 1.87	.	

A sustainable parameters soil after planting

An available –N (mg N kg soil^{-1})

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As shown in **Table** (9) results conducted to the unfermented and fermented manure of waste cow treatments Were affected significant ($p<0.05$) on N- available (mg N kg soil-1) in studied soil after 60 days planting as a factor to increase sustainable agriculture and health sandy soil in future so, under half and full NPK doses after 60 days planting N- available were 58.79 and 89.10 mg N kg soil-1 respectively as compared to control(no added) was 37.27 mg N kg soil-1 at increase36.6 and 58 % respectively while traditional recommendation(half and full NPK doses) N- available were 56.92 and 66.51 mg N kg soil-1 at increase 14 % for NPK doses , in addition to results showed at Table (9) that significant effect of interaction between NPK doses and manure when increase N-available from 36.65 mg N kg soil-1 at control to 99.86 mg N kg soil-1 at fermented manure with NPK full dose together that agreed with researches **Sun, et.al.(2019) and Delphi, (2020)**.

Table (9):The effect of unfermented and fermented manure on N-available (mgNkg^{-1} soil) under NPK doses

treatments	NPK half dose	NPK full dose	average
control	36.65	37.88	37.27
unfermented	55.78	61.8	58.79
fermented	78.34	99.86	89.1
average	56.92a	66.51b	61.72
RLSD$_{0.05}$ manure = NPK doses* manure=	8.33 11.09	.	

An available -P (mg P kg soil^{-1})

As shown in Table (10) results conducted to the unfermented and fermented manure of waste cow treatments Were affected significant ($p<0.05$) on P- available (mg P kg soil-1) in soil under half and full NPK doses after 60 days planting were 33.79 and 54.10 mg P kg soil-1 respectively as compared to control(no added) was 27.27 mg P kg soil-1 at increase 19 and 49% respectively while traditional recommendation doses P - available were 36,51 and 36.92 mg P kg soil-1 at increase 0.01 % for NPK doses , in addition to results showed at Table (10) that significant effect of interaction between NPK doses and manure when increase P- available from 26.65 mg P kg soil-1 at control to 59.86 mg P kg soil-1 at fermented manure with NPK full dose together , that agreed with researches when curtained on insignificant role of fermentation process to improve health and fertility soil parameters as P-available after ended planting then going on encouragement soil sustainable in future (**Hupfauf et .al.(,2016)and Delphi, (2020)**

Table (10):The effect of unfermented and fermented manure on P-available (mg P kg $^{-1}$ soil) under NPK doses

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treatments	NPK half dose	NPK full dose	average
control	26.65	27.88	27.27
unfermented	35.78	31.**8**	33.79
fermented	48.34	59.86	54.1
average	36.92a	36.51b	38.38
RLSD0.05 manure = NPK doses* manure=	1.33 3.09	.	

V. Conclusions

- Supporting the traditional mineral fertilizer dose with organic produced slurry by anaerobic fermentation
- Sustainable agriculture process need maintaining and protection soil health by enriched essential nutrients as nitrogen and phosphate to arrive maximum crop growth and soil production .

VI. References

Aday, H.; M. Abdulkareem ; S. Muhsin. Effect of the Manure Levels, Depth and Method of Applying Using Ditch Opener and Manure Laying Machine on Some of Soil Physical Properties. Basrah Journal of Agricultural Sciences. Sci. 30(1): 13-25. (2017) DOi: 10.21276/basjas

Abubaker, J. ; Cederlund, H. ; Arthurson, V.; and Pell, M.. Bacterial community structure and microbial activity in different soils amended with biogas residues and cattle slurry. Applied Soil Ecology(2013). 72: 171-180.

Ahmed, R., Niloy, M. A. H. M., Islam, M. S., Reza, M. S., Yesmin, S., Rasul, S. B., &

Alburquerque, J. A.; de la Fuente, C.; Ferrer-Costa, A.; Carrasco, L.; Cegarra, J.; Abad, M. and Bernal, M. P.. Assessment of the fertiliser potential of digestates from farm and agroindustrial residues. Biomass and bioenergy. (2012)b 40:181-189.

Arnous A,. Response of Barley for Organic liquid Fertilizer From anaerobic digestion to Poultry manure A thesis College of Agriculture - University of Basrah,2022

Black, C. A.) . Methods of soil analysis . Part 1. Physical Properties Amer. Soc. Agron, Inc. Pub., Madison, Wisconsin, U.S.A. (1965),PP: 770.

