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Effect of Vermicompost and NPK-Nano Fertilizer on Jojoba Plant under degraded Soil Condition

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ABSTRACT

Urban sprawl on the alluvial land of the River Nile and delta is one of the main problems that threaten the limited fertile land in Egypt. A pot experiment was carried out in the greenhouse of the National Research Centre; soil was collected from the agricultural soils affected by urban sprawl in Giza government to evaluate the effect of vermicompost and Nano nitrogen, phosphorus and potassium (NPK) fertilizer on some soil properties and NPK uptake of jojoba. Results showed that growth parameters of jojoba increased with Nano fertilizer as foliar application compared to none Nano fertilizer treatment, incorporating vermicompost in the soil with and without Nano fertilizer led to a decrement in bulk density and increments in total porosity of soil, water holding pores and hence soil water retention, hydraulic conductivity and mean diameter of soil pore, also obviously increased NPK uptake and all growth parameters of jojoba compared to none vermicompost treatment. It might be detected that jojoba as a biofuel crop and great salinity tolerant could be attained the financial income in such degraded soils using vermicompost as soil amendment and Nano fertilizer as foliar application on plant.

Keywords: Vermicompost, Nano nitrogen, phosphorus and potassium fertilizer, jojoba, plant growth, nutrient uptake and hydrophysical soil properties.

Introduction

Major challenges are resulting in the rapid change in socio-economic environment that threatens food security. This refers to the following: a) increase in world population; b) urbanisation; c) dietary changes; d) climate and global environmental change and the consequent loss of ecosystems; e) using food crops as a source of bioenergy and therefore f) the food and financial crises (Tirado *et al.*, 2010). Land degradation threatens the food security and livelihoods of millions of people, especially in dry lands, about 77million hectares of soils suffer from secondary salinization as a consequence of human activities. Land management, reclamation, and rehabilitation are essential to avoid environmental hazard of soil salinization especially in irrigated areas (Metternichta and Zinckb, 2003; Patel *et al.*, 2021).

FAO, (2021) reported that sectoral strategies and investments only cannot address important collaborations and trade-offs; as bioenergy crops e.g. corn, sorghum and sugarcane increases bioenergy source, but may increase conflict for land and water resources with its impact on local food security. However Rastegari *et al.*, 2019 showed bioenergy crops as a reliable alternative to fossil fuels could have positive impact on the environment by decreasing the level of carbon dioxide, emission of greenhouse gases and soil erosion. The biofuel plants increase soil carbon and fix atmospheric carbon and could also be used for the phytoremediation of heavy metal-contaminated soils.

jojoba (*Simmondsia chinensis*) as biofuel crop has a great salinity tolerance. Lesser possibilities for infection, lesser need for fertilizers, and generous financial income; jojoba seed can yield up to 60%

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pure oil chemically classified as liquid wax that gives it a great advantage as natural oil for industrial purposes, which also make it environmentally safe (El-Mogy, 1999; FAO, 2011).

Urban sprawl on the alluvial land of the River Nile and delta is one of the main problems that threaten the limited fertile land in Egypt, urban encroachment led to soil degradation especially in Giza and Cairo governorates.

Vermicomposting has been considered as an environmental friendly and cost effective technology for stabilization of organic waste with the participation of earthworms and microorganisms, particularly for non- developed countries (Aira *et al.*, 2007; Zandonadi and Busato, 2012; Huang *et al.*, 2013, 2020; Cao *et al.*, 2021).Vermicompost was revealed to stimulate soil microbial growth and activity This helps to increase soil organic matter content, which results in nutrients recycling, improvement of physical condition of soils, such as more stable aggregates and higher water holding, suitable chemical features such as enhancement of cation exchange capacity and nutrient availability and the consequent mineralization of nutrients for plant. Therefore it increases soil fertility and quality and contains plant growth promoting substances (e.g., vitamins, hormones, enzymes) that favor plant growth (Ievinsh,; Gutierrez-Miceli *et al.*, 2007; Pramanik *et al.*, 2007; Zaller, 2007; Zandonadi and Busato, 2012).
Some studies detected the significance of Nano fertilizers; some valuable effects include increment in nutrient use efficiency, better yield and reduced soil pollution (Naderi and Danesh-Shahraki, 2013.).The potential influence of Nano fertilizers in crop growth improvement and development due to its ability of greater absorbance and high reactivity (Vishekaii *et al.*, 2019). Nano fertilizers can possibly enter the plant cells directly through the sieve-like cell wall structures (Liu and R, 2015; Rose *et al.*, 2015). The soil scientists as well as the environmentalists should take in consideration the capability of Nano fertilizer for boosting soil fertility, declining pollution, enhancing biodiversity and abiotic stress tolerance, thus increasing plant nutrition availability and crop yield (Astaneh *et al.*, 2021; Singh *et al.*, 2021).

