



Studying the Efficacy of Some Organic Compounds as a Source of Potassium Fertilization and their Effect on the Wheat-Peanut Crop System in Sandy Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To encourage sustainable agriculture and increase net revenue for the agricultural community, the use of expensive chemical fertilizers should be reduced and replaced with locally produced organic byproducts. For this reason, a field experiment was conducted on sand soil at Ismailia Agric. Res. Station in Ismailia Governorate, Egypt, to evaluate the impact of various organic K rates (0, 50%, 75%, and 100% from the recommended plant dose) and three different K organic sources i.e., seaweed (SWE), yeast sludge (YS), and filter mud cake (FMC), in two successive seasons of wheat (*Triticum sativac. v. Giza 168*) as a winter crop and peanut (*Arachis hypogaeac. v. Giza 6*) as a summer crop season; to study how responsive they are to different potassium rates and

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sources applied to crop productivity. After both crops were harvested, the chemical features of the soil were also assessed. The current findings state that the use of varied organic K rates and sources boosted the yield components of wheat and peanut crops, as well as the nutritional total content in straw, grains, or seed of both wheat and peanut, as compared to the control treatment. Furthermore, the application of all treatments improved pH, EC, OM, and cation exchangeable capacity (CEC); the availability of P, K, and soluble K followed a similar pattern after the wheat-peanut crop was harvested. Furthermore, the highest increases resulted from 75% of the recommended K dose, and the best organic sources of K were YS and SWE for wheat and peanut, respectively. In conclusion, the use of tested organic potassium sources is a good alternative to mineral potassium fertilizers, is economical, which is reflected in crop yield, and is environmentally friendly.

Keywords: Seaweed; yeast sludge; filter mud; potassium fertilizers; wheat and peanut.

1. INTRODUCTION

Maintaining healthy soils is an important component of organic agriculture, since it increases crop system sustainability. At the moment, there is a growing need for agricultural output that not only meets high quality requirements, but also follows ecologically friendly techniques. Previous research has shown that the use of organic fertilizer meets the standards of sustainable agriculture, and organic fertilizer offers significant benefits over chemical fertilizer in many ways. According to El-Gamal et al. [1], as compared to organic fertilizers, chemical fertilizers are insufficient to provide all of the minerals and nutrients required by plant, namely nitrogen, phosphorus, and potassium. In fact, chemical fertilizers are incompatible with organic farming and have negative effect on both health and the environment. As well, Hong et al. [2] revealed that modern agriculture is looking for new biotechnological advances that would allow a reduction in the use of chemical inputs without affecting crop yield or the farmer's income.

Additionally, potassium is the most commonly used plant nutrient in agriculture, playing important roles in the transport of water, nutrients and nitrogen availability, stimulation of early growth, and resistance to insects and diseases [3,4] suggest that one option for countries with low availability of soluble K sources is research to develop new fertilizer technologies, including alternative sources such as algae, organic fertilizer sources such as fermenter sludge, and pressed sludge. It was reported that the aim is to promote Recently, natural algae extracts have been successfully used as biostimulants in agriculture. These increase crop productivity and reduce the use of traditional synthetic fertilizers. Ngoroyemoto [5] reported that algae-derived extracts are biodegradable, non-toxic, non-

polluting, and harmless to humans, animals, and birds. It also contains alginates, which bind soil particles together to form aggregates, resulting in a soil structure suitable for crop growth. It could help reduce the negative effects of current chemical agriculture. Also, Singh et al. [6] found that seaweed sap is a good source of potassium and phosphorus. Potassium helps regulate the plant's water status, controls stomata opening and closing, and promotes photosynthesis, while phosphorus supports root growth. Furthermore, Ali et al. [7] found that seaweed extracts are biostimulants rather than fertilizers, as they stimulate defense and growth responses when applied to plants. Additionally, Ngoroyemoto [5] found that the active components of seaweed-derived extracts are phytohormones such as auxin, cytokinin, and gibberellin.

Yeast sludge (distillers yeast sludge (DYS)) is excess yeast that accumulates as sludge at the bottom of fermentation tanks during fermentation processes in the sugar and distillery industries. Sometimes called waste yeast, yeast slurry, or trub. It is classified as a waste that is difficult to handle and dispose of Sharif et al. [8]. Several studies have shown that the nutritional composition of DHS varies greatly depending on the chemicals used, yeast strain used, type of molasses, fermentation time, crude protein, metabolic energy, amount of fat, and NFE (nitrogen-free extract) content. I know it's different [9]. Protein variation is primarily determined by the amount of yeast cells present in the biomass. Khan et al. [10] was found to have high biological value and approximately 30% protein, but also has an excellent amino acid profile including lysine, methionine, leucine, isoleucine, valine, and tryptophan. However, the phrase "filter mud cake" (FMC), often referred to as "press mud" or "filter mud FM," refers to the organic effluents from sugar mills that are utilized

to produce high-quality, nutrient-rich organic manure. One waste product from sugar mills is called press mud or filter cake. It is a dark brown to brown, fragile, spongy, amorphous material that regulates sugar, fibre, coagulated colloids (such as cane wax), albuminoids, inorganic ions, and dirt particles. In addition, it contains hormones, vitamins, auxins, enzymes, and plant development regulators that help to keep agricultural soils productive, fertile, and healthy [11,12]. Additionally, filter cake has been used as a biofertilizer and was reported by Ali et al. [13] to positively influence soil biochemical and physical parameters and plant development. It is also rich in nutrients and increases organic carbon, clay and water content, which improves crop productivity and maintains soil fertility. Fantaye [14] and Essa et al. [15] found that adding treated pressed mud to soil increased key nutrients such as phosphate and nitrogen.

The aim of the current study is to determine the effect of adding different concentrations and sources of organic potassium, such as seaweed, yeast sludge, and press slurry, as alternative sources of mineral potassium fertilizer in order to meet the needs of economically valuable plants, reduce production costs, and save hard currency.

