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Studying Some Characteristics of Sandy Soil Amended by Water Hyacinth, Bean Straw, and Compost

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TWO FIELD experiments were carried at the Ismailia Agricultural Research Station during the summer seasons of 2018 and 2019 to study some characteristics of sandy soil treated by three types of additives and cultivated by maize. Additives mixed with soil were the dried water hyacinth, straw of faba beanand compost each is loaded by 25, 50, and 100% of the recommended dose of nitrogen N and phosphorous P mineral fertilizers. Different treatments including control were distributed in a complete randomized block design with three replicates. Water holding capacity (%), field capacity (%), electrical conductivity (dSm^{-1}), bulk density ($g\ cm^{-3}$), cation exchange capacity ($cmol_c\ kg^{-1}$) and organic matter (%) content of soil before cultivation and after harvesting were estimated. Maize yield ($kg\ ha^{-1}$) and some yield components were also calculated for different treatments. Results indicated that after harvesting, water-holding capacity increased significantly by 20% using dried water hyacinth, non-significantly by 10 and 5% using bean straw and compost, respectively, compared to control at 100% NP application rate. Field capacity increased by 37.5% using dried water hyacinth and bean straw and by 12.5% using compost compared to the control. Non-significant change was observed in soil EC (dSm^{-1}) before planting and after harvesting. The application rate 100% NP showed the least bulk density values significantly decreased by 7.78% for compost, 4.44% for dried water hyacinth, and by 2.78% for beanstraw compared to the control. At application rates 50 and 100% NP, compost treatments provided the maximum available P and K in soil followed by dried water hyacinth then bean straw. At application rate 100% NP, yield of maize dry matter ($kg\ ha^{-1}$) significantly increased by 120.34, 116.96 and 27.44% for dried water hyacinth, bean straw, compost, respectively. Seed yield ($kg\ ha^{-1}$) increased significantly by 136.3, 135.85, and 33.63% for bean straw, dried water hyacinth, and compost, respectively.

Key words: Amendments, Bean straw, Compost, Maize, Sandy Soil, Water hyacinth.

Introduction

Soil degradation and environmental pollution due to intensive use of inorganic chemical fertilizers is increasing. It is accompanying the increase in the crop production to meet the world populations' needs. Nowadays, the world is oriented toward sustainable agriculture to minimize pollution sources. The use of organic fertilizers out of plant residues and animal manures have shown many advantages over chemical fertilizers and are recommended in agricultural practices worldwide (El-Gizawy et al., 2013).

On the other hand, the annual agriculture by-products in Egypt are around 30 million tons of dry material. Most of crop residues are burned or wasted, which is resulting in environmental pollution and health hazards. Agricultural residue disposal via open burning of biomass affects the global climate change by emitting particles and vapour pollutants (Lu et al., 2009). Utilization of such by-products is a method to control environmental pollution. The main components of agro-industrial residues (cellulose, hemicellulose, and lignin) are complex with low biodegradability, due to their resistance to degradation by microorganisms (Abd El-Galil & Ebtehag, 2011 and Istirokhatuna et al., 2015).

The importance of compost to crop productivity has been recognized widely as an alternative nutrient source (Abdelhamid et al., 2004). It improves soil structure, soil organic matter, CEC,

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pH, water retention, and decreases the need to fertilizers (El-Gizawy et al., 2013). The use of any organic manure in addition to the mineral NPK fertilizers increases dry matter, yield, and N, P, and K uptake by plants (PDA (www.pda.org.uk) 2009).

Most legumes used for human consumption produce by-products that are usually utilized as animal feeds. Faba bean (*Vicia faba* L.) is one of the most important grain legumes in Egypt and bean straw is important species of biomass. Straw has always been an important by-product of cereal production, with its main use as feed and bedding for livestock (Abd El-Galil and Ebtehag, 2011).

The recent rise in the price of fertilizer nutrients has led to a detailed consideration of straw. Straw showed a value for the fertilizer nutrients. Incorporating straw in soil may have some benefits being an additional organic matter to the soil, can help to improve soil structure, and returns the nutrients in the straw to the soil. Disadvantages may include incorporation difficulties and competition with crop for available soil nitrogen. Analysis showed that the nutrient content of spring cereal straw is higher than of winter straw, and that the potash content of straw is much higher than the phosphate content (Zhichen et al., 2011 and PDA, 2009).

Water-hyacinth (*Eichhornia crassipes*) is an important aquatic plant that is widely spreading in many countries and threatens water ecosystems throughout the world like Egypt, India, and Australia. It is a floating plant species rapidly cover the whole waterways to reach tons of wet weight. It forms dense, impenetrable mats over the water surface, resulting in blocking irrigation channels and rivers, restricting livestock access to water, reducing infiltration of sunlight, changing the temperature, pH and oxygen levels of water, increasing water loss through transpiration (Téllez et al., 2008). There has been an emphasis on converting water hyacinth into useful resources, including animal feed, composted fertilizer or for bio-energy production, but its high moisture content limits its handling (Abdelhamid et al., 2004; El-Gizawy et al., 2013 and Abdel Shafy et al., 2016).

