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Influence of groundnut and bean seeds fortification with slaughterhouse and palm oil mill wastewaters on growth performance

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Abstract
Recycling of waste water for agriculture can improve environmental sustainability while improving cost of farming. The aim of this work is to study the growth performance of groundnut and bean seeds fortified with slaughter house and palm oil mill waste waters. For each wastewater type, 6 concentrations of 100, 75, 50, 25, 10 and 5% were prepared with tap water as the control. The seeds were soaked in each of these samples for a period of 5 hours, 10 hours and 24 hours. The germination percentage was monitored for four weeks while leaf number, and stalk length were monitored for 14 weeks. The soil used was a gravely sandy soil with a bulk density of 2.39 g/cm^3. For palm oil mill wastewater, optimum germination for beans seeds was obtained with 10 hours of fortification as germination occurred in all tested concentrations and the control from week two in equal amounts. Meanwhile germination of groundnut seeds fortified with palm oil mill wastewater for 5 hours started with 5, 25 and 75% in week 2 but germination was observed in all concentrations from week 3 and control in week 4. For slaughter house wastewater, optimum germination for groundnut seeds was obtained with 24 hours of fortification for 5-100% in week 2 in equal amounts and control in third week, with similar results for beans fortified for 10 hours. Longer fortification periods (10 and 24 hrs) are more favourable in case of slaughter house wastewater for both seeds germination irrespective of the slaughterhouse wastewater concentration but shorter fortification period favourable for palm oil wastewater (5 hours for groundnut and 10 hours for beans). This results shows that at low concentrations of wastewaters tested irrespective of the fortification time, inhibitory effects on the germination percentages were low compared to higher concentrations.
Keywords
Beans and Groundnut; Wastewater; Seed fortification; Germination Growth performance;

Introduction

The freshwater that is available for use in drinking, agriculture, industry, sanitation, food, recreation and transportation is <1% of the total water on earth (Tsamo et al., 2018). Hence, the need to diversify different ways of recycling wastewater so as to reduce the pressure on existing water sources. The quantity of waste water generated globally is on the rise due to continuous growth in population, improvement in water supply, living standards, and economic growth. Reports show that about 380 billion m^3 of municipal wastewater alone is generated worldwide annually and

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this amount is expected to increase by 24% in 2030 and 51% in 2050 (Tsamo et al., 2023). Reports also show that, over 80% of all wastewater produced globally is discharged into the environment without adequate treatment although this level varies across different regions of the world (EIB, 2020). The UN Water estimates that high-income countries treat on average about 70% of their wastewater they generate against low-income countries like Cameroon, where only about 8% of wastewater generated undergoes treatment of any kind (EIB, 2020). There is growing interest in using these waste waters from different industrial processes in agriculture because these effluents can act as potential sources of many plant nutrients provided proper methods are employed to render these nutrients safer for plants survival (Natarajan and Srimathi, 2021). However, screening the tolerance of plants to different types of effluents is highly needed to ensure optimum growth performance. One area of application of industrial effluent in agriculture is seed fortification. Seed fortification is defined as physical way of treating the seeds to improve the quality of seeds for better germination, vigorous plant stand, growth and yield of crops (Das and Biswas, 2022). In seed fortification, desired substance is incorporated into seeds through imbibition phase. By the end of imbibition, seeds complete initial phase of metabolic activities required for germination. Therefore, when the seeds are sown in the field, the time taken for germination/emergence is reduced. For imbibition, seeds are soaked in either water or dilute solution of bioactive materials such as micro-nutrients, plant growth regulators, seed protection chemicals, vitamins, bio-fertilizers, crude plant extracts etc (Das and Biswas, 2022). Seed fortification improves seed germination through benefitting embryo growth. Many studies have reported the use of different environments for seed fortification. Vishwanath et al. (2015) studied the effect of seed fortification with spent wash and cow urine on the germination and vigour of maize, paddy and ragi seed. Hullur et al. (2016) studied the influence of Seed Fortification with ZnSO4, Borax, Arappu leaf powder on Plant Growth, Seed Yield and Quality of Pigeonpea (Cajanus cajana (L.) Millsp) var. BRG-2. Narayanan et al. (2019) in their study fortified sesame CV TMV 3 with GA3, IAA, $MnSO_4$, $FeSO_4$, Pungam (Pongamia pinnata) leaf extract, Prosopis (Prosopis juliflora) leaf extract, Arappu (Albizia amara) leaf extract and Tamarind (Tamarindus indica) leaf extract. Thane et al., (2020) studied the effect of seed fortification with Borax, $CaCl_2$, $FeSO_4$, $ZnSO_4$, $MgSO_4$, water soluble DAP on growth and seed yield in blackgram (Vigna mungoL.). Reddy et al., (2020), studied the Influence of fortification of cluster bean seeds with KH_2PO, $ZnSO_4$, $MgSO_4$, KNO_3, Gibberlic Acid, Salislic Acid, Pongamia Leaf Extract, Moringa Leaf Extract, Curry Leaf Extract, Neem Seed Kernal Extract, Cow Urine, Coconut Water with a soaking duration of 3 hours on growth, yield and seed quality in cluster bean (Cyamopsis tetragonaloba (L). The following studies used industrial effluents for seed fortification. Natarajan and Srimathi, (2021) fortified seeds of petunia with industrial effluents of Tamil Nadu News Print Paper Ltd (TNPL), dye, tannery and sugarcane distillery effluent diluted in different six concentrations of 5, 10, 20, 30, 40 and 50 per cent for 8 and 16 h meanwhile Zeid and Abou El Ghate, (2007) stimulated seed germination and early growth of beans seedlings using sewage water. The presented literature reveals that studies involving the use of effluents from slaughterhouse and palm oil mills for seed fortification are scarce in literature. This trend supports a reported by Jones et al. (2021), that wastewater is today considered as a potential and cost-effective source of freshwater, more especially in the domain of agriculture but very scanty research has been reported on wastewater as resource. The work is therefore aimed at studying the growth performance of groundnut and bean seeds fortified with slaughter house and palm oil mill waste waters. Our recent study using these two effluents to evaluate the growth performance of catfish showed steady catfish growth in these media, with the composition of the effluents having no effect on the growth (Tsamo et al.,2023). Matheyarasu et al, (2016) also reported that Abattoir Wastewater Irrigation of *S. alba* and *M. sativa* showed plants grown under tap water had about 70 % lower yields compared to those with abattoir wastewater irrigation. Interest in slaughterhouse effluent stems from the fact that the meat processing industry consumes 29% of the total freshwater used by the agricultural sector worldwide (Bustillo-Lecompte and Mehrvar, 2017; Tsamo et al. 2019; Dangwang Dikdim et al., 2022). According to reports, this trend will increase because in the past decade, worldwide production of beef, pork, and poultry meat doubled and is estimated to grow linearly until 2050 (Lecompte and Mehrvar, 2017). This slaughterhouse effluent is rich in organic content mainly from paunch, feces, urine, blood, lint, fat and

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lard, carcasses, undigested food, microbial pathogens, pharmaceuticals, disinfectants, loose meat, suspended material, and facility cleanings, oil and grease, carbohydrates, proteins, and lignin (Kospa et al., 2017). Similarly, for palm oil mill effluent, about 5 to 7.5 tons of effluents are produced from 1 ton of crude palm oil (CPO) in the palm oil mills [Hasanudin and Setiadi, 2016; Kospa et al., 2017]. This effluent is a colloidal suspension containing 95–96% water, 0.6–0.7% oil and 4–5% total solids including 2–4% suspended solids (Hasanudin and Setiadi, 2016; Bashir et al., 2022). For each wastewater type, 6 concentrations of 100, 75, 50, 25, 10 and 5% were prepared with tap water serving as the control. The seeds were soaked in each of these samples for a period of 5 hours, 10 hours and 24 hours prior to planting. This study will contribute in fulfilling the United Nations Sustainable Development Goal 6 (UN SDG6) highlighting the necessity of recycling wastewater to guarantee water availability for individuals (Al-Hazmi et al., 2023) as well as numbers 2 and 6 respectively of its 17 Sustainable Development Goals (SDGs) that prescribes Zero Hunger and Clean Water and Sanitation (Dalhatou et al., 2022).