Therefore this investigation aims to study the influence of vermicompost and NPK-Nano Fertilizer on degraded soil and jojoba plant.

Materials and Methods

Soil amendment needs pre-trial before its application in degraded soil for enhancing soil health and productivity (Adeleke *et al.*, 2021). So a pot experiment was conducted at the greenhouse of the National Research Centre in 6.07.2015-01.06.2016 to evaluate the effect of vermicompost and Nano fertilizer of nitrogen, phosphorus and potassium on jojoba plant growth using agricultural soils that affected by urban sprawl. The analyses of studied soil, irrigation water and vermicompost are shown in tables (1, 2 and 3). Every trail pot received 10 kg of the soil affected by urban encroachment. Calcium super phosphate (15.5% P2O5) and potassium sulphate (48.5% K2O) were added for all treatments before sowing. Urea (46% N) was added in two equal portions after 60 days seed sowing for all treatments.

Investigation materials

Vermicomposting bedding system was used to convert different organic wastes (animal manure (cattle manure) + agriculture residues) into vermicompost under this study according to (Abul-Soud *et al.*, 2009). Vermicomposting implemented via Epigiec earthworms (vermicomposting worms), Lumbriscus Rubellus (Red Worm), Eisenia Fetida (Tiger Worm), Perionyx Excavatus (Indian Blue) and Eudrilus Eugeniae (African Night Crawler).

The used clay soil was collected from the agricultural soils affected by urban sprawl in Giza government. Vertical plastic 8 L volume pots were filled by 10 kg of the collected soil in open pot system. Vermicompost was incorporating in 10 % of soil weight per pot before jojoba sowing.

While Nano fertilizer (19:19:19 NPK) of nitrogen, phosphorus and potassium (2 ml/litre) was foliar applied on plant at two successive times 90 and 120 days after sowing.

The study treatments

Vermicompost and Nano-fertilizer applications in pot experiment were investigated under the current study as follows:

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1. Vermicompost treatment
None vermicompost
Vermicompost

2. Nano fertilizer treatment
None Nano fertilizer
Nano fertilizer of Nitrogen, Phosphorus and potassium

The experimental design was a complete randomized blocks experiment with 3 replicates.

Measurements of vegetative growth characteristics

Plant height, No. of branches per plant, No. of leaves per plant, fresh plant weight and dry plant weight of jojoba were measured after about one year of sowing jojoba's seeds.

Determination of soil properties

Soil texture was determined using the pipette method (Klute, 1986). soil pH, Electrical conductivity (EC) were determined according to (Cottenie *et al.*, 1982), Soil bulk density and total porosity were determined according to (Dewis and Freitas, 1970). Moisture retention is carried out using the pressure membrane apparatus (Loveday, 1974). Hydraulic conductivity was determined under constant head as described by (Singh, 1980), mean diameter of soil pore was estimated (Dielman and De Ridder, 1972). Vermicompost was incorporating in 10 % of soil weight per pot before jojoba sowing while Nano fertilizer of nitrogen, phosphorus and potassium (2ml/litre) was foliar applied on plant at two successive times 90 and 120 days after sowing. Plant height, No. of branches per plant, No. of leaves per plant, fresh plant weight and dry plant weight of jojoba were measured.