The optimal growth conditions are 25°C - 27°C, growth stops if water temperature below 10°C or above 40°C, at pH 7 (pH 3.2–4.2 is very toxic for the plant, 4.2–4.3 inhibitory(Lu *et al.*, 2009; Abd El-Galil and Ebtehag, 2011). Location and season affect its chemical composition. Constituents of the dried waterhyacinth on dry weight basis were 10% crude protein, 11% ash and 79% organic matter varying between different plant organs such as leaves stems and roots (Abdel Shafy et al., 2016). Such plants could be used as a biological indicator for environmental contamination by heavy metals due to its ability to uptake some toxic heavy metals such as Cd, Zn, Cu and Pb within their tissues (Abdel-Sabour et al., 1996; Abdel Shafy et al., 2016). It is suitable as animal fodders due to their valuable nutrient contents with care not to collect such plant from contaminated water (Abdel Shafy et al., 2016). The fresh stalks comprises of 90-95% of water while dried stalk has good amount of cellulose, hemicellulose and lignin (PDA, 2009).

Chemical analysis indicated that extracts of leaves contain biologically active phyto-chemicals including antiviral, antifungal, antitumor, antimicrobial and antibacterial agents (Abdelhamid et al., 2004). Extracts may be used together with known drugs or utilized for developing pharmacological agents.Functional medicinals include flavonoids, alkaloids, tannins, carotenoids, and phenols (Baral et al., 2011 and Baral & Vaidya, 2011). Water hyacinth is rich in oxidative enzymes and non-enzymatic antioxidant metabolites may be involved in the chemical defences of plants against plant pathogens. The foliar spray using the *E. crassipes* extract significantly decreased the wheat leaf spots and increased grain yield (Haggag et al., 2017).

This work aims to study the utilization of two types of agricultural wastes in sandy soil cultivated by maize.They are the dried water hyacinth and straw of faba bean in comparison with compost. The study focuses on their efficiency in improving soil moisture content as well as its nutritional status. The ultimate goals of the study are to: (a) improve some moisture properties of sandy soil to safe its water requirements, (b) increase use efficiency of chemical fertilizers applied for sandy soil, and (c) effective utilization of the studied plant residues as sustainable organic additives for sandy soil.

Materials and Methods

Area of study

The field experiment has been carried out during the summer seasons of 2018 and 2019 at the Ismailia Agricultural Research Station, (30° 35' 30" N 32° 14' 50" Eelevation 3 m) Agricultural Research Center (ARC). Some properties of the experiment sandy soil (*TypicTorripsamment; Entisol* [Arenosol AR] (FAO, 2014)) are presented in Table 1.

TABLE 1. Some characteristics of the experiment soil before cultivation

	Particle size distribution (%)			
	Coarse sand	Fine sand	Silt	Clay
	70.12	14.32	6.22	9.34
Texture class	$CaCO_3$ (g kg^{-1})	Organic Matter OM (g kg^{-1})	pH†	Electrical Conductivity EC (dS m^{-1})‡
Sandy	3.8	2.6	7.90	0.40
	Available nutrients (mg kg^{-1})			
	N	P	K	
	25.50	2.20	55.16	

† (1:2.5 soil: water suspension) ‡ (1:5 soil : water extract)

Materials used in the study and planting

The studied additives were water hyacinth (A) collected from the Abo-Khalifa village 17 km Ismailia – Port Said Road at the end of the Ismailia canal, straw of faba bean (B) obtained from the experimental farm, and compost (C). Both A and B were air-dried for 10 days and cut into 5-10 mm specimens. Some of their properties were estimated and presented in Table 2.

All organic additives were mixed with surface soil at a constant application rate for each one that is 47.62 m^3 ha^{-1} equivalent to11.9, 19.1 and 23.8 ton ha^{-1} of A, B, and C, respectively.

Mineral fertilizers were nitrogen (N) as ammonium sulphate and phosphorous (P) as super phosphate mixed with A, B, or C additives. Three application rates 1, 2, and 3 of mineral NP were 25%, 50% and 100%, respectively, of the recommended doses (333.2 kg N ha^{-1} and 36.89 kg ha^{-1} as P_2O_5) were used; each of which was divided in two halves. One-half was mixed with the desired dose of the organic additive treatment, left for a weak, then mixed with surface soil before sowing. The second half of the desired NP dose was applied forty days after sowing in three additions. One dose of K;114.24 kg ha^{-1}, was applied sixty days after sowing as K_2O.

Mineral NP treatments without organic additives were used for comparison. They included a control treatment at recommended dose as well as mineral (M) treatments at 25% (M1), 50% (M2), and 100% (M3) of the recommended NP dose. All thirteen treatments were distributed in a complete randomized blocks design with three replicates and plot area 3.6 m × 4 m.

Each plot has received the desired treatment before sowing, maize seeds were sown on 5 May 2018, and 5 May 2019 after soil preparation as mentioned. Irrigation was scheduled to meet the water requirements for maize (6190.5 m^3 ha^{-1}) at the field capacity of soil with its saturation percentage 20%. Fertilization and other agronomic practices were followed according to the Ministry of Agriculturerecommendations.

Soil and plant sampling

Representative soil samples from all treatments' plots were taken after application of different treatments before sowing as well as after harvesting maize crop to estimate the following characteristics (Black 1982): water holding capacity (WHC, %), field capacity (FC, %), electrical conductivity (EC, dSm^{-1}), bulk density (BD, g cm^{-3}), cation exchange capacity (CEC, $cmol_c$ kg^{-1}) and organic matter content (OM %).