2. MATERIALS AND METHODS

A field experiment was carried out on sand soil at the Ismailia Agriculture Research Station in Ismailia Governorate, Egypt, to investigate the influence of certain organic potassium sources on reducing the need of mineral potassium fertilizers. The farm is in latitude 30° 35' 41.901" N, longitude 32° 16' 45.834" E. Some physicochemical parameters of the examined soil are shown in Table 1 using the methodology given by Page et al. [16]. This experiment was conducted over two consecutive seasons, on

wheat (*Triticum sativacv.* Giza 168) in the winter (2021-2022) and peanut (*Arachis hypogaeac.v.* Giaz 5) in the summer (2022). The experimental design was a split-plot design with three replications. The main plot was four rates of potassium (0 (recommended dose of K as potassium sulfate), 50, 75, and 100%) of the recommended dose. The sub-main plots included three treatments: a. Seaweed extract (SWE) (El Anglo Co.) in powder form, b. Yeast sludge (YS) or fermenter sludge (El Hawmdia factory for sugar industry) in powder form, c. Filter mud cake (FMC) or press mud (El Anglo Co.) (it was produced from the organic wastes of Quos Sugarcane Factory). Table (2) shows some of the chemical features of organic compounds used as an alternative to potassium fertilization.

Before cultivation, the usual agricultural practices were applied according to agricultural guidance for each crop. All treatments received mineral fertilizers (N and P) at the recommended doses for both wheat and peanut crops. Calcium super phosphates (P2O5 15%) in rate of 200 kg fed-1 was applied on soil surface during preparation soil for cultivation of both wheat and peanut plants, respectively. In addition, wheat plant received 120 kg fed-1 N in the form ammonium nitrate (33% N) in four equal doses every 15 days from planting whereas; peanut plant received 100 kg fed-1 N in two split equal doses at sowing and after one month from planting. Potassium fertilizer was applied at a rate of 50 kg fed-1 K2O as potassium sulphate (K2SO4) for the control treatment (without organic addition), in addition (SWE, YS, and FM) for tested organic K sources at different rates of 50, 75, and 100% of the recommended dose for both cultivated crops as an alternative to potassium fertilization. Throughout both seasons, all types of K were applied twice (30 and 60 days after planting).

Table 1. Some physicochemical properties of the experimental soil

Particle size distribution		Soil physical properties		Soil chemical properties	
Coarse sand %	69.00	Bulk density g cm ⁻³	1.73	Organic matter %	0.36
Fine sand %	24.65	Total porosity %	34.7	*pH	7.73
Silt %	3.52	SP	23.0	**EC dSm ⁻¹	0.44
Clay %	2.83				
Soil texture	sandy				
Soluble cations (meq L ⁻¹)		Soluble anions (meq L ⁻¹)		Available nutrients (mg kg ⁻¹)	
Ca ²⁺	1.02	CO ⁻	Nd	N	39
Mg ²⁺	0.99	HCO ₃ ⁻	1.92	P	8.1
Na ⁺	1.30	Cl ⁻	1.20	K	50
K ⁺	1.00	SO ₄ ⁻	1.19		

*pH (Soil-water suspension ratio, 1:2.5); **EC (soil paste extract)

Table 2. Some chemical properties of tested organic materials are used as an alternative to potassium fertilization

Organic K sources	Chemical properties						
	N%	P%	K ₂ O%	pH*	EC** dSm ⁻¹ 1Sm ⁻¹	ddSm ⁻¹	OM %
Seaweed extract	0.50	0.28	16.0	8.95	5.03		1.35
Yeast sludge	1.46	0.18	16.0	7.38	7.24		0.37
Filter mud	0.42	0.14	14.8	6.99	7.61		0.15

*pH (1:2.5 suspension); ** EC (1:5 water extract)

2.1 Evaluations of the Experiment

2.1.1 Soil examination

Soil samples were taken after harvested air-dried, and passed through 2 mm sieve for analysis according to Cottenie et al. [17] as follow:

- 1- Electrical conductivity (EC) dSm⁻¹ in soil water extract at ratio (1:5).
- 2- pH in soil water suspension at ratio (1:2.5).
- 3- Organic matter (OM) content.
- 4- Cation exchange capacity (CEC).
- 5- Available P and K forms (soluble and available).

2.1.2 Plant examination

When the plants reached maturity, they were harvested. Samples of harvested wheat and peanut plants were obtained in one-square meter increments to calculate the yield components based on the weight of the straw and the grain or seed yield for each plant, respectively. In order to determine the nutritional status, plant samples were oven dried for 48 hours at 70 °C, up to a constant dry weight, and then crushed and digested using a combination of H₂SO₄ and H₂O₂. This process was reported by Page et al. [16].

2.1.3 Statistical analysis

All data were statistically analyzed by season using the approach outlined by Snedecor and Cochran (1980). The significance of differences between treatments was determined using the Least Significant Differences (LSD) test at the 0.05 probability level. Finally, all statistical analyses were carried out using the "MSTAT-C" computer software program, as described by Freed et al. [18]. The correlation coefficient (R²) was obtained using the Microsoft Excel program.

3. RESULTS AND DISCUSSION

One of the minerals that is fundamentally needed for plant growth and development is potassium. There have been reports of potassium depletion in agricultural soils, and low potassium levels have a detrimental impact on crop production. Some organic K sources can be used as substitutes for commercial K fertilizers to counteract the negative impacts of mineral K fertilizers. Their effects on the following parameters should be investigated.

3.1 Yield Components of the Wheat-Peanut Crop System

The data in Fig. 1 show the effect of different organic K rates (0, 50, 75, and 100% of the recommended dose of both studied plants) and organic K sources (SWE, YS, and FMC) on the growth parameters of wheat (biological yield, straw, and grains) and peanut (biological yield, straw, pods, and seed yield) in sandy soil conditions. The application of different rates from organic K sources increased the plant growth parameters of wheat and peanut as compared to the control treatment. In addition, the superior rate of organic K was 75% from recommended doses of plants, which increased by 120, 158, and 69% for the biological, straw yield, and grain yield of wheat, respectively. While it was (97, 101, 82, and 152%) for the biological, straw, pods, and seed yield of peanuts, respectively. Also, results indicate that there is no significant difference between the 75% and 100% rates of organic K application. In contrast to inorganic fertilizer, which improved only nutrient supply, Akrawi [19] found that the highest increase in yield parameters was obtained with 100% K in organic fertilizer. He relates these findings to the organic K source being an improved soil physical condition for plant growth, along with increasing availability of nutrients at the early stage of crop growth. Wu et al. [20] reported that the application of filter mud at different rates (3%, 5%, 7%, 9%, and 13%) enhanced plant

productivity, and the maximum increase was observed at 7%.