Table 1: The analysis of studied soil.

Mechanical analysis %				
Coarse sand	**Soft sand**	**Silt**	**Clay**	**Texture**
22.3	10	34.2	33.5	Loamy clay

Chemical soil characteristics			
pH suspension of soil past	**ECe dS^{-1} (Extract of soil past)**	**$CaCO_3$ %**	**O.M. %**
8.03	9.2	2.8	1.29

Soluble cations (me/l of soil paste)				Soluble anions (me/l of soil paste)		
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**$CO_3^{--}+HCO_3^{-}$**	**Cl^{-}**	**SO_4^{--}**
12.8	10	66.9	1.3	1.3	80.9	8.8

Hydro-physical analysis							
Bulk density g cm^{-3}	**Total porosity %**	**Saturation percentage %**	**Field capacity**	**Wilting point**	**Hydraulic conductivity m day^{-1}**	**Water holding pores**	**Mean diameter µm**
1.53	42.25	57	34	14.1	12.98	52	22.26

Table 2: The analysis of irrigation water

EC dS^{-1}	EC ppm	pH	Solube Anions				Soluble Cations				SAR
			CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na	K	
0.4	256	7.7	0	2	3.26	0.43	1.03	0.45	2.36	0.14	1.93

Table 3: Chemical analysis of vermicompost

C/N ratio	N %	P %	K %	Ca %	Mg %	Fe ppm
26.41	1.29	0.48	1.03	1.28	0.37795	2118.4
Cu ppm	**Mn ppm**	**B ppm**	**Zn ppm**	**Nippm**	**Cd ppm**	**Pb ppm**
14.4	260.1	4.4	59.7	0.4	0	0

Determination of N, P and K in the plant

The plant samples were milled and then digested with H_2SO_4 and H_2O_2, N, P and K analyses were confirmed according to (Cottenie *et al.*, 1982).

Statistical Analysis

The treatments were designed as a complete randomized blocks experiment. The obtained data were analyzed using the variance (two ways ANOVA test) by CoStat - Statistics Software Computer program and compared between means of treatments according to (Gomez and Gomez, 1984) at probability of 5 %.

Results and Discussion

The changes in land use from agricultural land to impervious surface (i.e. roads, houses, buildings) through the process of urbanization caused losses of vegetation area and lack of its ability to uptake carbon (Nuarsa *et al.,* 2018; Zhong *et al.,* 2019; Hu *et al.,* 2020).

Vermicompost produced from various organic wastes is an essential agricultural supplement because of their beneficial effects on diverse properties of soil, enhances the growth of plants by providing essential nutrients, improving beneficial microorganisms, and managing harmful pests and diseases and thus effect on agroecosystem productivity and sustainability, can be managed successfully without affecting human health and the environment and chemical-free food can be provided to humankind in the future (Mas-Carrió *et al*., 2018; Domínguez *et al*., 2019; Zandvakil *et al*., 2019; Stewart-Wade, 2020; Yatoo *et al*., 2021).

Effect of Vermicompost Application on Some Soil Properties

In the salt affected soil, swelling of the clay particles mainly causes a decrease of hydraulic conductivity and negatively affect on other soil properties through sodium (Na+) dominated soils , dispersion and migration of clay particles into the accompanying pores lead to plugging the soil pores (Pupisky and Shainberg, 1979).

Incorporating vermicompost in the soil improved its hydrophysical properties through decreasing its bulk density and increasing its total porosity, void ratio, water holding pores and hence moisture retention (total holding capacity, field capacity and wilting percentages), hydraulic conductivity and mean diameter of soil pores compared to the other treatments (table 4). Similar result was found by (Cogger, 2005; Moreno-Reséndez *et al*., 2013, 2015) who detected that vermicompost enhanced moisture retention, could decline soil water depletion during the crop season and raise crop water productivity under semi-arid conditions.

Table 4: Effect of treatments on soil hydrophysical properties, water retention and transmission.