At harvest, each plot contained around eighty plants from which plant samples were randomly selected and air-dried. Yield (t ha^{-1}) and some yield components such as seed yield (tha^{-1}), 100-seeds weight (g), and shelling (%) have been calculated based on the seed yield per plot area and the mean of the two seasons was recorded.

Analysis of soil and plant samples' content of N, P, and K

The soil available N, P, and K were extracted by 1% K_2SO_4, 0.5 N $NaHCO_3$, and 1 N NH_4OAc (pH 7.0), respectively (Black, 1965; Jackson,1973).

Maize seeds and straw were dried at 70ºC for 48 h and ground. A half gram of the ground seeds and/ or straw was wet digested using the acid mixture (1:1 $H_2SO_4/HClO_4$) (Chapman and Pratt, 1961). Total concentrations of N, P and K in plant and soil extracts were estimated by distillation using Kjeldahl apparatus, colorimetrically by the UV-Vis. Spectrophotometer and by flame photometer, respectively.

Nutrient Use Efficiency Indices: they were calculated for A, B, and C treatments according to Craswell and Godwin (1984) and Roozbeh et al. (2011). Use efficiency (UE) also expressed as apparent recovery (AR) as well as agronomic efficiency (AE) for both N and P fertilizers applied along with A, B, and C were calculated as follows:

Nutrient Use Efficiency (UE/AR) =

$$\frac{(Pn_f - Pn_0)}{\text{Fertilizer rate (N or P, kg ha-1)}} \times 100$$

P_n = seed nitrogen (N, g kg^{-1}) and/or phosphorus (P, g kg^{-1})

P_{nf} = seed N in fertilized plots f = fertilized plots (by A, B, or C)

P_{n0} = seed N in non fertilized plots 0 = non-fertilized plots (M control treatments)

Agronomic Efficiency (AE) =

$$\frac{Yf - Y0}{\text{Fertilizer rate (N or P , kg ha-1)}}$$

Y = seed yield (kg ha^{-1})

Statistical analysis

The statistical significance (LSD) of treatments effect was estimated by the one-way analysis of variance (ANOVA) (Gomez and Gomez, 1984). Calculations were carried out at a significance level *P = .05* using the Co-State software Package (Ver. 6.311), a product of Cohort software Inc., Berkley, California.

Results and Discussion

The organic materials used in the present study possessed different properties as presented in Table 2. Water hyacinth A had the maximum moisture content (%), minimum bulk density (g cm^{-3}) and minimum total NPK content (g kg^{-1}). Faba bean straw B showed minimum moisture content (%), middle values of bulk density and total NPK content between A and C. Compost C had a middle value of moisture content (%), maximum bulk density and maximum NPK content.

Materials A, B, and C showed neutral pH and non-saline EC (dS m^{-1}), which will not alter soil pH or EC. The role-played by A, B, and C, especially after loading by NP fertilizers and applied to sandy soil is dependent on their different properties(Abd El-Galil & Ebtehag,2011 and Bhuvaneshwari & Sangeetha, 2016).

Effect of the applied materials on the moisture properties of the experimentsoil

Table 3 shows that treatments of A at 25, 50, and 100% NP application rates, increased the WHC (%) and FC (%) before planting compared to control significantly by 50 and 100%, respectively. Non-significant increase in the WHC before planting was by 25% in case of C and by 20% in case of B compared to control while FC significantly increased by 62.5% for C,then by 37.5% for B.

TABLE 2. Some properties of air-dried materials used before applicationin the study

Material	Moisture, %	BD†, g cm^{-3}	pH‡	EC‡, dS m^{-1}	CEC, $cmol_c$ kg^{-1}	Total g kg^{-1}		
						N	P	K
Water hyacinth (A)	26	0.25	7.51	1.18	-	8.78	2.23	12.3
Straw of FB (B)	16	0.40	7.00	1.43	-	12.8	2.9	15.1
Compost (C)	23	0.50	7.74	0.87	47	19.5	8.0	20.4

† Bulk Density, g cm^{-3} ‡ Compost (1:20), Straw of FB (1:5), Water hyacinth (1:20)

TABLE 3. Water holding capacity (WHC) and field capacity (FC) of soil for different treatments

Application rate	Treatment	Before planting		After harvesting	
		WHC (%)	FC (%)†	WHC (%)	FC (%)†
	Control	19	8	20	8
25% NP	M1	20d	8d	20e	8d
	A1	30a	16a	24a	11a
	B1	24c	11c	21d	10b
	C1	25b	13b	21d	9c
50% NP	M2	20d	8d	20e	8d
	A2	30a	16a	23b	11a
	B2	24c	11c	22c	11a
	C2	25b	13b	21d	9c
100% NP	M3	20d	8d	20e	8d
	A3	30a	16a	24a	11a
	B3	24c	11c	22c	11a
	C3	25b	13b	21d	9c
L.S.D $_{5\%}$		6.80	1.18	3.44	7.03
Significance of factors		***	***	***	***

†After 24 hr of irrigation

After harvesting, WHC (%) increased significantly by 20% using A, non-significantly by 10 and 5% using B and C, respectively, compared to the control at 100% NP application rate. In addition, FC (%) increased by 37.5% using A and B and by 12.5% using C compared to the control.