Moreover, results in Fig. 1 showed that, regardless of the different concentrations, the application of organic K sources (SWE, YS, and FMC) increased the crop productivity of the wheat-peanut crop system as compared to the control treatment. The highest treatment for the wheat crop was the YS treatment, as well as the SWE treatment for the peanut crop, compared to other sources. These outcomes are probably attributable to organic sources' capacity to improve soil fertility and nutrient availability. Therefore, various nutrients and fatty acids that promote development may be found in organic wastes, which benefit plant characteristics and productivity. In addition to potassium's beneficial effects, which are seen in both wheat and peanut growth and productivity, this mineral is also essential for several fundamental activities, including protein synthesis, enzyme activation,

material transport, and osmosis control. These data are consistent with the findings of Chen et al. [21], who found that seaweed extract contains a significant amount of gibberellic acid, which activates the genes encoding amylase in aleurone cells and functions to provide a signal during seed germination. Furthermore, because seaweeds have vital fatty acids, vitamins, amino acids, minerals, and growth-promoting compounds, they can increase plant development and productivity. Additionally, Yousef et al. [22] and El-Kamar [23] indicated that yeast waste treatment may have a good influence on plant development, yield, and yield quality since it includes plant-growth-enhancing amino acids, trace elements, auxins, gibberellins, and cytokinins. Rathore et al. [24] reported similar results, stating that the use of seaweed extract considerably boosted straw and grain yields, with the highest value reached with seaweed extract plus filter mud treatment.

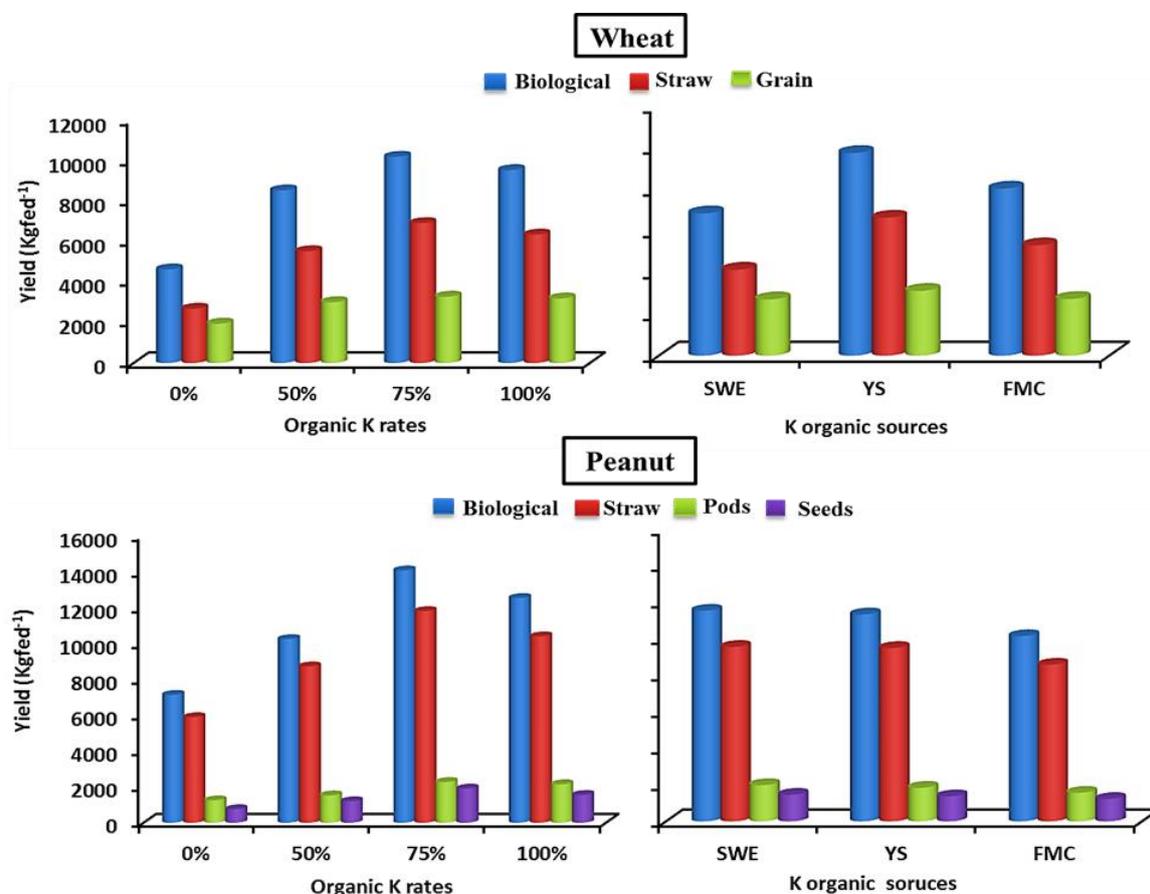


Fig. 1. Yield components of the wheat-peanut crop system as a response to the application of different rates of potassium organic and three different organic potassium sources under sand soil conditions