Materials and methods

Soil sampling and analysis

The soil used for this experiment was collected at mile 3, Nkwen (5.9770^{0}N, 10.1830^{0}E). Air dried samples were sieved through a 2 mm sieve for soil property analysis. The soil was characterized using particle size distribution, bulk density, and organic matter content (Tsamo et al., 2022). Particle size distribution analysis was determined by hydrometer method using sodium hexametaphosphate and sodium carbonate as dispensant while the textural class was obtained using the USDA textural triangle. Here, the percentage of gravel, sand, silt and clay were obtained. Bulk density measurement was determined according to the method of ASABE standard. Accordingly, a cylinder with a 500 mL volume was weighed (M_5). A soil sample was filled to the 500mL volume mark in the cylinder and the mass of the cylinder and its content weighed (M_6). The bulk density measurement was repeated five times and the average value and range were reported. The bulk density was calculated from the relationship:

$$Bulk\ density\ (B_d) = \frac{M_6 - M_5}{V} \qquad [1]$$

where M_5= mass of empty cylinder, M_6= mass of sample and cylinder, V= volume occupied by soil. Soil organic matter was determined using the loss on ignition method at about 440 ^{0}C in a furnace (ASTM D 2974 Method C).

Experimental procedure

Wastewater was collected from mile 4 Nkwen (Lat 5.9927^0 N and Long 10.1843^{0}E) and Akosia local palm oil mill (Lat 6^0 04' 60.00" N and Long 10^0 05'60.00" E). as described by Tsamo et al., (2023). The physico-chemical analysis of the used waters is given in Table 2. The waste water samples were diluted into six treatments of various concentrations ranging from 5, 10, 25, 50, 75, 100% and tap water used as the control method (Table 1). Each of the samples was placed in metal pans with the seeds so as to have enough surface area for absorption of the nutrients. The pans were labelled A (A1, A2, A3, A4, A5, and A6) for slaughterhouse wastewater, B (B1, B2, B3, B4, B5, B6) palm oil mill wastewater, C (tap water) (Table 1). Once the seeds were soaked in the various samples, they were removed at required time intervals and planted in the soil immediately. The soil was fertilized using plantain peelings biochar as organic fertilizer. To prepare the biochar, plantain peelings were gotten from households, dried and burnt in an enclosed container for 20 minutes, and 5g of the biochar was measured and spread in each pod. The crops selected were groundnut and bean seeds. The seeds were genetically pure seeds gotten from the delegation of scientific research, the Cameroon government council service for Agricultural research (5.9517^{0}N, 10.1698^{0}E). The experiment was done in duplicate giving a total of 78 pods for both waste waters (Table 1). 234 seeds of both groundnut and beans were planted i.e. 3 seeds per pod, fortified with each waste water type and concentration as well as the control for a period of 5, 10 and 24 hours (Table 1). The germination percentage was collected based on the number of seeds germinated equation [2]:

$$Germination\ percentage = \frac{Number\ of\ germinated\ seeds \times 100}{Total\ number\ of\ seeds\ planted} \qquad [2]$$

The crops in all the 78 pods were irrigated for 14 weeks with tap water and data recorded once a week. The different parameters monitored were number of germinated seeds (for 4 weeks), leaf number, and stalk length for 14 weeks.

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Parameter	Water sample		
	sample C	sample A	sample B
SO_4(mg/L)	617.13	1234.25	349.7
Alu (mg/L)	2.16	1.44	5.04
Fe(mg/L)	0.22	2.58	16.38
Carbonate (mg/L)	80.24	13.2	83.28
Bicarbonate ions (mg/L)	18	22.5	29
Cl(mg/L)	56.8	39.05	78.1
NTU(NTU)	10	480.5	84.5
Cond(µS/Cm)	330	360	1510
P(mg/L)	169.38	396.75	93.13
NO_3(mg/L)	0	0	136.44
N(mg/L)	70	7	175
COD(mg/L)	5600	4160	2200
BOD_5(mg/L)	3600	3200	2500
$N0_2$(mg/L)	0	0	92.43
Hardness (mg/L)	3.4	3.6	3.2

Table 2. *Physicochemical parameters of the waters used (Tsamo et al., 2023)*

Results and discussion

Properties of the soil used

Results of the particle size distribution of the soil used are presented in Table 3 and Figure 1, where it can be observed that the tested soil is dominated by sand and gravel, 56.12 and 28.63% respectively. This used soil is therefore gravelly sand soil because gravelly sand soils have respectively respectively gravel, sand, silt and clay content of 20-40%, 40-80%, 0-20% and 0-20 % (Indiana Government Resources, 2019). These soils are therefore classified as gravelly sand soil**.** This soil will definitely not hold nutrients due to its porous nature, hence the need to use some organic amendment. While this soil may be good for cultivating groundnut because groundnut seeds grow better in well-drained sandy loam soils, this may not be the case with beans which grow best in clay or silt loam soils (Schuh, and MacKenzie, 2022). Results of organic matter analysis shows that the soil has organic matter of 10.36. Soils with organic content between 7 and 13% are said to have little organic matter (Huang et al., 2009), implying the used

Waste water sample	Different wastewater treatments used	Codes	Number of hours of fortification
Slaughterhouse wastewater (sample A)	5 %	A1(A1T1, A1T2, A1T3)	5
		A1(A1T1, A1T2, A1T3)	10
		A1(A1T1, A1T2, A1T3)	24
	10%	A2 (A2T1, A2T2, A2T3)	5
		A2 (A2T1, A2T2, A2T3)	10
		A2 (A2T1, A2T2, A2T3)	24
	25%	A3 (A3T1, A3T2, A3T3)	5
		A3 (A3T1, A3T2, A3T3)	10
		A3 (A3T1, A3T2, A3T3)	24
	50%	A4 (A4T1, A4T2, A4T3)	5
		A4 (A4T1, A4T2, A4T3)	10
		A4 (A4T1, A4T2, A4T3)	24
	75%	A5 (A5T1, A5T2, A5T3)	5
		A5 (A5T1, A5T2, A5T3)	10
		A5 (A5T1, A5T2, A5T3)	24
	100%	A6 (A6T1, A6T2, A6T3)	5
		A6 (A6T1, A6T2, A6T3)	10
		A6 (A6T1, A6T2, A6T3)	24
Palm oil wastewater (sample B)	5%	B1 (B1T1, B1T2, B1T3)	5
		B1 (B1T1, B1T2, B1T3)	10
		B1 (B1T1, B1T2, B1T3)	24
	10%	B2 (B2T2, B2T2, B2T3)	5
		B2 (B2T2, B2T2, B2T3)	10
		B2 (B2T2, B2T2, B2T3)	24
	25%	B3 (B3T1,B3T2, B3T3)	5
		B3 (B3T1,B3T2, B3T3)	10
		B3 (B3T1,B3T2, B3T3)	24
	50%	B4 (B4T1, B4T2, B4T3)	5
		B4 (B4T1, B4T2, B4T3)	10
		B4 (B4T1, B4T2, B4T3)	24
	75%	B5 (B5T1, B5T2, B5T3)	5
		B5 (B5T1, B5T2, B5T3)	10
		B5 (B5T1, B5T2, B5T3)	24
	100%	B6 (B6T1, B6T2, B6T3)	5
		B6 (B6T1, B6T2, B6T3)	10
		B6 (B6T1, B6T2, B6T3)	24
Tap water (Sample C)	100%	C1 (C1T1, C1T2, C1T3)	5
		C1 (C1T1, C1T2, C1T3)	10
		C1 (C1T1, C1T2, C1T3)	24