Obviously, varied values of WHC and FC for the studied soil amended by A, B, C, and D did not change by increasing the application rate of NP fertilizers from 25 to 100%. This indicates that variation in WHC and FC of soil is due to different properties of A, B, C, and D rather than loading by NP fertilizer. Water hyacinth A showed higher moisture content (26%) than C (23%) and B (16%) and lower bulk density (0.25 g cm^{-1}) than B (0.4 g cm^{-1}) and C (0.5 g cm^{-1}). Hydrophilic light plant fibers of A when mixed with soil may provide better textural properties of sandy soil and may make it less compacted than the more dens B or C.Water hyacinth (A) was a better carrier for mineral NP fertilizersthan B and C compared to the sole application of NP fertilizers without organic additives although A showed minimumNPK content (Abdelhamid et al., 2004 and Zhichen et al., 2011).

Effect of applied materials on the electrical conductivity and bulk density of the experiment soil

As expected, amending sandy soil under study by A, B, and C showed non-significant change in its EC (dSm^{-1}) neither before planting nor after harvesting (Table 4). This is because soil, A, B, and C are all in the same range of EC: 0.4 – 1.43 dSm^{-1}. However, EC of soil increased in the order: B < A < C compared to the control and regarding NP application rate in the order: 25% < 50% < 100% NP.Maximum increase was by 13.16% recorded for C3 treatment. Compost (C) had higher nutrient content than A or B in addition to its load of NP fertilizers. It releases solublenutrient moieties more than A and B and hence showed greater EC. Upon mixing additives with soil, the chemical state of soluble salts (cations and anions) may be alteredby different organic and inorganic constituents of soil. Also, textural properties of soil containing A, B, or C behaves different in its leaching characteristics. In turn, different treatments showed different EC values of soil (Abdel Shafy et al., 2016).

TABLE 4. Electrical conductivity (EC) and bulk density (BD), Cation exchange capacity (CEC) and organic matter (OM) content of soil of soil for different treatments

Application rate	Treatment	Before planting		After harvesting		CEC‡ (cmolc kg-1)	OM‡ (%)
		EC (dSm^{-1})†	BD, $g\ cm^{-3}$	EC (dSm^{-1})†	BD, $g\ cm^{-3}$		
	Control	1.14bc	1.80a	1.12bc	1.80a	4.17bcd	1.65ab
25% NP	M1	1.12c	1.80a	1.10c	1.79a	3.59d	1.64ab
	A1	1.20abc	1.74abc	1.24abc	1.71a	4.05cd	1.21c
	B1	1.14bc	1.76abc	1.13bc	1.75a	4.17bcd	1.77a
	C1	1.25ab	1.69bc	1.27ab	1.68a	5.79ab	1.76a
50% NP	M2	1.13bc	1.80a	1.12bc	1.78a	4.02cd	1.59ab
	A2	1.22abc	1.74abc	1.23abc	1.72a	4.75abcd	1.60ab
	B2	1.15bc	1.75abc	1.14abc	1.74a	5.25abcd	1.76a
	C2	1.28a	1.68bc	1.30a	1.68a	6.25a	1.48abc
100% NP	M3	1.13d	1.80a	1.15abc	1.80a	4.75abcd	1.47abc
	A3	1.22abc	1.72abc	1.26abc	1.71a	4.17bcd	1.62ab
	B3	1.14bc	1.75abc	1.17abc	1.75a	5.56abc	1.35bc
	C3	1.29a	1.66c	1.30a	1.65a	6.29a	1.70a
L.S.D 5%		0.13	0.09	0.16	0.17	1.71	0.32
Significance of factors		ns	*	ns	ns	*	*

† EC in soil saturation extract ‡before planting: CEC = 3.24 $cmol_c\ kg^{-1}$, OM = 1.36 %

Mixing sandy soil with A, B, or C decreased soil BD ($g\ cm^{-3}$) significantly before planting compared to the control M in the order B > A > C (Table 4). The application rate 100% NP showed the least BD values significantly decreased by 7.78% for C3, 4.44% for A3, and by 2.78% for B3 compared to the control M.

Bulk density decreases when either weight unit decreases in unit volume or volume unit increases with respect to weight unit. Although C itself had greater BD = 0.5 $g\ cm^{-3}$than B (0.4 $g\ cm^{-3}$) or A (0.25 $g\ cm^{-3}$), it showed less soil bulk density. Thiseffect may be caused by soil particles mixed with compost and distributed between different components of compost.Such sand particles of soil differentiate compost particles,create in between voids, and expand volume of applied weight of compost.Therefore, BD of soil decreased by C due to increased volume of soil. Same effect may apply to A and B but to less extent because lower weight of A or B is in unit volume that is less affected by soil particles. Increased soil volume may lead to escape of water and leaching of nutrients from expanded matrix, decrease WHC and FC as well as available nutrients.

Planting and agronomic practices throughout the maize cultivation season affected the soil so that variation in BD was non-significant after harvesting for different treatments as indicated by Table 4. However, same effect of A, B, and C, observed before planting may apply after harvesting but non-significantly (Ewis et al., 2014).

Cation exchange capacity (CEC) and OM of soil are built up on the long range and not easily changed at short time. Additives in the present study significantly affected both CEC ($cmol_c\ kg^{-1}$) and OM (%) of the experiment soil compared to the control treatments, which may be expected a temporary change over the season of application. Soil CEC significantly increased in the order C > B > A, and increased as the application rate increased from 25% NP to 100% NP. This is may be due to a higher content of the completely composted organic matter in compost C compared to un-composted organic A and B. However, presence of bioactive phyto-chemicals and ligands in A and B may enhance their adsorption capacity, which increases CEC compared to the control. Increase in therate of NP fertilizerfrom 25 to 100% increased the concentration of soluble N and P nutrients bound and/or adsorbed to the particles of A, B and C. Particles are dispersed and give greater surface area, adsorption capacity and hence CEC.