Treatments		Bulk density g/ cm^3	Total porosity%	Void ratio	Water holding pores
None vermicompost	None Nano fertilizer	1.53	42.25	0.73	40.18
	Nano fertilizer	1.53	42.25	0.73	40.19
Vermicompost	None Nano fertilizer	1.20	54.74	1.21	60.84
	Nano fertilizer	1.20	54.74	1.21	60.84
LSD 0.05		0.015	0.571	0.022	1.064

Table 4: Cont.

Treatments		Non- useful pores	Available water	Hydraulic conductivity m/day	Mean diameter of pores µm
None vermicompost	None Nano fertilizer	16.61	23.57	1.55	7.70
	Nano fertilizer	16.62	23.57	1.55	7.68
Vermicompost	None Nano fertilizer	23.20	37.64	4.81	12.62
	Nano fertilizer	23.20	37.65	4.81	12.52
LSD 0.05		1.320	1.183	0.082	1.23

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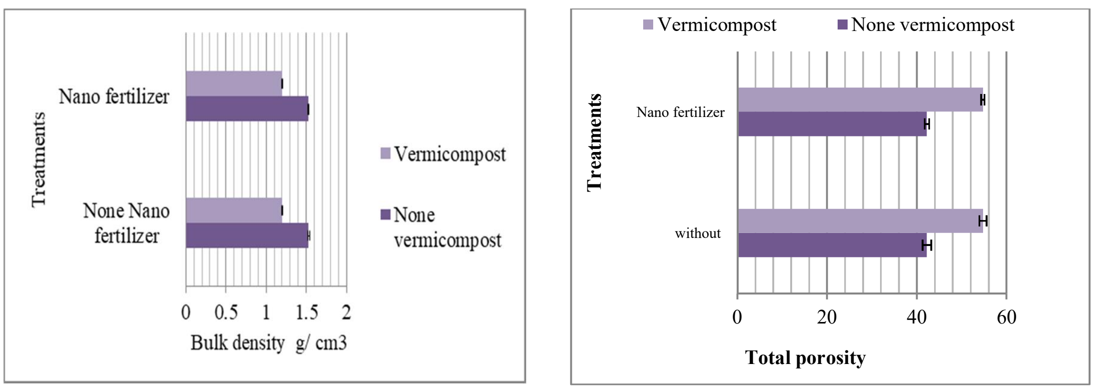
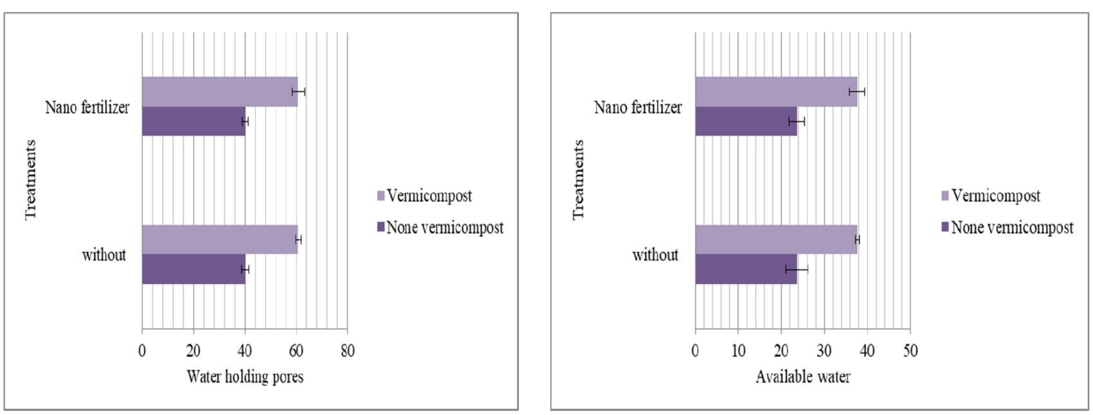
This may be attributed to application of vermicompost significantly improved several soil characteristics and induced a significant change in the rhizosphere soil fungal community (Zhao *et al*., 2017).