Table 1. *Table of treatment units*

soil was not rich in organic matter. This is in agreement with results of particle size distribution (Table 3) in which the soil is gravelly sand soil type. It is generally desirable to have soil with a low bulk density (<1.5 g/cm^3) for optimum movement of air and water through the soil (Hunt and Gilkes, (992). Soils with a bulk density higher than 1.6 g/cm^3 tend to restrict root growth (Hunt and Gilkes, 1992; Tsamo et al., 2021). The soil used had a bulk density higher than 1.6 g/cm^3 or 2.39 g/cm^3 which means the used soil may restrict root growth.

% of Gravel	% of Sand	% 0f Silt	% 0f Clay
Φ >2mm	2> Φ >0.02mm	0.02> Φ >0.002mm	Φ <0.002mm
28.63	56.12	10.15	5.10

Table 3 Results of particle size distribution

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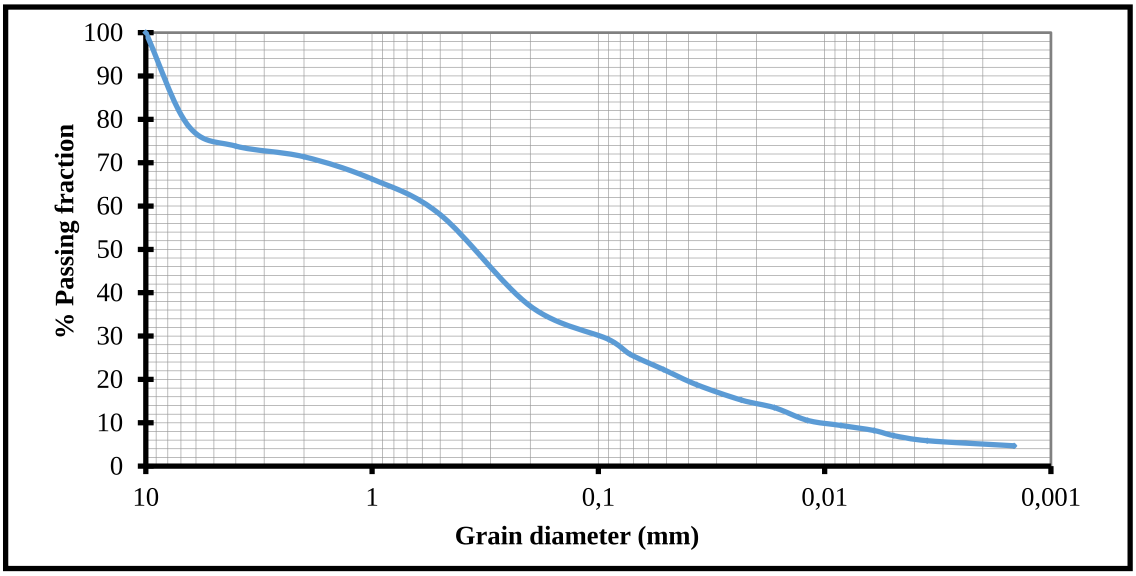

Figure 1
Particle size analyses curve

Influence of seed fortification by slaughter house and palm oil mill waste waters on the germination of groundnut and bean seedlings

Effect of fortification in 5 hours. The results of seed germination fortified for 5 hours are presented in Figure 2a for beans, and Figure 2b for groundnut seeds for slaughterhouse wastewater; Figure 2c for beans, and Figure 2b for groundnut seeds in the case of palm oil mill wastewater. In Figure 2a, it can be observed that though beans germination started from the second week for treatments, 5%, 25%, 50% and control, beans seeds fortified with slaughterhouse wastewater had only 33% germination against 66% for tap water (control), indicating the wastewater exert some stress on the seeds. No germination occurred in beans seeds fortified with slaughterhouse wastewater at 10, 75 and 100%. Meanwhile from Figure 2b, no germination of groundnut seeds was recorded for 25, 50 and 100% slaughterhouse wastewater concentration fortified seeds, as opposed to 5%, 10% and 75% where germination started in the second week. The fact that tap water fortifying groundnuts seeds started germinating in the fourth week suggest slaughterhouse wastewater contain nutrients that can enhance seed germination. There is a statistical difference (p-values <0.05) among the treatment groups for both seeds. Beans and groundnut seeds were also fortified with palm oil mill wastewater for 5 hours and the results are presented in Figure 2c a for beans seeds and in Figure 2d for groundnut seeds. In Figure 2c, it can be seen that fortification with palm oil mill wastewater had a significant effect (p-value <0.05) on beans seed germination as the germination started in the control om the second week with 66% germination as opposed to germination in seeds fortified with 5%, 25% and 75% palm oil mill wastewater concentration where germination started in the third week. Contrarily, germination of groundnut seeds fortified with palm oil wastewater for 5 hours showed better results compared to the control (Figure 2d). Germination started in the second week in groundnut seeds fortified with 5%, 25% and 75% palm oil mill wastewater, in the third week for 10% and 100% and in the fourth week for the control hence a significant effect with a p-value <0.05. Beans seeds fortified with palm oil wastewater in 5hours showed delayed germination compared to germination in beans seeds fortified with slaughterhouse wastewater. However, the reverse is observed with groundnuts seeds where better germination is obtained for groundnut seeds fortified with palm oil wastewater at all concentrations against germination occurring only in seeds fortified with slaughterhouse wastewater concentrations of 5%, 10% and 75%. The poor germination of groundnut seeds fortified with tap water is due probably to the fact that this water may not have some constituents that can stimulate rapid germination in groundnuts seeds. This low germination may also be due to the gravel sandy soil type and high bulk density which restrict root growth. According to Schuh, and MacKenzie, (2022), well-drained sandy loam soils are good for cultivating groundnut as opposed to beans which grow best in clay or silt loam soils.

a)