Observed decrease in some OM (%) values may refer to consumption of OM solubilized under the effect of increased rate of NP to 100% of the recommended dose.

Available N, P, and K in soil

Table 5 shows a significant variation in the available N, P, and K in soil treated by A, B, and C loaded by NP fertilizers compared to control values before cultivation and after harvesting. Application of the NP fertilizers increased nutrient availability in soil by different degrees depending on the type of carrier matrix whether it is A, B, C, or without organic additive (control). More available N, P, and K often enhance uptake by plant and sometimes decrease residue in soil (El-Basioni et al., 2015; El-Gizawy et al., 2013).

At application rates: 50 and 100% NP, C2 and C3 treatments provided the maximum available P and K in soil followed by A2 and A3 then B2 and B3. This is in agreement with their NPK content shown in Table 2 except for N. The decreased available N from compost may be due to N consumption by microorganisms in compost compared to A and B.

Effect of the studied treatments on yield and yield components

Yield of maize dry matter, ears, and seeds (kg ha^{-1}) significantly increased by additives applied to soil as presented in Table 6. Compared to the control, application rate of 25% NP with A, B, C, reduced the dry matter yield (kg ha^{-1})significantly. This may be attributed to the smaller dose of NP fertilizers than recommended being less than maize requirement. Nutrient imbalance and the textural properties of A, B, C mixed with soil may affect nutrient mobility through soil matrix and decrease their uptake by plant.

TABLE 5. Soil available NPK after harvesting

Application rate	Treatment	Available (mg kg-1)		
		N	P	K
	Before planting	26.9f	2.4bcd	55.5g
	Control	38.7c	2.4bcd	73.3d
25% NP	M1	38.7c	2.2cd	73.3d
	A1	38.7c	1.2d	55.8g
	B1	35.3d	2.7bc	55.8g
	C1	35.3d	4.5a	146.6a
50% NP	M2	38.7c	2.1cd	83.6c
	A2	48.8a	2.9bc	62.8f
	B2	35.3d	1.9cd	55.8g
	C2	30.6e	3.8ab	132.6b
100% NP	M3	35.2g	2.4bcd	83.7c
	A3	35.3d	2.3cd	73.3d
	B3	45.4b	1.8cd	66.3e
	C3	32.0 bcd	4.5a	132.6b
L.S.D 5%		١,٢٧	1.48	1.71
Significance of factors		***	*	***

TABLE 6. Yield and some yield components

Application rate	Treatment	Dry matter yield (kg ha^{-1})	Ears yield (kg ha^{-1})	seed yield (kg ha^{-1})	100-seed wt. (g)	Shelling (%)†
	Control	3497.2f	2513.9f	1941.2e	25.18abc	77.22 a
25% NP	M1	377.8l	313.9l	238.1i	29.04abc	75.84 a
	A1	1463.9j	1018.1j	860.5g	23.53bc	84.52 a
	B1	2496.5h	1865.9h	1563.3f	32.67a	83.78 a
	C1	1719.4i	1279.2i	972.2g	31.63ab	76.00 a
50% NP	M2	1020.1k	836.1k	693.5h	23.37bc	82.94 a
	A2	4090.9d	2903.5d	2488.5cd	27.90abc	85.71 a
	B2	5235.4b	4113.9b	3432.8b	28.79abc	83.44 a
	C2	3802.1e	2788.9e	2378.2d	29.51abc	85.27 a
100% NP	M3	2969.4g	2233.3g	1916.7e	25.81abc	85.82 a
	A3	7705.6a	5472.9a	4578.3a	29.14abc	83.65 a
	B3	7587.5a	5427.8a	4587.1a	27.81abc	84.51 a
	C3	4456.9c	3175.0c	2594.0c	22.78c	81.70 a
L.S.D 5%		147.13	111.23	141.76	8.74	17.49
Significance of factors		***	***	***	ns	ns

† Shelling (%) = (Seed weight (g)/Ears weight (g)) × 100

When the fertilizer dose increased to 50% NP, dry matter yield (kg ha^{-1}) of maize significantly increased by 49.7, 16.98, and 8.72% for B, A, C, respectively, compared to the control. At application rate 100% NP, the dry matter yield (kg ha^{-1}) significantly increased by 120.34, 116.96, 27.44% for A, B, C, respectively.

Similarly, ears yield (kg ha^{-1}) of maize at 25% NP application rate decreased significantly by 59.5, 49.11, and 25.78% for A, C, B, respectively, compared to the control. At rate 50% NP ears yield increased significantly by 63.65, 15.5, and 10.94% for B, A, C, respectively. At rate 100% NP, ears yield increased significantly by 117.71, 115.91, 26.3% for A, B, C, respectively.

Seeds yield (kg ha^{-1}) decreased significantly at rate 25% NP by 55.67, 49.92, 19.47% for A, C, B, respectively. At rate 50% NP, Seeds yield was increased significantly by 76.84, 28.19, and 22.51% for B, A, and C, respectively. At rate 100% NP, it was increased by 136.3, 135.85, and 33.63% for B, A, and C, respectively.