SWE Seaweed; YS Yeast sludge; FMC Filter mud

3.2 The Interaction between Potassium Rates and Potassium Organic Sources on Wheat-Peanut Crop Productivity

Data in Table 3 showed the effect of different rates (50, 75, and 100% of the K recommended dose) with SWE, YS, and FMC as organic K sources on the yield components of wheat and peanut. In general, the application of all treatments increased the growth parameters of the studied plants as compared to the control treatment. As well, the growth parameters of wheat and peanut increased with the increasing K rate, which was applied from three organic K sources. The best rate of K from organic sources, according to the data, was 75% for wheat and was acquired from the YS organic K source. A similar trend was shown for peanuts when employing organic K sources in the form of SWE. These findings corroborate those of Zein El-Abdeen [25], who found that the application of YS, SWE, and FMC typically resulted in a considerable increase in the growth parameters of wheat and peanut when compared to the control treatment. Wu et al. [20] and Essa et al. [15] refer to the increasing sugar beet yield with filter mud due to increasing physiological activity by the enhancement of the activity of the photosynthesis enzyme and the enhancement of CO₂ assimilation as well as stomata conductance and Phosphoenolpyruvate Carboxylase (PEPC) activity reaching the maximum value at rates of 7%, more than 3%, 9%, and 13%, which was consistent with the proportion of filter mud when the biomass of sugar beet leaves reached the maximum value. Also, press mud increases the

amount of light energy intercepted by leaves, increases photosynthetic pigments and photosynthesis, and, in turn, increases synthesized metabolites and consequently leaves and grains. The stomatal conductance of sugar beet seedling leaves did not change significantly in several treatments, with the percentage of filter mud exceeding 7% due to the limitation of stomatal opening. Furthermore, seaweeds are known to include a variety of organic elements such as polysaccharides, proteins, and fatty acids, which help to retain moisture and nutrients in the soil, boosting microbial activity and enhancing soil texture. Seaweed-based fertilizers have been shown to promote root development by increasing microbial diversity and activities such as nutrient mineralization and mobilization [26].

3.3 Correlation Analysis between Organic K Rates and Grain or Seed Yield of the Wheat-peanut Crop System

Data on the wheat-peanut crop system's grain or seed production was gathered for this study. After that, an analysis was done on these data to see how they related to organic K rates. For this reason, the association between two variables was assessed using simple linear regression. The analysis's findings are displayed in Fig. 2, which also depicts the link between the two variables that were previously discussed. The findings demonstrated a good correlation between the organic K rates and wheat grain yield ($R^2 = 0.76, 0.88, \text{ and } 0.77$ for SWE, YS, and FMC, respectively). However, for FMC alone, there was a considerable positive

Table 3. Response of wheat-peanut yield to the interaction between various K rates and three different organic K sources under sand soil conditions

K Rates	Organic K form	Wheat (Kg fed ⁻¹)			Peanut (Kg fed ⁻¹)			
		Biological yield	Straw	Grain	Biological yield	Straw	Pods	Seeds
	Control	4620	2679	1941	7140	5893	1247	755
50 %	SWE	6840	4124	2716	11025	9252	1773	1343
	YS	11040	7642	3398	10500	9021	1479	1161
	FMC	7680	4789	2891	9240	7923	1317	1086
75 %	SWE	8312	5046	3266	15260	12575	2685	2172
	YS	11675	8261	3414	14980	12501	2479	2172
	FMC	10546	7405	3141	12040	10388	1652	1373
100 %	SWE	7608	4694	2914	12740	10515	2225	1558
	YS	11665	7958	3707	12740	10587	2153	1402
	FMC	9294	6359	2935	12180	10122	2058	1693
LSD at 5%		1773	2103	714.8	3086	2972	31734	399.1

SWE Seaweed ; YS Yeast sludge; FMC Filter mud

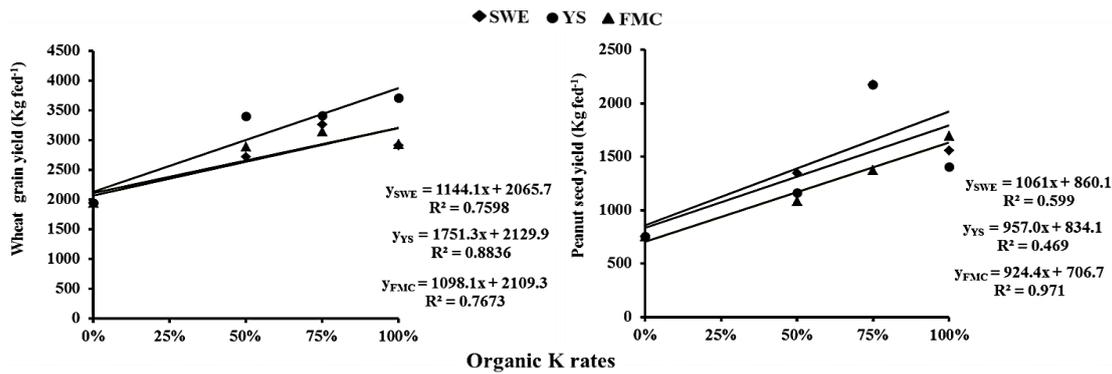


Fig. 2. Relationship between organic K rates and grain or seed yield of wheat - peanut crop system

SWE Seaweed; YS Yeast sludge; FMC Filter mud

correlation ($R^2 = 0.97$) between the seed production of peanuts and organic K rates. The application of different rates of K from different organic sources was found to be a reliable indicator of grain or seed yield in this study, which may be helpful in determining the best organic rates and sources of K to increase grain or seed yield of wheat and peanut in sand soil conditions.