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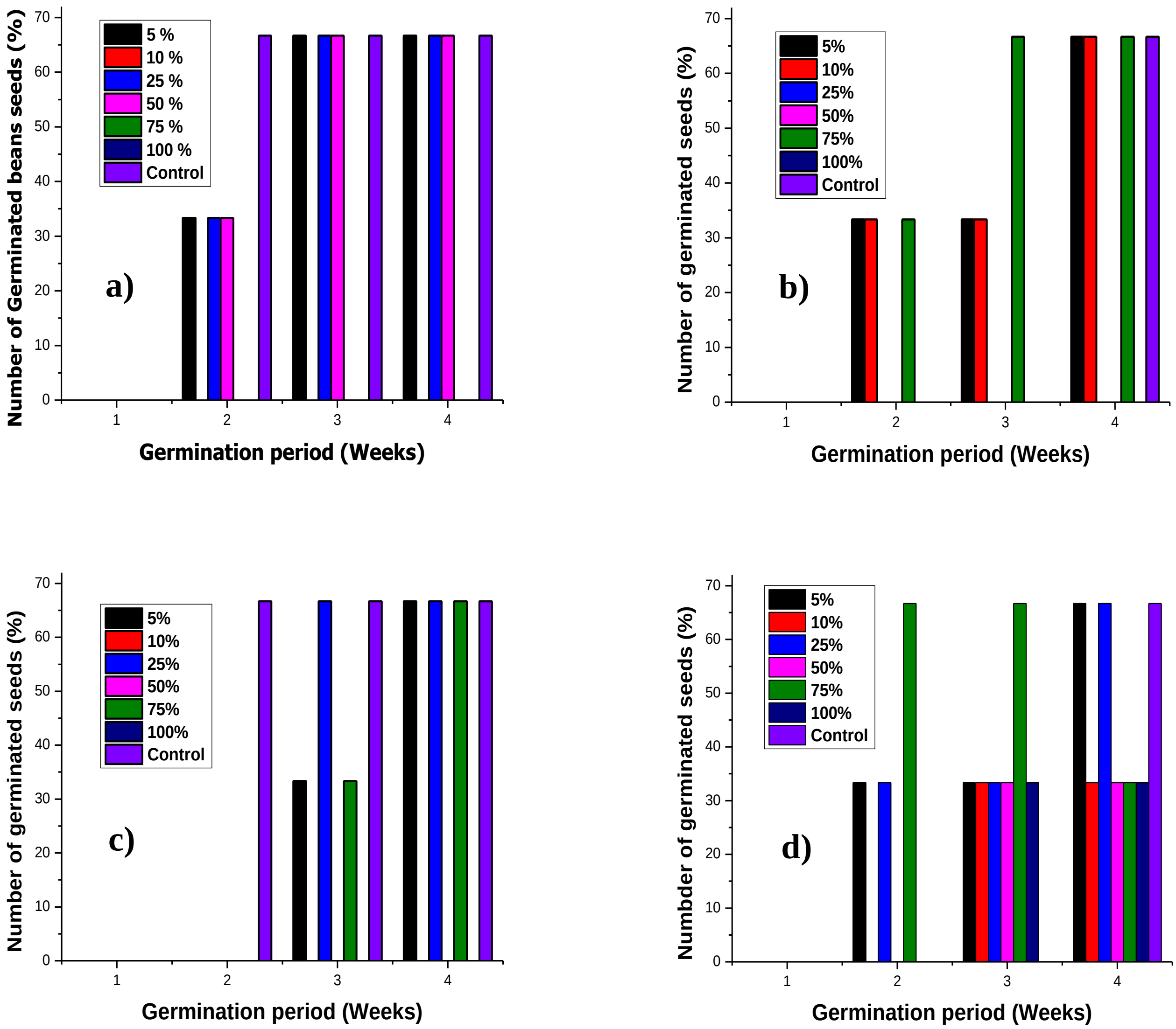

Figure 2. ***Seed germination rate of a) beans b) groundnut seeds fortified with slaughterhouse wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 5 hours***

Effect of fortification in 10 hours. Figure 3a presents the number of seeds that germinated after 10 hours of fortification with slaughterhouse wastewater for beans seeds and Figure 3b for groundnut seeds. For beans seeds, Figure 3a results revealed that germination occurred in all the treatments during the second week at a percentage of 33.33% which attained all 66% in the fourth week except at 100% treatment. These results are slightly different for groundnut seeds (Figure 3b), where germination equally started from the second week for 5-25% treatments and the control, with zero germination for treatments 75% and 100%. The reduction in germination percentage recorded at higher concentrations might be due to the presence of excess. amount of toxic metobolites in the effluents causing depletion of acids from tricarboxylic acid cycle which reduces the respiration rate and cumulatively reduced the germination. It might also be due to the higher concentrations of solids in the effluents that had retarded the seed germination due to their toxic effect (Natarajan and Srimathi, 2021). The fact that treatment 25% for groundnut seed shows better germination values compared to the control indicate the uptake of some nutrients from the slaughterhouse water at some optimum conditions necessary for growth. The low germination values obtained at higher waste water conditions for both seeds and long fortification period indicate a probable accumulation of some undesirable a)

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substances from the wastewater on the organs of the seeds. Results of the effect of fortification of beans and groundnut seeds with palm oil wastewater in 10 hours are presented in Figure 3c for beans seeds and Figure 3d for groundnut seeds. In Figure 3c for bean seed, it can be observed that all the treatments grew from the second week in equal amounts, attaining 66% from the third week. However, this was not the case with groundnut seeds (Figure 3d) as germination started in the second week only for 10% treatment and the control with zero germination for 100% treatment. Interestingly 66% germination was obtained in all the treatments in the fourth week, suggesting the seeds went through some initial stress from wastewater before overcoming it with time.

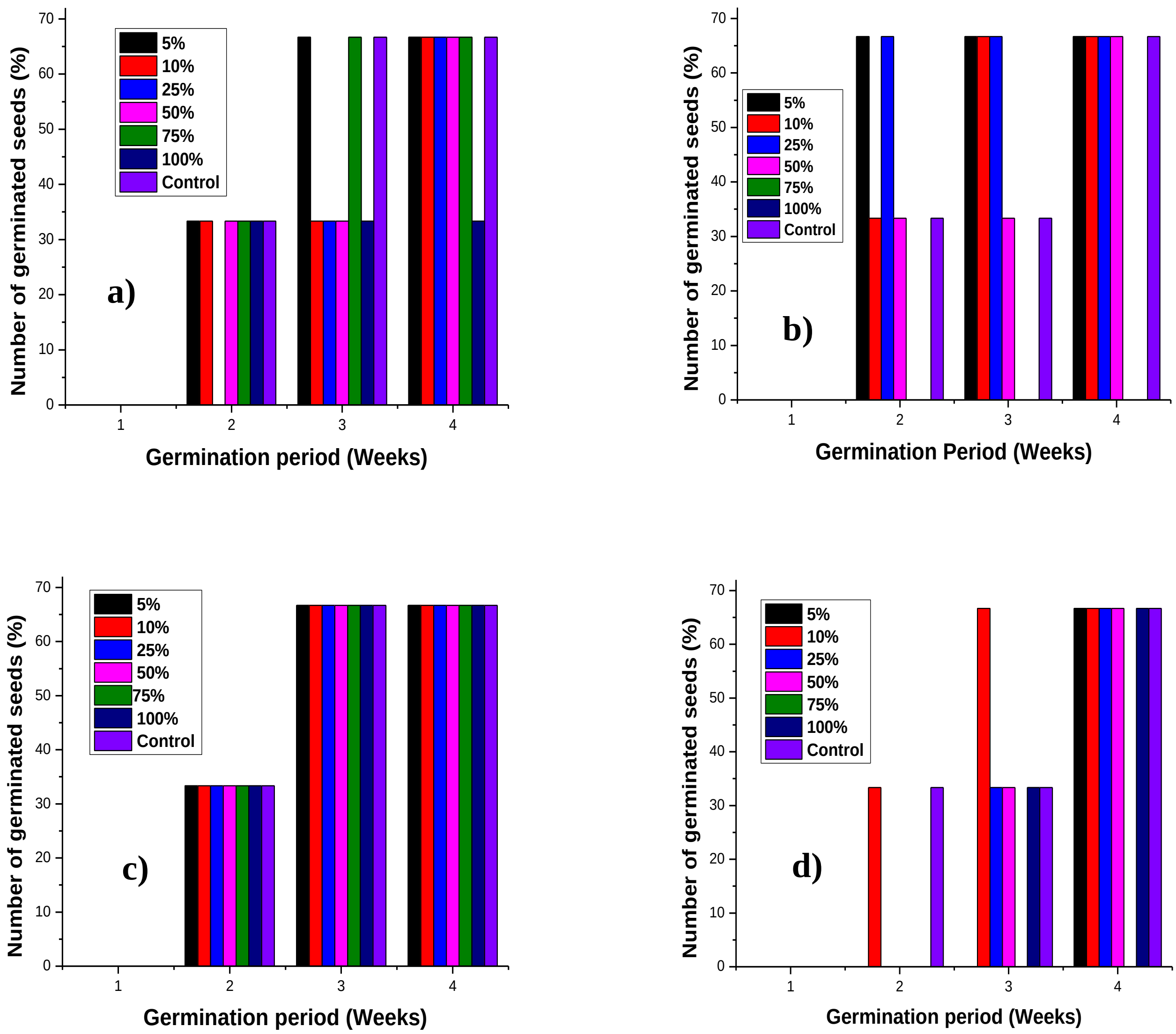

Figure 3. *Seed germination rate of a) beans b) groundnut seeds fortified with slaughterhouse wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 10 hours*