Considering maize yield and yield components, A was almost the most significant when loaded by 100% NP fertilizer followed by B then C. Physical and chemical properties of A provided optimum N, P, and K availability, better textural and moisture state and more stable supporting matrix for sandy soil. These advantages may apply to B matrix but to a less extent. Decreased efficiency of compost C compared to A and B may be due to its biodegradability in addition to presence of microorganisms that consume N and decrease available N in soil. Presence of biologically active phyto-chemicals in A inhibits organisms' activity and hence keeps its N content available for plant. It offers some chemical defence against plant pathogens (Abdelhamid et al., 2004 and Haggag et al., 2017).

Variation in the 100-seed weight (g) and shelling (%) was non-significant for different treatments. However, maximum values of 100-seed weight were recorded for B and C at 25% NP rate increased by 29.75 and 25.62%, respectively, while minimum values were recorded for C at 100% and M at 50% decrease by 9.53 and 7.19%, respectively.

Effect of the studied treatments on the total N, P, and K content in maize seeds and straw

Table 7 shows significant increase in the total N in maize seeds and almosttotal N, P, and K content in straw compared to the control. Treatments A1-A3 showed the most significant increase in seed N (g kg^{-1}) by 22.29% because A provided the most significant available N in soil. Compost treatments C1-C3 showed non-significant maximum increase of seed content of P and K by 73.13 and 10.79 %, respectively at 100% NP rate. This is because C provided the most significant available P and K in soil.

Almost significant increase can be observed for N, P, and K content in maize straw. At rate 100% NP, A3 showed the most significant increase in N and K content (g kg^{-1}) in straw by 26.73 and 42.3%, respectively, compared to the control.The treatment C3 increased straw P content significantly by 47.37% compared to the control, similar results were obtained in sandy soil (El-Dissoky et al., 2017).

Nutrient use efficiency affected by different additives

Nitrogen use efficiency

Another goal of loading of A, B, and C as supporting matrix by NP fertilizers in the present study is to provide efficient utilization of nutrients in sandy soil and safe them from leaching. Use efficiency for N and P nutrients; NUE and PUE, as well as their agronomic efficiency (AE) were calculated for treatments of A, B, and C loaded by NP fertilizers at different rates. Figure 1 shows that NUE and PUE decrease when application rate increases from 25 to 100% NP for A, B, and C.Nitrogen UE decreased by 80.56, 66.67, and 33.33%, while PUE decreased by 67.62, 65.37, and 72.31% for A, B, and C, respectively. Water hyacinth A showed the maximum NUE while compost C showed the maximum PUE at different application rates of NP fertilizers.

This behaviour indicates that the rate of 100% NP that is a recommended dose in absence of a carrier matrix provides excess N and P nutrients, which may leach from soil. Mixing NP fertilizers with a carrier like A, B, or Cdecreased leaching due to improved soil physical characteristics like WHC, FC, and BD (Craswell and Godwin, 1984).

Figure 2 indicates that maximum AE can be obtained for N and P nutrients by mixing A, B, or C with 50% NP of the fertilizers' recommended dose. Increasing the rate of NP fertilizers to 100% recommended dose would decrease its AE for N by 25.93, 51.22, and 77.27%, and for P by 25.82, 51.22, and 79.9% for A, B, and C, respectively.

TABLE 7. Total N, P, and K in maize seeds and straw

Application rate	Treatment	Seeds (g kg^{-1})			Straw (g kg^{-1})		
		N	P	K	N	P	K
	Control	10.65bc	2.70ab	4.28b	5.38d	1.7cd	5.95de
25% NP	M1	10.44c	2.43ab	4.28b	5.74a	1.7cd	7.15abcd
	A1	13.44a	3.70ab	5.12ab	6.72bcd	0.9e	7.06abcd
	B1	11.20bc	3.57ab	5.05ab	6.72bcd	0.9e	6.68cde
	C1	11.20bc	3.93ab	5.49ab	8.74a	2.2abc	8.32a
50% NP	M2	10.55bc	2.50ab	5.10ab	6.39abc	1.3de	6.43cde
	A2	13.44a	3.93ab	5.51ab	7.38d	1.4de	7.44abc
	B2	12.10ab	3.57ab	4.67b	7.39abc	2.0bcd	7.61abc
	C2	11.20bc	4.13a	5.19ab	7.39abc	2.5ab	7.61abc
100% NP	M3	10.99d	2.27b	5.56ab	6.36e	1.9e	5.65e
	A3	13.44a	3.92ab	5.47ab	8.06ab	2.6ab	8.04ab
	B3	12.10ab	3.85ab	5.07ab	8.06ab	2.4abc	6.81bcde
	C3	12.99a	3.93ab	6.16a	8.05cd	2.8a	6.89bcde
L.S.D $_{5\%}$		1.62	1.75	1.48	1.48	0.72	1.27
Significance of factors		**	ns	ns	*	***	**