3.4 Nutrient Total Content in Yield of Wheat-Peanut Crop System

The data in Fig. 3 illustrates the reaction of the plant nutrient total content to the application of various potassium rates and organic K sources, as well as their interaction. The results show that applying K at different rates (50, 75, and 100% of the recommended plant dose) or from different organic K sources (SWE, YS, and FMC) enhanced the total K and P content of straw, grain, or seeds for wheat and peanut when compared to the control treatment. The greatest increases were observed at 75% of the prescribed K dosage, and the best organic sources of K were YS and SWE for wheat and peanut, respectively (for straw and grain or seed K content). This might be because organic potassium fertilizers provide nutrients that plants require, such as nitrogen, potassium, and phosphorus. It also helps plants absorb these components more effectively, which is evident in plant development, as demonstrated by the results. These results are confirmed by Marzauk et al. [27], Nasser et al. [28], and Yousef et al. [22]. Also, these findings are consistent with those of Zein El-Abdeen [25], who discovered that, in comparison to the control treatment, the overall content of N, P, and K rose considerably

in both of straw and grains and/or seeds of wheat and peanut crops. Furthermore, seaweed treatment is the best, followed by filter mud and yeast sludge. An increase in seaweed nutrients may be the cause of this, since it makes up for soil deficiencies in N, P, and K [29,30]. Eisa [31] also mentioned that applying seaweed extract greatly raised the percentages of K and P in the plant leaves. Furthermore, yeast waste has been shown to include a variety of nutrients, growth regulators, and amino acids that promote root development and enhance soil nutrient absorption [22,23]. Additionally, Kubar et al. [32] found that as the rate of K application rose, so did the K content of grain and straw, as well as the grain yield of wheat.

3.5 The Interaction between Potassium Rates and Potassium Organic Sources and its Influence on Total K and P Content in the Wheat-Peanut Crop System

The total K and P contents in straw, grain, or seed for wheat and peanut, respectively, are shown in Table 4 as a response to the interaction between potassium at varying rates (50, 75, and 100% of the plant's recommended dose) and its various organic sources (SWE, YS, and FMC) in sand soil conditions. When compared to the control treatment, the collected results generally indicate an increase in the total K and P content in straw, grain, or seed for wheat and peanut, respectively. When YS was given at a rate of 75% of the recommended dose for wheat and SWE was applied at a rate of 75% of the recommended dose for peanuts, the highest values of the studied plants were achieved.

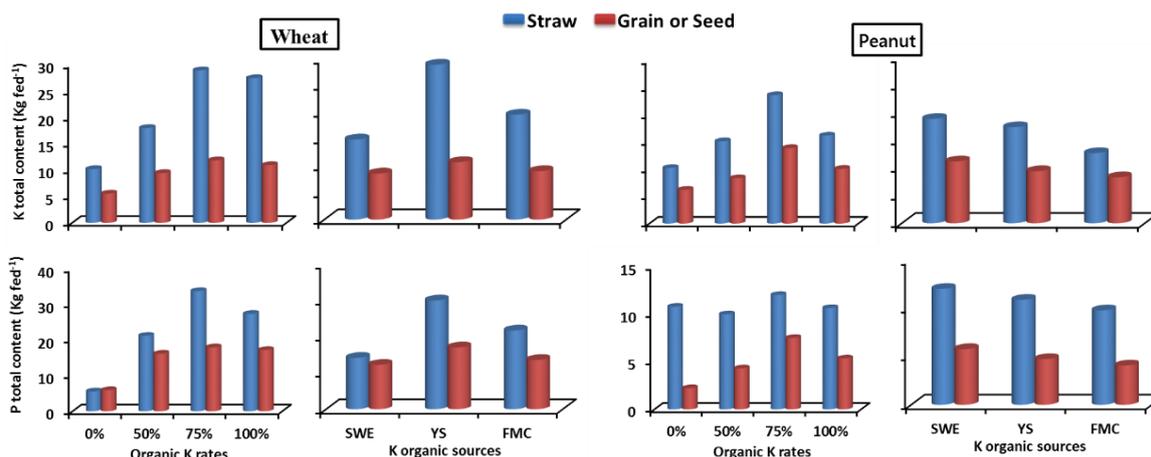


Fig. 3. Total phosphorus and potassium content in both wheat and peanut crops as a response to different K rates and organic K sources applied under sandy soil condition
SWE Seaweed; YS Yeast sludge; FMC Filter mud

Table 4. Effect of interaction between various potassium rates and different organic sources on the K and P total content of straw, grain, or seeds for wheat and peanuts under sandy soil

K Rates	Organic sources	Wheat				Peanut			
		P content (Kg fed ⁻¹)		K content (Kg fed ⁻¹)		P content (Kg fed ⁻¹)		K content (Kg fed ⁻¹)	
		Straw	Grain	Straw	Grain	Straw	Seed	Straw	Seed
	Control	5.56	5.93	10.2	5.6	10.82	2.24	10.25	6.23
50 %	SWE	13.67	14.6	13.5	8.8	11.0	5.19	17.36	9.91
	YS	30.02	17.8	25.0	10.3	10.2	4.21	16.79	8.48
	FMC	19.94	16.1	15.6	9.2	9.0	3.57	11.39	6.71
75 %	SWE	18.72	13.6	17.9	10.7	14.0	9.9	30.57	17.13
	YS	46.71	24.5	42.2	13.6	12.3	7.86	24.81	14.84
	FMC	35.99	15.8	26.7	11.3	9.9	4.83	15.66	9.82
100 %	SWE	18.89	15.0	18.2	9.3	12.3	5.78	17.43	11.56
	YS	37.87	20.1	38.3	13.5	10.3	4.65	17.73	8.18
	FMC	25.43	16.6	25.9	10.1	9.5	5.68	13.51	10.54
LSD at 0.05%		7.746	6.315	10.49	1.278	3.66	1.98	4.71	4.015

SWE Seaweed; YS Yeast sludge; FMC Filter mud

3.6 Correlation Analyses between Organic K Rates and K Contents in Straw and Grain or Seed for Wheat and Peanut

The correlation studies between organic K rates and K total content in wheat and peanut straw, grain, or seed, respectively, are displayed in Fig. 4. The findings clarify that there was a good correlation between the K contents in wheat straw and grain and organic K rates, with an R² ranging from 0.736 to 0.933. It suggests that wheat grain and straw have noticeably greater K levels. Plants that get organic K treatments are able to absorb more K. Furthermore, the R² values for wheat were greater than the R² values for peanuts, despite the fact that there was a

marginally positive connection between the K contents in the grain and straw for peanuts and the organic K rates.