Effect on fortification in 24 hours. Figures 4a and 4b illustrates the number of beans and groundnut seeds respectively that germinated when fortified with slaughterhouse wastewater, at different concentrations for 24 hours. For groundnut seeds (Figure 4b) fortification for 24 hours, a positive ef-

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fect on germination was observed during the second week for all wastewater treatments against the control that started from the third week. These results contrast those of beans in Figure 4a, where germination was negatively affected as it happened only in three treatments (5, 10% and 50% from second week and 100% from fourth week). Similarly, results for germination of beans and groundnuts fortified with palm oil mill wastewater presented respectively in Figures 4c and 4d show similar trend for beans as for those with slaughterhouse wastewater. However, for groundnut seeds the trend is different as germination started in the second week for 5-50% treatments like the control with no germination occurring in 100% treatment on the fourth week for 75% treatment.

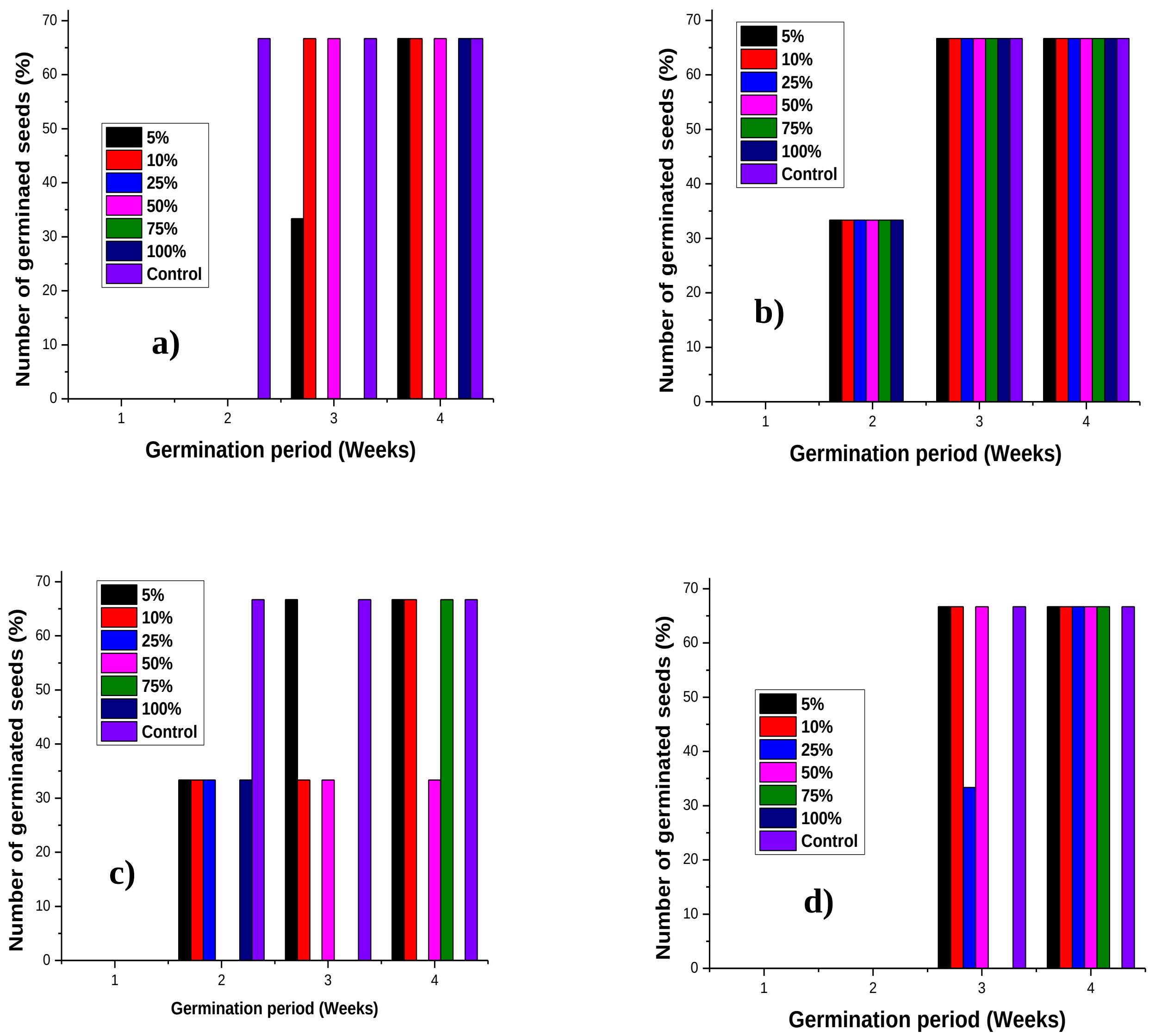

Figure 4. *Seed germination rate of a) beans b) groundnut seeds fortified with slaughterhouse wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 24 hours*

Results shows that 10 hours' fortification was more suitable for both seeds and for the two wastewater especially for beans (Figures 3a, 3c). But 24 hours' fortification time was more suitable for groundnut seeds for both wastewaters (Figures 4b ad 4d). According to Das and Biswas, (2022) with proper

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use, seed fortification can exert positive impact on seed germination and thereby, optimum and vigorous plant stand. However, beneficial impact of seed fortification depends on proper standardization of materials, concentration/quantity of materials, duration and method of treatment. According to Vishwanath et al. (2015) during fortification, the first phase of germination ends with completion of imbibitions process and hence the time taken from sowing to emergence is much reduced. Acccording to them, fortification of seed increased the germination by promoting embryo growth so that there is improvement in field emergence which may be due to activation of cells, which results in the enhancement of mitochondrial activity leading to the formation of higher energy compounds and vital biochemicals, which were made available during the early phase of germination.

Results of this study also shows that there was generally delayed germination starting generally in the second week and some cases the third and fourth week. However, maximum germination was obtained in nearly all the cases in the fourth week. This delay according to Adraino et al., (1973) (Natarajan and Srimathi, 2021) is that the higher solid and nutrients content of the effluent might be the limiting factor and it should be the cause for delay in germination. According to them, the growth parameters of the seedlings increased at lower concentrations of effluents due to invigourative effect, while at higher concentrations it decreased due to toxic effect. The high solid and nutrients content of the effluents such as sulfate, turbidity, COD, BOD_5 (Table 2) also probably restricted supply of oxygen to seeds, hence delay in growth.