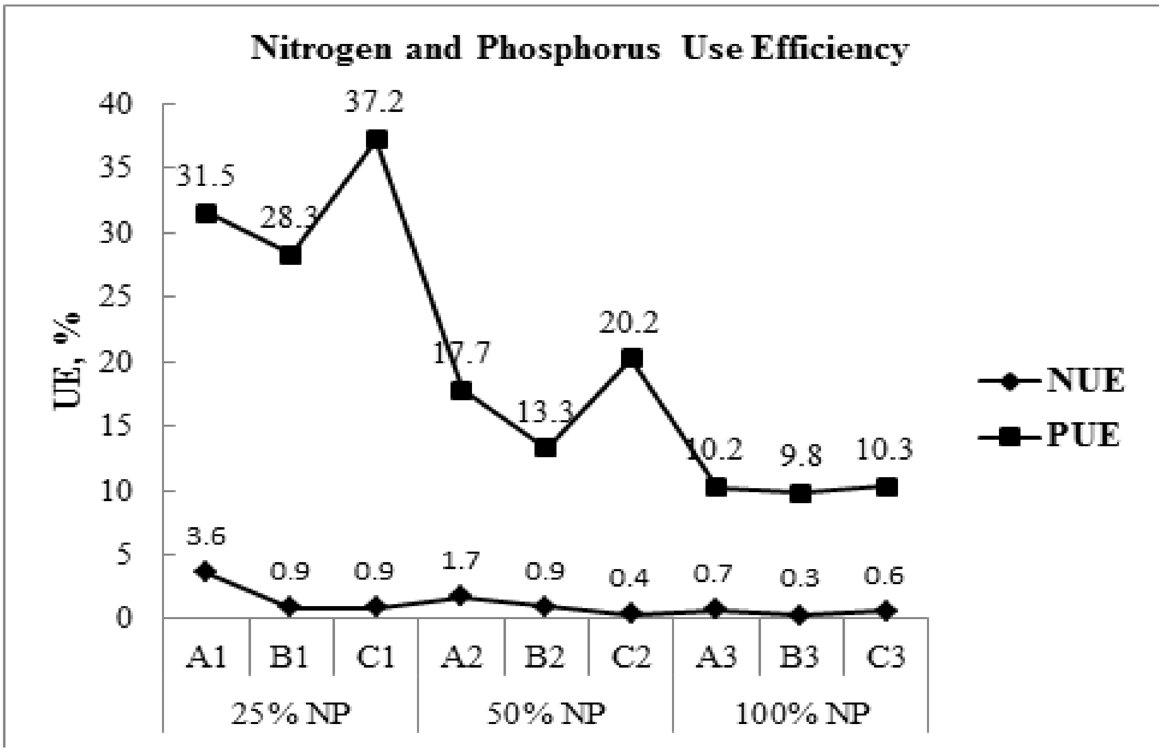

Fig.1. Nitrogen and phosphorus use efficiency for A, B, and C treatments at application rates 25, 50, and 100% NP

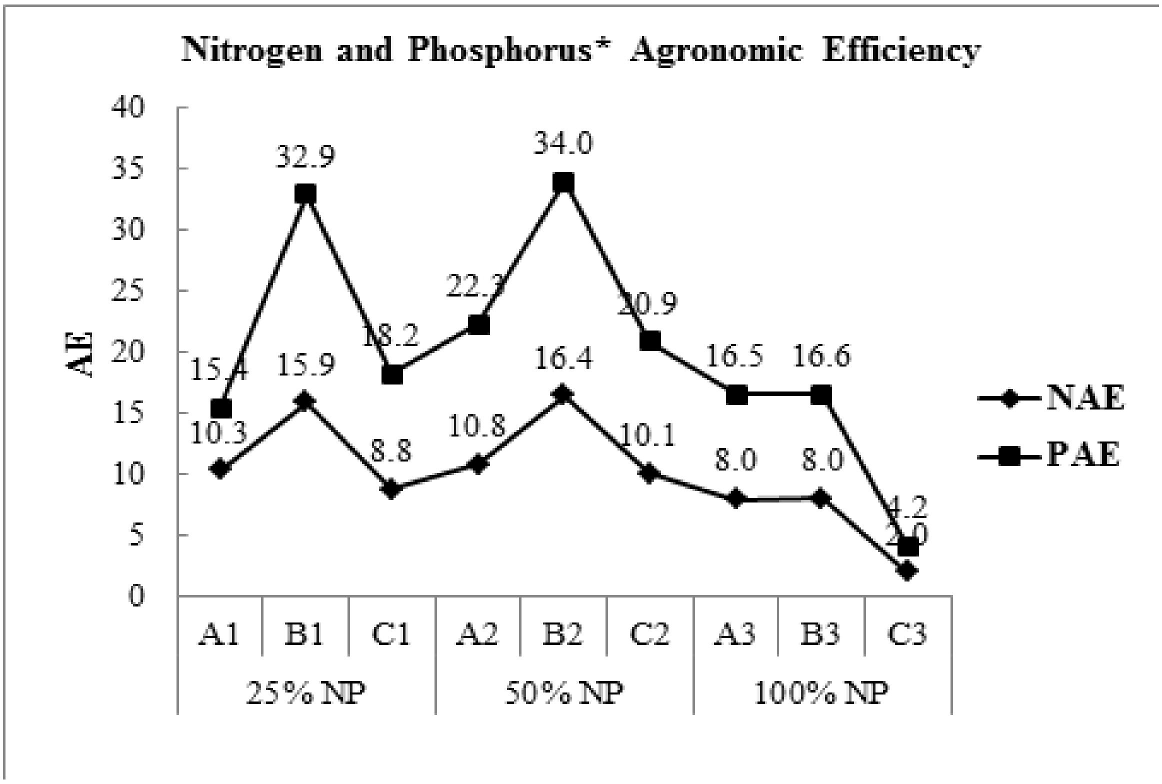

Fig. 2. Nitrogen and phosphorus agronomic efficiency for A, B, and C treatments at application rates 25, 50, and 100% NP (*Value divided by 10 to fit the plot scale)