Baria M. and Z K. Hasan.Effect of fermentation periods of poultry manure on its characteris when fermented with differents ways , J .Glob.Innov.Agri.Sci. 2024, DOI: https://doi.org/10.22194/JGIAS/24.1128

http://www.jgiass.comCavali, M., Libardi Junior, N., de Mohedano, R. A., Belli Filho, P., da Costa, R. H. R., & de Castilhos Junior, A. B. Biochar and hydrochar in the context of anaerobic digestion for a circular approach: An overview. Science of the Total Environment, (2022).,822, 153614. https://doi.org/10.1016/j.scitotenv.2022.153614

Delphi, Hussein Finjan Khudair. The effect of fermentation of organic residues on some of their chemical and physical properties and the effect of their addition on soil characteristics and the vocabulary of growth and yield of sunflowers. PhD thesis, College of Agriculture - University of Basrah - Iraq. (2020)

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https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.v13ii 34.*

Cresser, M.S. and J.W. Parsons .Sulphuric-Perchloric acid digestion of plant material for the determination of nitrogen, phosphorus, potassium, calcium and magnesium Analytica Chimica Acta. (1979). 109:431-436.

Gizawy El-, E. S. A., Atwa, A. A. I., Talha, N. I., & Mostafa, R. A. I. (2013). Effect of compost and compost tea application on faba bean crop and some soil biological and chemical properties. Journal of Soil Sciences and Agricultural Engineering, 4(9), 863–874.

Garg, R. N.; Pathak, H.; Das, D. K. and Tomar, R. K. (2005). Use of flyash and biogas slurry for improving wheat yield and physical properties of soil. Environmental monitoring and assessment. 107(1): 1-9.

Goel, B., Pant, D. C., & Kishore, V. V. N.. Two-phase anaerobic digestion of spent tea leaves for biogas and manure generation. Bioresource Technology, 80(2), 153–156. (2001) https://doi.org/10.1016/S0960-8524(01)00083-9

Hupfauf, S.; S.Bachmann ; M. F. D.Juarez ; H. Insam and B. Eichler-Löbermann (2015). Biogas digestates affect crop P uptake and soil microbial community composition. Science of the Total Environment, 542, 1144-1154.

Khandakar, J.. Optimizing tea waste as a sustainable substrate for oyster mushroom (Pleurotus ostreatus) cultivation: A comprehensive study on biological efficiency and nutritional aspect. Frontiers in Sustainable Food Systems, 7, Article 1308053. (2024) https://doi.org/10.3389/fsufs.2023.1308053

Mohammed, Ebtisam Jassim. Evaluation of the effect of organic and chemical fertilization on some soil properties and the growth and yield of cucumbers. Master's thesis. University of Basra. Faculty of Agriculture (2013).

Sun, H.; Cui, X.; Stinner, W.; Shah, G. M.; Cheng, H.; Shan, S. and Dong, R. (2019). Synergetic effect of combined ensiling of freshly harvested and excessively wilted maize stover for efficient biogas production. Bioresource technology. 285:121-338.

Svoboda, N.; Taube, F.; Wienforth, B.; Kluß, C.; Kage, H. and Herrmann, A.. Nitrogen leaching losses after biogas residue application to maize. Soil and Tillage Research. (2013) 130: 69-80.

Yu, F. B.; Luo, X. P.; Song, C. F.; Zhang, M. X. and Shan, S. D). Concentrated biogas slurry enhanced soil fertility and tomato quality. Acta Agriculturae Scandinavica Section B–Soil and Plant Science. . (201060(3): 262-268.

Wilkinson, K. G.. A comparison of the drivers influencing adoption of on-farm anaerobic digestion in Germany and Australia. Biomass and bioenergy. (2011) 35(5): 1613-1622.

Xiaohu W.; Chonglan D.; Xiaoyan H.; Weiming W.; Xiaoping J. and Shangyun J.. The influence of using biogas digesters on family energy consumption and its economic benefit in rural areas—comparative study between Lianshui and Guichi in China. Renewable and Sustainable Energy Reviews. (2007)11: 24 –1018.

Zhai, Ningning; Zhang, Tong; Yin, Dongxue; Yang, Gaihe; Wang, Xiaojiao; Ren, Guangxin and Feng, Yongzhong). Effect of initial pH on anaerobic co-digestion of kitchen waste and cow manure. In j.wasman. (2015 38 (0): 126–131.

Zhao, J.; Ni, T.; Li, J.; Lu, Q.; Fang, Z.; Huang, Q. and Shen, Q. Effects of organic–inorganic compound fertilizer with reduced chemical fertilizer application on crop yields, soil biological activity and bacterial community structure in a rice–wheat cropping system. Applied soil ecology. (2016). 99: 1-12.

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