Influence of seed fortification by slaughter house and palm oil mill waste waters on groundnut and beans leaf number

Effects of fortification in 5 hours. Figures 5a and 5b shows the results on leaf number obtained from fortifying bean and groundnut plant with slaughterhouse wastewater. From Figure 5a, it is observed that number of leaves were steadily increasing with time, giving a maximum (14-15 leaves) for 50%, 100%, 25% and 75% for beans seeds fortified with slaughter house waste water. The least number of leaves were produced by the 5% (1 leaf) slaughter house waste water fortification followed by the control (11 leaves) and 10% (12 leaves) respectively. For fortification of groundnut seeds for 5 hours with slaughter house waste water (Figure 5b), maximum of four leaves were produced by nearly all the treatments except 25% treatment with 3 leaves. The 5% treatment started producing leaves in 8th week. The reason for low and delayed leaves production could probably be due to low phosphorus, nitrogen, photosynthetic and respiration rates taking place in the plant (Li et al. 2021).

Fortification of both beans (Figure 5c) and groundnut (Figure 5d) seeds by palm oil mill effluent for 5 hours showed very significant increase in leaf numbers attaining almost 60 leaves in most cases. Contrary to beans seeds fortification with slaughter house waste water where 50% had the best results, it had zero leaf production with palm oil mill effluent. The order of leafs production was 55 for 75%, 53 for 25%, 50 for the control, and about 35 for 5%. From Figure 5d, on number of leafs produced from fortification of groundnut seeds for 5hrs with palm oil mill effluent, 50% had highest results (55 leafs) followed by the control (52 leaves), 10% (50 leaves), 100% (48 leaves) 75% 40 leafs), 255 (39 leaves and 5% (18 leaves produced in the last two weaks of the study).

The trends presented shows that palm oil mill has more nutrients that are favourable for beans and groundnut germination. For example, it has a NO_3 (mg/L) content of 136.44 against zero for slaughter house effluent and the control. It also has 93.13 mg/L of phosphorus which may more suitable for growth, compared to 396.75 mg/L for slaughter house effluent and 169.38 mg/L for the control.

Effects of fortification in 10 hours. Effects of slaughter house waste water fortification on bean and groundnut leaf number for 10 hours are presented in Figures 6a and 6b. The results in Figure 6a for beans revealed a linear increase in all treatments with the highest leaf number recorded in the10% treatment and the lowest in the control. Meanwhile Figure 6b for groundnut, shows that groundnut leaf number had highest leaf number for 5% treatment followed by 25%, 50% and the control and least number with 75% treatment. The leaf numbers obtained with beans (Figure 6c) and groundnut (Figure 6d) seeds fortified with palm oil mill effluent for 10 hours show similar trends to those with slaughter house waste waters but with higher leaf numbers going above 50 with beans for the treatments 20-65 for groundnuts, with the control having highest number of leafs in either case.

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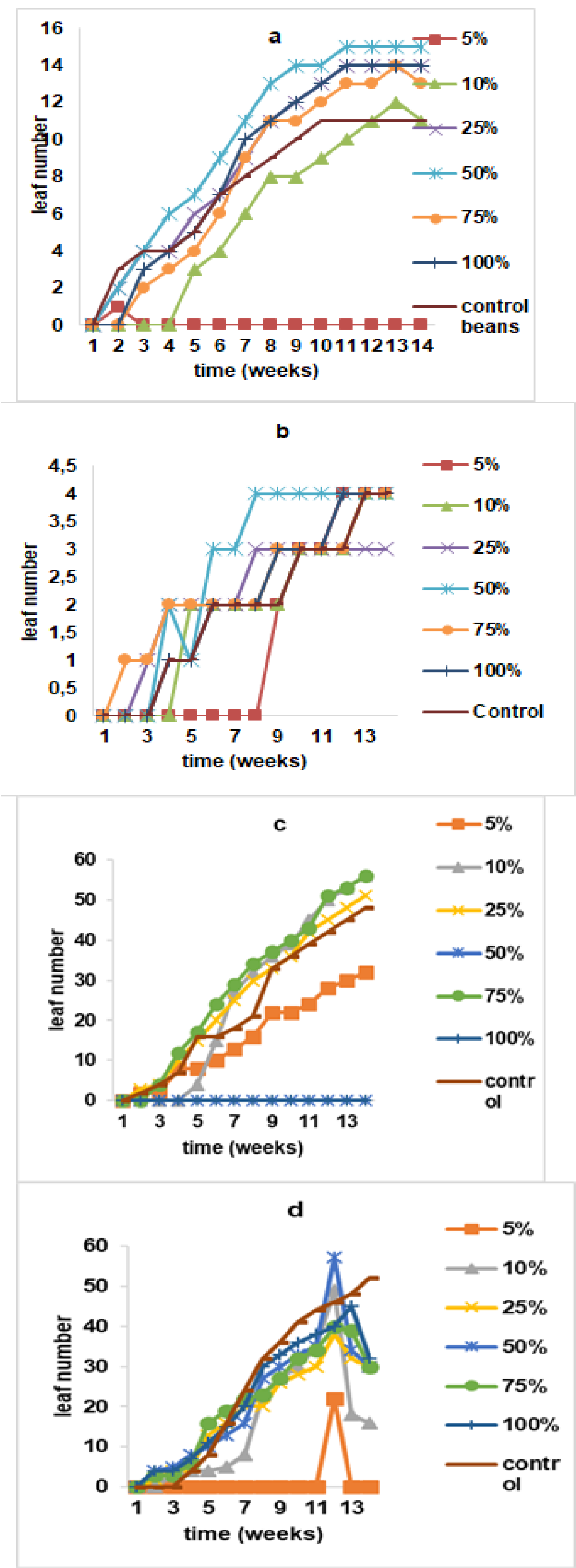

Figure 5. *Leaf number of a) beans b) groundnut seeds fortified with palm oil mill wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 5 hours*