3.7 Correlation Analysis between K Total Content and Yield (Grain or Seed) of the Wheat-Peanut Crop System

The results in Fig. 5 showed a substantial positive connection between grain or seed K total content and grain or seed production in the wheat-peanut crop system. The strongest correlation was found in SWE treatments for both plants, R² = 0.995 for wheat and R² = 0.988 for peanuts. Furthermore, Fig. 5 demonstrated that the association between the two aforementioned factors was greater for wheat plant than peanut.

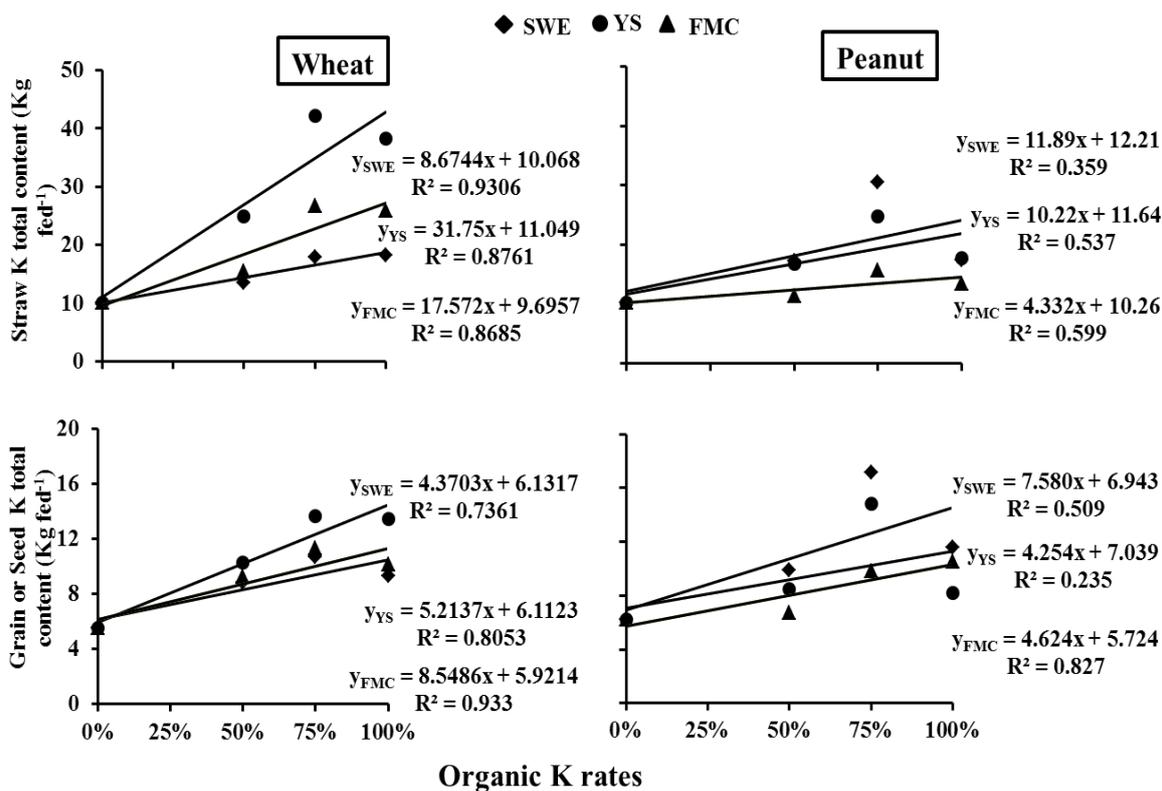


Fig. 4. Correlation analyses between organic K rates and K content in straw and grain or seed for wheat and peanut crop system
 SWE Seaweed; YS Yeast sludge ; FMC Filter mud

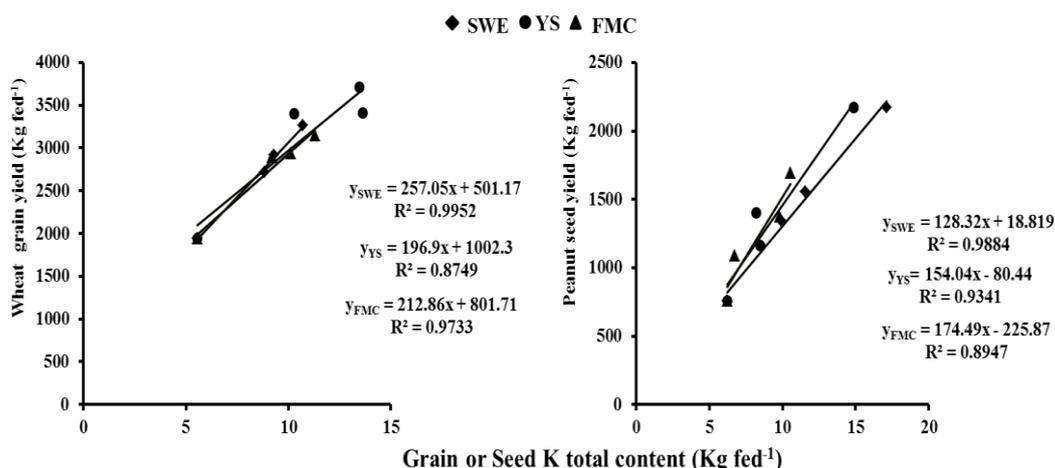


Fig. 5. Relationship between K total content of grain or seed and their yield of wheat or peanut crop
 SWE Seaweed; YS Yeast sludge; FMC Filter mud