The soil water contents, aeration, availability of organic matter, soil temporal fluctuation and soil properties have been actively involved in the mineralization of available organic source through the efficient microbial activity (Tejada *et al*., 2010; Jack *et al*., 2011; Shah *et al*., 2015). This mineralization mechanism of organic matter produces partially to fully decompose organic carbon contents. The organic carbon improves the soil structure, friability, water holding capacity, porosity, tillage, soil fertility which in turn contributes in boosting up the yield of all crops (Adeleke *et al*., 2021). (Lorin *et al*., 2016) noticed that the vermicompost have a good potential to adsorb heavy metals such as cadmium and lead. Table (4) and figures (1, 2 and 3) showed that incorporating vermicompost in the soil obviously increased field capacity, wilting point, available water and hydraulic conductivity over none vermicompost treatments. Increments in field capacity, wilting point, available water and hydraulic conductivity of the soil treated with vermicompost were 33.95, 28.42, 37.37 and 61.47 % regarding applying vermicompost, respectively, this due to vermicompost enhance soil aeration microbial action, organic matter, porosity and structure (Pandya *et al*., 2014; Lim *et al*., 2015; Zhu *et al*., 2017; Yatoo *et al*., 2021).



a) b)

Fig. 1: (a and b) Effect of vermicompost and NPK-Nano fertilizer on soil bulk density and total porosity of soil and the standard errors.



a) b)

Fig. 2: (a and b) Effect of vermicompost and NPK-Nano fertilizer on water holding pores of soil and soil available water and the standard errors.

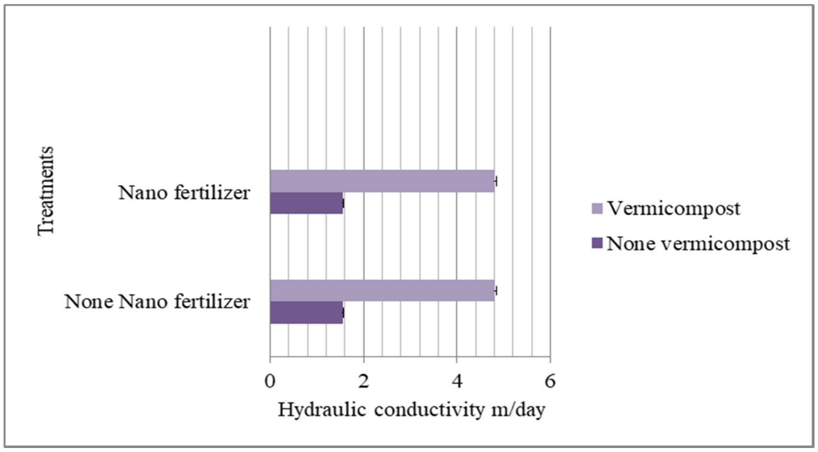


Fig. 3: Effect of vermicompost and NPK-Nano fertilizer on hydraulic conductivity of soil and the standard errors.

Effect of Vermicompost and Nano Fertilizer on jojoba Plant

Concerning the individual effect of treatments, obtained results showed that incorporating vermicompost in the soil obviously increased all growth parameters i.e. plant height, No. of branches per plant, No. of leaves per plant, fresh plant weight and dry plant weight of jojoba compared to the soil that didn't treat with vermicompost (Cao *et al*., 2021). Kumari and Singh, 2017 showed that dynamic and monitoring of soil health is useful for analysing its productivity and changes, so they found The land was shielded by many grasses and shrubs due to increasing nutrition availability, EC, WHC and moisture per cent, organic, and organic carbon. Sahab *et al*., 2021 revealed the effect of the individual vermicompost in saline soil management; vermicompost can be incorporated in high soil salinity. Vermicomposting organic wastes to bio-fertilizers with rich humic-like chemicals and probiotics can improve microbial community and enzymatic activities and boost growth and crop production (Bhat *et al*., 2018; Sanchez-Hernandez and Domínguez, 2019; Yatoo *et al*., 2021).