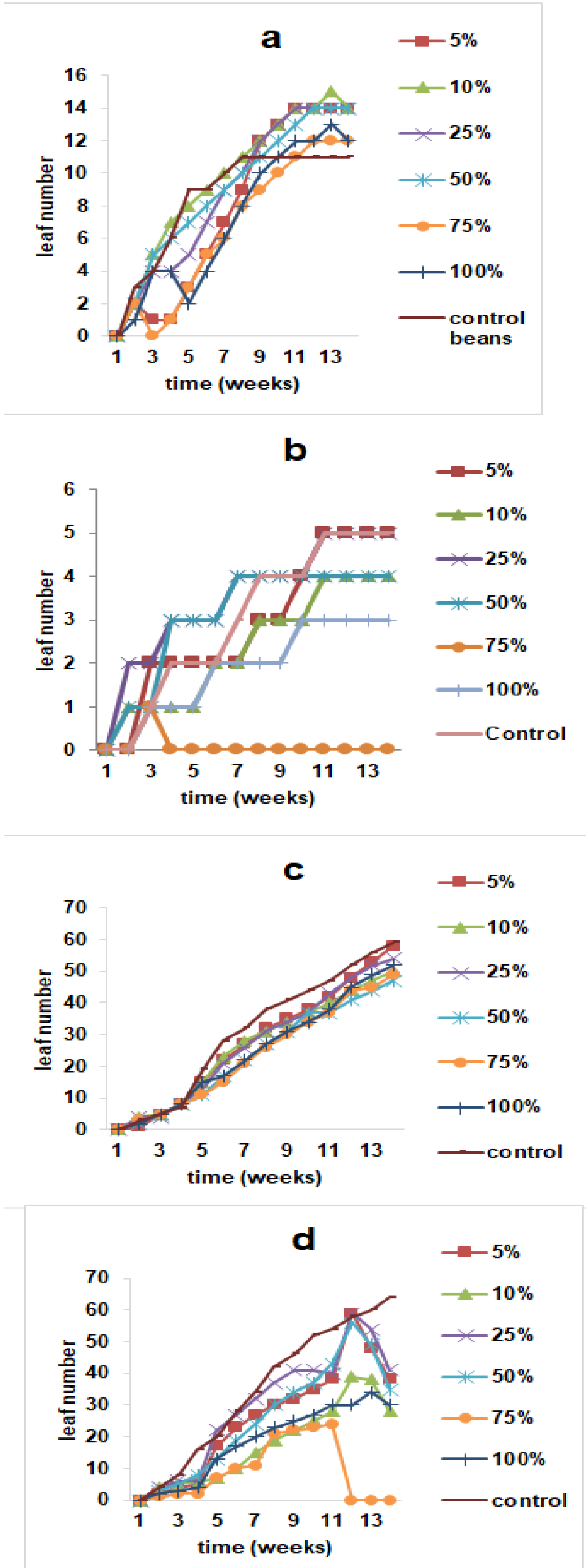

Figure 6. *Leaf number of a) beans b) groundnut seeds fortified with palm oil mill wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 10 hours*

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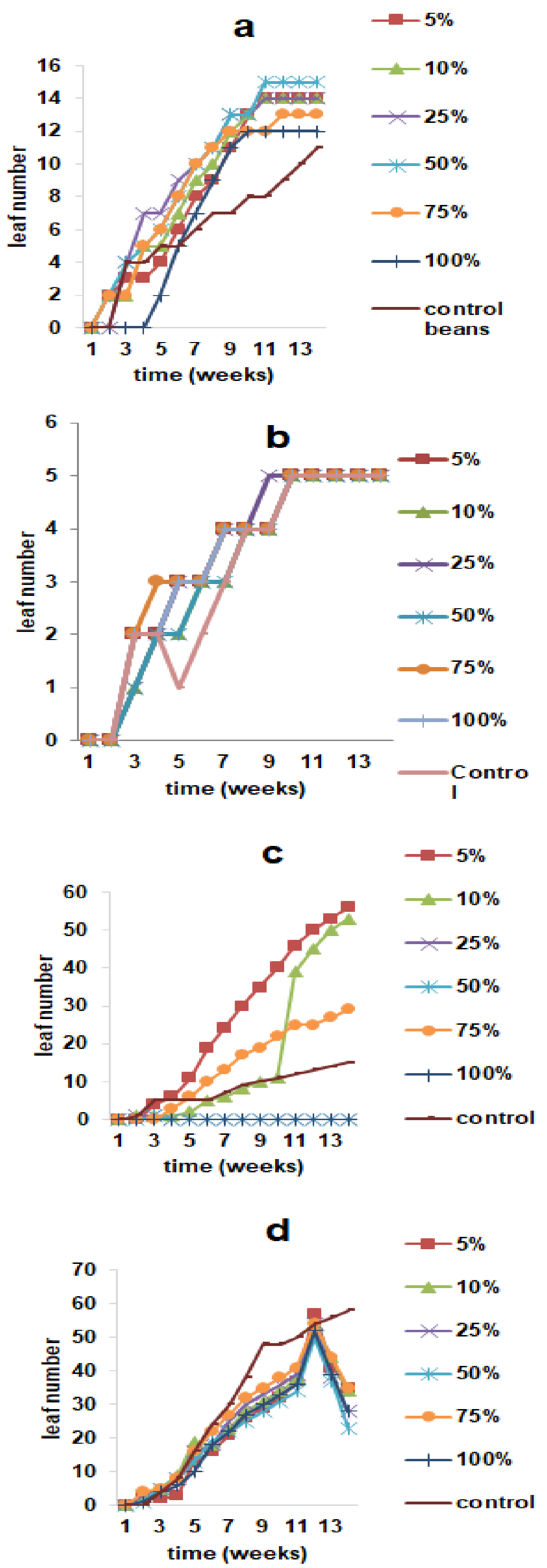

Figure 7. *Leaf number of a) beans b) groundnut seeds fortified with palm oil mill wastewater c) beans d) groundnut seeds fortified with palm oil mill effluent, for 24 hours*

Effects of fortification in 24 hours. Results present in Figures 7a and 7b for the effect slaughterhouse wastewater fortification on beans and groundnut leaf number in 24 hours respecticely shows a linear increase in leaf number in all the treatments with the control having the least leaf numbers in case of beans (Figure 7a) and all the groundnut seeds that germinated having the same leafs numbers (Figure 7b). This is the same trend with palm oill mill effluent fortification of beans (Figure 7c) and groundnut (Figure 7d) seeds for 24 hours, with maximum leaf numbers occuring in the order 5%>control>75%=10, 25%, 50% and 100% treatments.

Results from Figures 5 to 7 on leaf numbers shows that the control had better leaf numbers in palm oil mill effluent treatments (Figures 5 c and d Figures 6 c &d, Figure7 d). This was the reverse for treatments with slaughter house waste water (Figures 5 a&b Figures 6 a &b, Figure7a&b). This may be due to the rich organic matter in the control having COD (mg/L) and BOD_5(mg/L) of 5600 and 3600 compared to 2200 and 2500 for palm oil waste water. The organic matter could be a vital source of nutrients for the seeds. These values for slaughter house waste water were closer to those of the control in which both had no NO_2 compared to palm mill oil wastewater which contains 92.43 mg/L of NO_2 (Table 1). Jiechen et al. (2021) studied the effects of tobaccos exposed to different concentrations of NO_2. They reported that at about 16 μLL^{-1} NO_2 concentration, the leaves started to wither, and the plants were about to die after five days. Meanwhile 8 μLL^{-1} NO_2 concentration promoted the growth of plants, but the old leaves began to show signs of damage, such as bruising and yellowing. Sheng and Zhu, (2019) studied the physiological responses of plants exposed to NO_2. Their results showed that NO_2 polluted the plants and that NO_2 exposure affected leaf chlorophyll contents in most functional groups.

Influence of seed fortification by slaughter house and palm oil mill waste waters on groundnut and beans stalk length

The effect of fortification with tested effluents on groundnut and beans stalk length are presented in Figures 8a to 8L. Figures 8a &b for 5hours fortification of the two seeds with slaughter house effluent, Figures 8c &d for 5hours fortification of the two seeds with palm oil effluent, Figures 8e &f for 10hours fortification of the two seeds with slaughter house effluent, Figures 8g & h for 10hours fortification of the two seeds with palm oil effluent, Figures 8i & j for 24hours fortification