3.8 Chemical Properties for Experimental Soil

Table 5 displayed data indicating several soil chemical characteristics that were altered by

various organic potassium rates (0, 50, 75, and 100% of the plant's required dosage) and sources (SWE, YS, and FMC) in sand soil. The results showed that, when compared to the control treatment, applying different K rates and

sources enhanced soil attributes such as pH, EC, OM and CEC under sand soil conditions following wheat and peanut harvesting. Furthermore, the data showed that applying varying rates of organic K had relatively small impacts on pH, EC, OM and CEC across both seasons. The maximum soil OM value (0.91% for wheat and peanut) was attained by applying 75% (from the required dose of plant) organic K sources. Additionally, findings indicate that using various sources of organic K did not significantly alter pH or EC. The results for organic matter show a trend that differs from those for pH and EC, with an increase in OM content following the administration of various sources of organic K. For both of the examined plants, SWE was the best organic K source. The highest OM values were 1.1% for peanuts and 0.92% for wheat. Zein El-Abdeen's [25] study results show that applying different organic amendments (yeast waste, seaweed extract, or filter mud) enhanced soil organic matter content and some macronutrient availability after harvesting wheat and peanut plants. This increase could be attributed to the presence of carboxylate groups, which have a direct effect on nutrients released into the soil soil [12,13] and a variety of organic acids are produced during organic residue decomposition [33], which mobilize nutrients from fixed sites and make them easily available to plants [34]. According to De Sosa et al. [35], adding composted materials with the greatest ratio of seaweed to the control marginally raised pH values. This is likely because the raw material, which was rich in Na and came from a marine source, was assimilated in a larger amount. Furthermore, these increases were demonstrated by Kumar and Chopra [36], who concluded that the higher EC values of the filter-mud-treated soil might be due to the presence of more cations and anions in the soil suspension as well as the soil's higher pH. It was also shown that there was a positive correlation between the different filter mud treatments and the values of the soil's EC, OC, certain cations, and anions. These soil parameters increased steadily as a result of the filter mud treatments. According to Paul et al. [37], adding filter mud to an area raised its pH, EC, and total organic carbon (TOC). Given that yeast sludge and seaweed are alkaline, the same reaction may be taking place with both. According to El-Kamar [23], yeast includes amino acids like glycine and glutamine, which may be the reason for the waste's health benefits. The polar amino acids release protons and retain a negative charge when the pH of the

soil is higher than that of the amino acids. This draws Ca^{2+} ions from calcium carbonate and raises the calcium ion concentration in the soil clay, replacing Na^+ [38].

Gadd [39] pointed out that yeast interaction with cations in soil, effect on their chemical and physical properties. The organic acid release from the biochemical activity of yeast can affect cations speciation and mobility in the soil. Organic acid provides both sources of protons for solubilizing and metal chelating anion to complex the metal cations [40]. They have the double function: (1) to acidify the substrate thus enhancing ion solubility, (2) to form complexes with solubilized ions which lead to ion mobilization [41]. These data confirmed with the data obtained by Nasser et al. [28], and Xi et al. [42]. Surface charge on yeast cell and carboxylate and phenolate group gives yeast waste and humic acid, the ability to form complex with nutrients prevent them from leaching through profile [43].

Furthermore, results in Table 5 represent that the interaction between different rate of organic K and different organic K sources had a little effect on pH, EC, and OM of soil for two seasons. In addition, the application of 100% recommended dose of K from SWE organic source was highest value of OM of wheat as compared to other dose. The highest value of OM content was 0.97 % while the lowest value of pH and EC were 7.2 and 0.12, respectively. Similar trend was observed for peanut which received to 75% recommended dose of K from SWE organic source which increased soil OM content by 1.01%.

Jamil et al. [44] revealed that extremely important changes in soil characteristics as a result of press mud application. It resulted in improving the organic matter content of soil, which increased macro and micronutrient contents of the soil. Bokhtiar and Sakurai [45]; Nehra and Hooda [46] also reported similar trends during their experiments. They found that press mud application increased organic matter content in soil, improved soil physical conditions, reduced soil bulk density and increased porosity. These are extremely important changes because reduction in bulk density helps in better roots development and proliferation. On the other hand, increased porosity helps in better soil aeration and water retention [47].

Table 5. Some chemical properties of sand soil after wheat and peanut harvested

K Rates	Organic sources	Wheat							Peanut						
		pH	EC (dSm ⁻¹)	OM %	CEC meq /100g soil	P mg Kg ⁻¹	Ava. K*	Sol. K**	pH	EC (dSm ⁻¹)	OM %	CEC meq /100g soil	P (mg Kg ⁻¹)	Avail. K*	Sol. K**
50 %	Control	6.76	0.116	0.80	3.70	3.7	99	25.4	7.20	0.177	0.78	6.70	6.7	33.0	106
	SWE	7.38	0.113	0.81	7.10	71.5	118	29.3	7.87	0.122	1.14	8.60	46.0	142	24.3
	YS	7.39	0.120	0.78	6.40	70.3	114	29.3	7.87	0.18	0.80	7.00	44.0	129	23.4
	FMC	7.38	0.126	0.73	4.20	67.0	105	27.3	7.22	0.203	0.68	5.40	36.0	109	23.4
75 %	Mean	7.38	0.120	0.77	5.90	5.90	113	28.6	7.65	0.17	0.87	7.00	7.00	42.0	127
	SWE	7.31	0.111	0.96	8.60	77.7	133	33.2	7.81	0.166	1.03	6.60	73.0	145	25.4
	YS	7.30	0.121	0.92	7.00	72.8	130	33.2	7.79	0.184	0.88	6.40	72.0	136	23.4
	FMC	7.19	0.138	0.84	5.40	66.0	113	31.2	7.41	0.202	0.81	5.50	59.0	126	22.0
100 %	Mean	7.27	0.123	0.91	7.00	7.00	125	32.5	7.67	0.18	0.91	6.20	6.20	68.0	136
	SWE	7.27	0.108	0.97	6.20	97.5	137	33.2	7.58	0.204	0.87	8.60	62.0	125	23.4
	YS	7.25	0.124	0.74	6.10	84.2	120	31.2	7.33	0.432	0.81	7.90	55.0	106	21.5
	FMC	7.25	0.138	0.61	6.10	78.8	111	27.3	7.21	0.544	0.76	6.60	38.0	103	21.0
Mean	Mean	7.25	0.123	0.78	6.1011	6.10	122	30.6	7.37	0.39	0.81	7.70	7.70	51.7	111
	SWE	7.32	0.111	0.92	7.30	82.2	129	31.9	7.75	0.164	1.01	8.00	60.3	137	26.0
	YS	7.31	0.122	0.81	6.50	75.8	121	31.2	7.66	0.265	0.83	7.10	57.0	124	22.8
	FMC	7.27	0.134	0.73	5.20	70.6	110	28.6	7.28	0.316	0.75	5.90	44.3	113	22.1
LSD at 5%		0.1341	0.0173	0.0948	0.250	18.16	23.88	1.08	0.222	Ns	ns	0.094	3.375	4.99	1.52