Table 5: Effect of treatments on plant growth parameters of jojoba

Treatments		**Plant length cm**	**No of branches per plant**	**No of leaves per plant**	**Fresh plant Weight g**	**Dry plant Weight g**
None vermicompost	**None Nano fertilizer**	49.33	2.67	49.67	5.23	2.74
	Nano fertilizer	63.67	3.67	63.33	9.00	4.92
Vermicompost	**None Nano fertilizer**	73.83	4.67	76.33	18.78	10.59
	Nano fertilizer	82.67	5.33	82.33	24.34	11.34
LSD 0.05		5.564	1.153	4.354	1.158	0.589

Also, Nano fertilizer of nitrogen, phosphorus and potassium as foliar application led to increment in growth parameters of jojoba growth parameters. These results are in agreement with (Al-Juthery *et al*., 2021; Alyasari *et al*., 2019; Modi *et al*., 2021; Yata *et al*., 2018). Nano-fertilizers have slow release and high efficiency in mitigating the effect of abiotic stress and increase crop yield (Sajyan *et al*., 2019, 2020; Sassine *et al*., 2020).

With respect to the interaction between vermicompost and Nano fertilizer of nitrogen, phosphorus and potassium, data illustrated in figures (4 and 5) explained that all growth parameters of jojoba clearly increased by applying vermicompost to soil and adding Nano fertilizer as foliar spray on the plant compared to the treatments that did not receive vermicompost or Nano fertilizer.

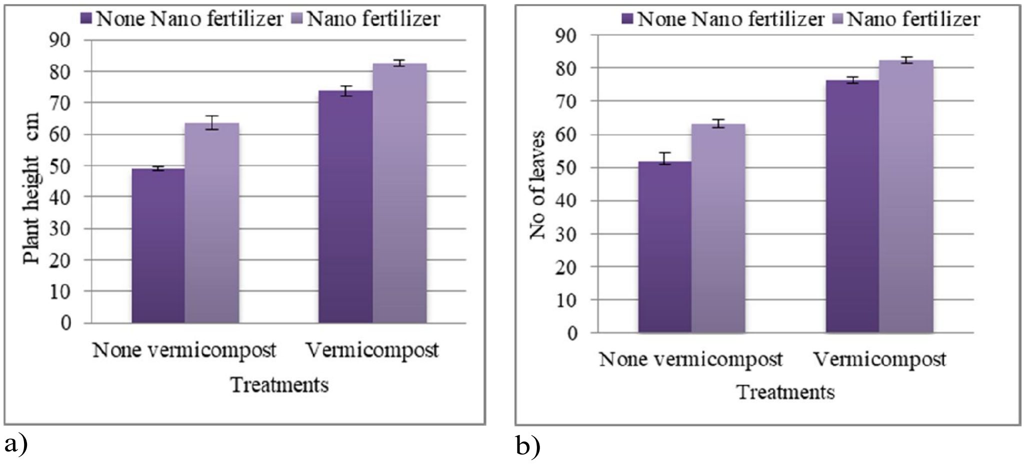


Fig. 4: (a and b) Effect of vermicompost and NPK-Nano fertilizer on plant height and No. of leaves per plant and the standard errors.