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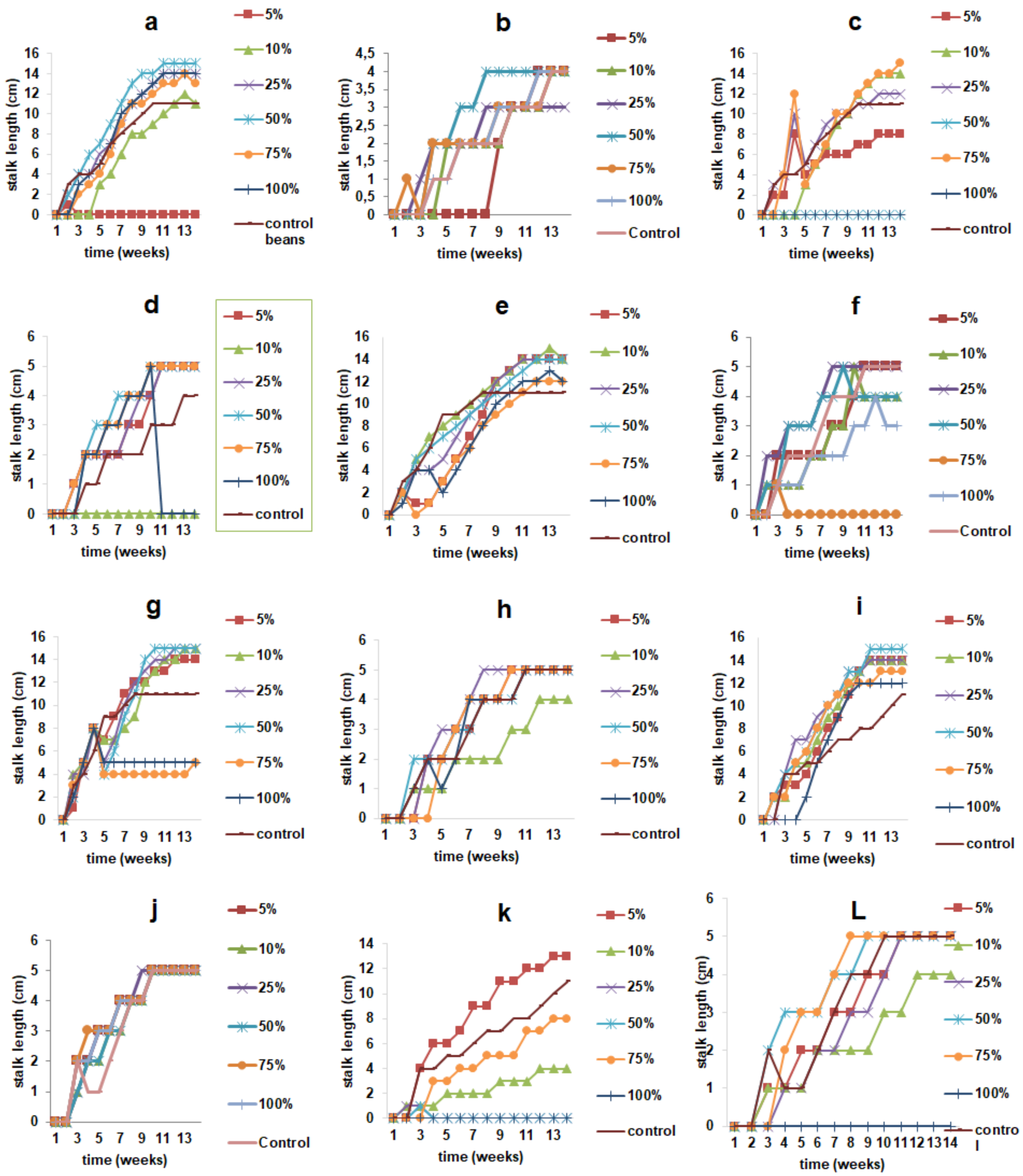

Figure 8. *Stalk length of beans and groundnut seeds fortified with slaughterhouse and palm oil mill effluents for 5, 10, and 24 hours* ***a*** *(beans) and* **b** *(groundnut) 5hours fortification with slaughter house effluent,* **c** *(beans) and* **d** *(groundnut) for 5 hours fortification with palm oil effluent;* **e** *(beans) and* **f** *(groundnut) 10 hours' fortification with slaughter house effluent,* **g** *(beans) and* **h** *(groundnut) for 10 hours fortification with palm oil effluent;* **i** *(beans) and* **j** *(groundnut) 24 hours' fortification with slaughter house effluent,* **k** *(beans) and* **L** *(groundnut) for 24 hours' fortification with palm oil effluent)*

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of the two seeds with slaughter house effluent, Figures 8k and L for 24 hours fortification of the two seeds with palm oil effluent. As observed from these Figures, the pattern of stalk length is basically the same like that of number of leaves for each corresponding treatment. There is however, a difference with Figure 8g (for 10hours fortification of beans seeds with palm oil effluent) where there was not stalk length increase for 75% and 100% treatments from the 5th week. Also from Figure 8h (for 10hours fortification of groundnut seeds with palm oil effluent), the 75% treatment that stop producing leafs by the 11th week had the highest stalk length. Also from Figure 8L (for 24hours fortification of groundnut seeds with palm oil effluent), all the seeds that germinated and produced leafs had the same values of stalk length except for the 10% treatment. The number of leafs obtained in this study were generally more than 60 for both beans (Fig. 5c, 6c, and 7c) and groundnuts (Fig. 5d, 6d, and 7d) fortified with palm oil mill waste water. These values were higher than with slaughter house waste water fortified seeds, which was about 16 for beans (Fig. 5a, 6a and 7a) and maximum 5 for groundnuts (Fig. 5b, 6b and 7b). The stalk length for beans in all the treatments for both wastewaters is 16 cm maximum and 5 cm for groundnut in the treatments also. Results obtained in this study or leaf number and stalk length are similar to other studies. Results of this study is similar to that of Biloet al. (2015) who studied the effect of Pb concentration on the length of stems of beans after 12 days of germination and reported a maximum stalk length of 16 cm. Values of stalk length for groundnut seeds in this study for all the treatment were smaller compared to those of Fagbemigun and Oguntola, (2019) who studied the effect of organ mineral nitrogen starter fertilizer on the growth and yield of groundnut (*Arachis hypogeal* L.) and reported that stalk length varied from 11.13 to 25.66 cm and leaf number varied from 23 to 81. The differences observed may be due to beans species as seeds are produced locally to fit local growth conditions as well as the nutrient content of the fortify-cation agents. Furthermore, the soil used bulk density of 2.39 g/cm^3 probably did not favour roots develop-ment and less uptake of nutrients for effective growth.

Conclusions

The percentage germination, leaf number, and stalk length were used to investigate the growth performance of beans and groundnut seeds fortified by slaughterhouse and palm oil mill effluents, each for 5, 10 and 24 hours. The soil used was gravelly sand soil, has 10.36 % organic matter, and bulk density of 2.39 g/cm^3 which may render the soil impermeable to roots of plants for effective growth. 10 hours' fortification was more suitable for both seeds and for the two wastewaters especially for beans. There was generally delayed germination starting generally in the second week and some cases the third and fourth week. However, maximum germination was obtained in nearly all the cases in the fourth week. The leaf numbers obtained shows that the control had better leaf numbers in palm oil mill effluent treatments. This was the reverse for treatments with slaughter house waste water. The number of leafs obtained in this study were generally more than 60 for both beans and groundnuts fortified with palm oil mill waste water. These values were higher than with slaughter house waste water fortified seeds, which was about 16 for beans and maximum 5 for groundnuts. The stalk length for beans in all the treatments for both wastewaters is about 16 cm maximum and 5 cm for groundnut in all the treatments as well. In most treatments, seeds fortified with slaughter house and palm oil mill waste waters germinated faster than those fortified with tap water. For example, for 5 hrs of fortification with slaughterhouse effluent, the tap water fortified groundnuts seeds started germinating in the fourth week meanwhile the 5, 10 and 75% treatments started germinating in the second week. Results of this study thus confirm that a faster germination of beans and groundnut seeds can be achieved by fortification using slaughter house and palm oil mill waste waters. However, it will be recommended to study the fortification with these wasters at other concentrations in order to obtain an optimum as well as study to nutrient content of seeds after fortification to understand the nutrients favouring germination and those that may be toxic to the seeds.

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