*Available potassium (mg Kg⁻¹); **Soluble potassium (mg Kg⁻¹); SWE Seaweed; YS Yeast sludge; FMC Filter mud
Available P, K and soluble K

The results of a study examining the impact of varying organic K rates (0, 50, 75, and 100% of the recommended plant dosage) and/or its organic sources (SWE, YS, and FMC) on the availability of P, K, and soluble K are shown in Table 5. The results indicated that applying various organic K concentrations and/or K organic sources to wheat and peanut plants enhanced their availability of P, K, and soluble K in comparison to the control treatment. According to El-Tayeh et al. [11], greater microbial activity was noted as a result of the soil's improved filter mud amendment, which also boosted root dispersion and nutrient availability and absorption. Additionally, Aboyeji et al. [48] found that applying K fertilizer considerably raised the concentrations of N, P, and K in the soil when compared to the control.

Furthermore, the findings in Table 5 demonstrated that the suggested dose of 75% K resulted in enhanced soil availability of P, K, and soluble K, independent of the organic K source. Furthermore, regardless of K concentration, the SWE K organic source application outperformed both examined plants in terms of the aforesaid characteristics. Furthermore, the interference between different concentrations of organic K and different organic K sources had a significant effect on the soil availability of P, K, and soluble K for two seasons, and the highest treatment

was the application of a 100% K recommended dose of SWE as a K organic source for wheat, while it was a 75% K recommended dose of SWE as a K organic source for peanut. The use of organic K sources (press mud) may have improved soil structure, which in turn has improved microbial activity in the wheat rhizosphere [49], hence enhancing crop nutrition. This might account for some of the evidence observed. For crop yield to increase and remain stable, the aforementioned changes in soil conditions are crucial. In addition, the addition of K enhanced the availability of phosphate and nitrogen [50].

3.9 Correlation Analysis between Applied Organic K (Rates and Forms) and Available K in Soil

Fig. 6 represents the relationship between applied organic K (rates and forms) and available K in the soil after both wheat and peanut crops were harvested. Results indicated a significant positive correlation ($R^2 = 0.98, 0.70,$ and 0.84 for SWE, YS, and FMC, respectively) between organic K rates and sources with available K in soil after wheat harvest. For the peanut crop, a comparatively different pattern was noted; there was no significant correlation found between the organic K rates and forms and the available K in the soil.

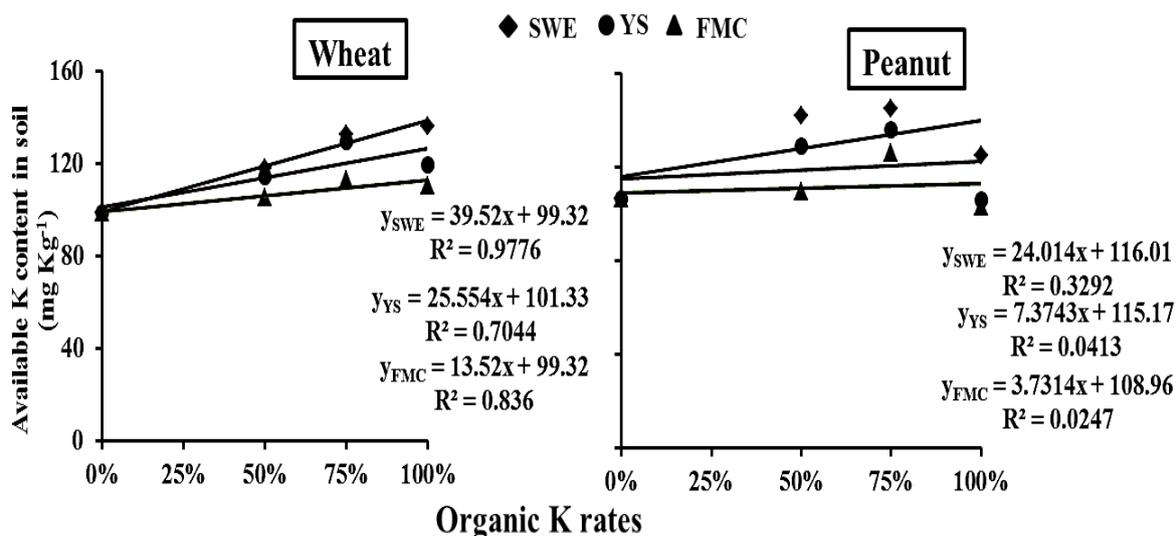


Fig. 6. Correlation analysis between organic K (rates and forms) and available K in soil after the wheat-peanut crop system is harvested
SWE Seaweed; YS Yeast sludge; FMC Filter mud

4. CONCLUSION

One way to encourage sustainable agriculture and increase net profitability for farmers is to gradually replace expensive chemical fertilizers with locally produced organic byproducts. Based on the aforementioned findings, it can be deduced that, in comparison to the control treatment, the application of diverse organic K rates and sources (SWE, YS, and FMC) enhanced the growth parameters of wheat and peanut crop system. In sand soil conditions, a comparable pattern was noted for the overall K and P content of wheat and peanut. Also, the application of organic compounds from various rates and sources as potassium fertilizers was enhanced soil chemical properties (pH, EC, OM, and CEC), and soil macronutrients availability. The greatest organic sources of K were YS for wheat and SWE for peanut. The largest increases came from 75% of the recommended K dose. Finally, in order to achieve plant safety, lower environmental pollution, and high production for wheat and peanut, chemical K fertilization should be replaced. Additionally, there is a growing tendency in agriculture to use organic fertilizers due to the high cost of mineral fertilizers and the rising trends in their costs, particularly in the country's arid and semi-arid regions. Consequently, it might be cost-effective and sustainable to apply them to agricultural soils.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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