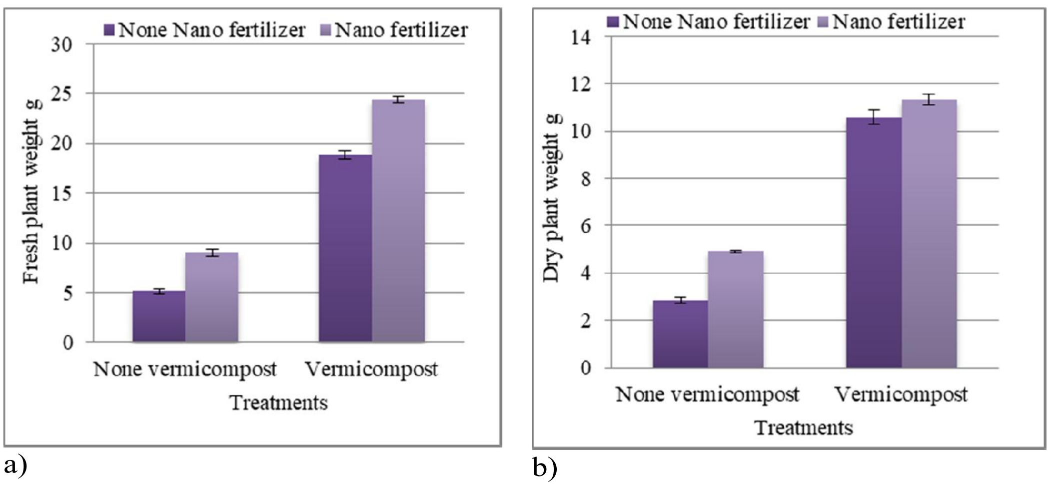


Fig. 5: (a and b) Effect of vermicompost and NPK-Nano fertilizer on jojoba fresh plant weight (g) and dry plant weight (g) and the standard errors.

Table 6: Effect of treatments on nitrogen, phosphorus and potassium concentrations and uptakes

Treatments		N %	P %	K%	N uptake g/plant	P uptake g/plant	K uptake g/plant
None vermicompost	**None Nano fertilizer**	1.599	0.076	0.670	0.044	0.002	0.018
	Nano fertilizer	2.079	0.122	1.104	0.102	0.006	0.054
Vermicompost	**None Nano fertilizer**	2.240	0.138	1.188	0.237	0.015	0.126
	Nano fertilizer	2.348	0.161	1.191	0.266	0.018	0.135
LSD 0.05		0.273	0.022	0.057	0.011	0.001	0.006

Uptake of nitrogen, phosphorus and potassium in jojoba plants were significantly affected by applying vermicompost in the soil and flaring Nano NPK fertilizer on the plant (fig.6). The more the amount of applied vermicompost was, the higher was nitrogen, phosphorus and potassium uptake by the plant. In detail, increments in nitrogen, phosphorus and potassium uptake of plants treated with vermicompost over the plants which did not treated were 81.43, 86.66 and 85.71 %, respectively (Fornes *et al*., 2012; Shah *et al*., 2015; Balachandar *et al*., 2021). Adeleke *et al*., 2021 mentioned that Physiological plant root activities are consist of nutrient dynamics and availability changing nutrient evolution and amendment decomposition. Mahaly *et al*., 2018 noticed that vermicompost have high

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total nitrogen, total phosphorus, total potassium, available nitrogen, available phosphorus, available potassium, total calcium and total magnesium.

The increase percentages in K/Na ratio and Ca/Na ratio (table 7and figure 4) were 55.17 and 20.71 by incorporating vermicompost in the soil while 15.21 and 15.90 by spraying nano NPK fertilizer on the plant consequently 55.80 and 27.45 by applying vermicompost to the soil and nano NPK fertilizer to the plant. Munns *et al*., 2006 considered K/Na as a good indicator of high salt-stress tolerance.