Conclusion

Water hyacinth (A) and faba bean straw (B) were promising as sandy soil amendments compared to the conventional compost (C). Compost possessed greater BD = 0.5 g cm^{-3} than B (0.4 g cm^{-3}) or A (0.25 g cm^{-3}) but showed less soil bulk density. This may be due to sand particles of soil that differentiate compost particles, create in between voids, and expand volume of applied weight of compost. Volume of soil increased versus weight unit of compost more than A and B.Increased soil volume may lead to escape of water and leaching of nutrients from expanded matrix and decrease WHC and FC. Water holding capacity (WHC, %) increased significantly by 20% using A, non-significantly by 10 and 5% using B and C, respectively.

At application rate 100% NP, seed yield of maize (kg ha^{-1}) increased significantly by 136.3, 135.85, and 33.63% for B, A, and C, respectively. Treatments of A showed the most significant increase in seed N (g kg^{-1}) by 22.29% because A provided the most significant available N in soil. Compost (C) treatments showed non-significant maximum increase in seed content of P and K by 73.13 and 10.79 %, respectively at 100% NP rate because C provided the most significant available P and K in soil.

Physical and chemical properties of A provided optimum N, P, and K availability, better textural and moisture state and more stable supporting matrix for sandy soil. These advantages may apply to B matrix but to a less extent. Decreased efficiency of compost C compared to A and B may be due to its biodegradability in addition to presence of microorganisms that consume N and decrease available N in soil. Presence of biologically active phyto-chemicals in A inhibits organisms' activity and hence keeps its N content available for plant. Maximum AE can be obtained for N and P nutrients by mixing A, B, or C with 50% NP of the fertilizers' recommended dose. Increasing the rate of NP fertilizers to 100% recommended dose would decrease its AE for N and P for A, B, and C, respectively.

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Conflict of Interest

The authors declare no conflict of interest.

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دراسة بعض خصائص التربة الرملية المعاملة بورد النيل وقش الفول البلدى والكمبوست

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالإسماعيلية خلال موسمى صيف ٢٠١٨ و٢٠١٩ لدراسة بعض خصائص التربة الرملية المعاملة بثلاثة أنواع من الإضافات والمزروعة بالذرة . الإضافات المخلوطة بالتربة كانت عبارة ورد النيل المجفف وعرش الفول البلدى المجفف والكمبوست , كل منها تم تحميله ب ٢٥٪ و ٥٠٪ و ١٠٠٪ من الجرعة الموصى بها من أسمدة النيتروجين N والفوسفور P المعدنية . تم توزيع المعاملات المختلفة متضمنة الكنترول فى تصميم قطاعات كاملة العشوائية بثلاث مكررات . تم تقدير السعة التشبعية (٪) والسعة الحقلية (٪) والناقلية الكهربية ($dS\ m^{-1}$) والكثافة الظاهرية (جم سم^٣) والسعة التبادلية الكاتيونية للتربة ($cmol_c\ kg^{-1}$) ومحتوى التربة من المادة العضوية (٪) قبل الزراعة وبعد الحصاد . كذلك تم حساب إنتاجية الذرة ($kg\ ha^{-1}$) وبعض مكوناتها للمعاملات المختلفة . أظهرت النتائج أنه بعض الحصاد زادت السعة التشبعية معنويا بنسبة ٢٠٪ بإستخدام ورد النيل , وغير معنويا بنسبة ١٠٪ و ٥٪ بإستخدام عرش الفول البلدى والكمبوست على التوالى بالمقارنة مع الكنترول عند معدل إضافة السماد المعدنى ١٠٠٪NP . زادت السعة الحقلية بنسبة ٣٧,٥٪ بإستخدام ورد النيل وعرش الفول البلدى وبنسبة ١٢,٥٪ بإستخدام الكمبوست بالمقارنة مع الكنترول . لوحظ تغير غير معنوى فى الناقلية الكهربية للتربة قبل الزراعة وبعد الحصاد . أظهر معدل الإضافة ١٠٠٪NP أقل كثافة ظاهرية للتربة بإنخفاض معنوى مقداره ٧,٧٨٪ للكمبوست و٤,٤٤٪ لورد النيل و٢,٧٨٪لعرش الفول مقارنة بالكنترول . عند معدلات إضافة ٥٠٪ و ١٠٠٪NP أعطت معاملات الكمبوست أعلى فوسفور P وبوتاسيوم K ميسر فى التربة , يليها معاملات ورد النيل ثم عرش الفول البلدى . عند معدل إضافة ١٠٠٪NP زادت إنتاجية المادة الجافة للذرة ($kg\ ha^{-1}$) معنويا بنسبة ١٢٠,٣٤٪ و ١١٦,٩٦٪ و ٢٧,٤٤٪ لكل من ورد النيلوعرش الفول البلدى والكمبوست على التوالى . كما زادت إنتاجية الحبوب ($kg\ ha^{-1}$) معنويا بنسبة ١٣٦,٣٪ و ١٣٥,٨٥٪ و ٣٣,٦٣٪ لكل من عرش الفول البلدى و ورد النيل والكمبوست على التوالى .