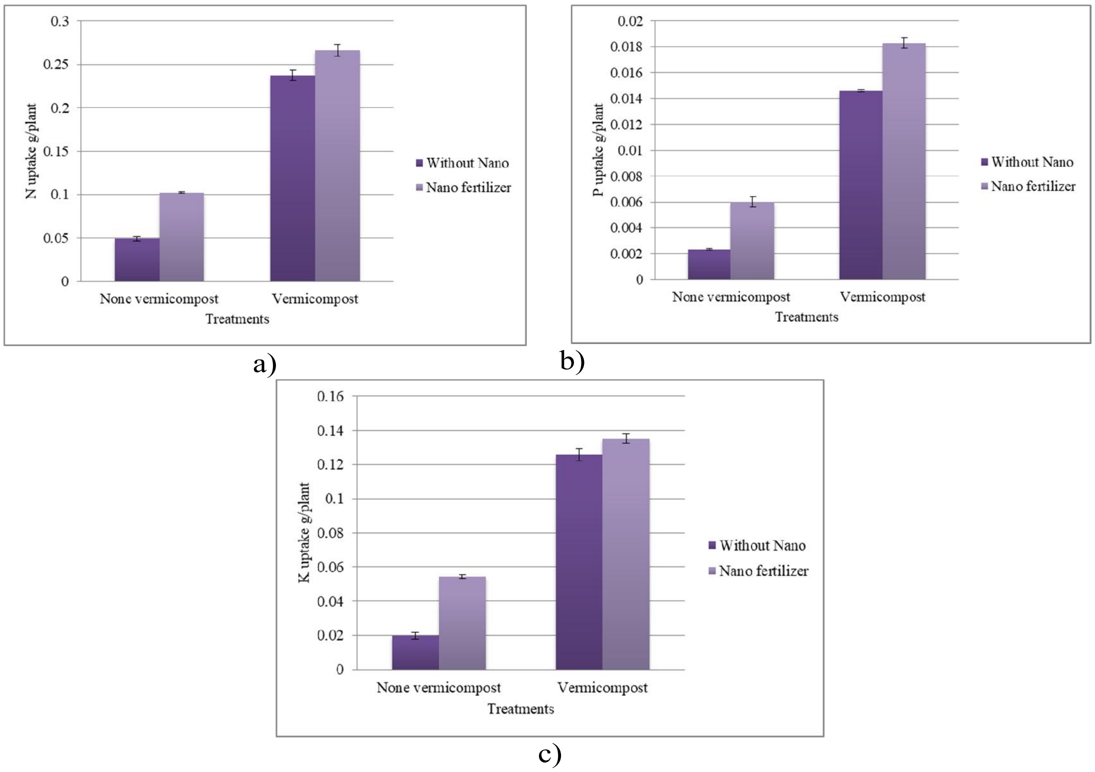

Fig. 6: (a,b and c) Effect of vermicompost and NPK-Nano fertilizer on nitrogen, phosphorus and potassium uptake of jojoba (g/plant) and the standard errors.

Table 7: Effect of treatments on K/Na ratio and Ca/Na ratio in jojoba plant

Treatments		**K/Na ratio**	**Ca/Na ratio**
None vermicompost	**None Nano fertilizer**	1.56	1.11
	Nano fertilizer	1.84	1.32
Vermicompost	**None Nano fertilizer**	3.48	1.40
	Nano fertilizer	3.53	1.53
LSD 0.05		0.338	0.079

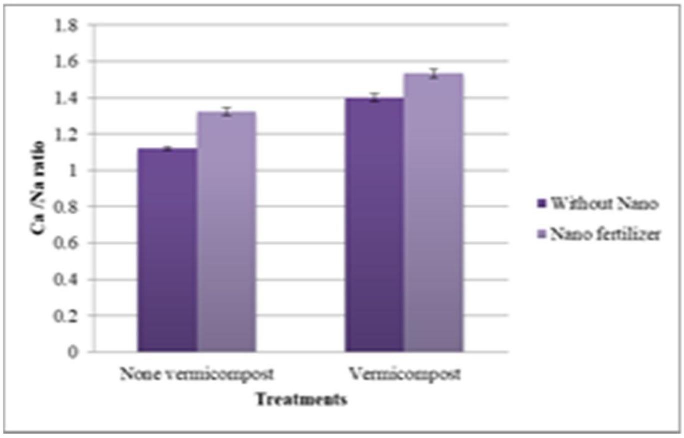

Fig. 7: Effect of vermicompost and NPK-Nano fertilizer on Ca/Na ratio in jojoba plant and the standard errors.

Conclusion

Vermicompost as organic soil amendment decreased soil bulk density and increased total porosity of soil, water holding pores and hence moisture retention, hydraulic conductivity and mean diameter of soil pore. This associated with foliared Nano-NPK fertilizer positively reflects on soil nutrient availability, nutrient uptake and plant growth. Conclusion of this study is that the combination of vermicompost incorporated in the soil and Nano-NPK fertilizer foliared on the plant not only increases nutrient uptake and plant growth of jojoba as biofuel crop, but also improves soil properties of degraded soil and reduces its negative effect on the environment by enhancing soil health and productivity.

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