Sahel Journal of Life Sciences FUDMA (SAJOLS)
December 2023 Vol. 1(1):124-129
ISSN: 3027-0456 (Print)
ISSN: xxxx-xxxx (Online)
DOI: *https://doi.org/10.33003/sajols-2023-0101-013*
https://saheljls.fudutsinma.edu.ng/index.php/saheljls/article/view/7/version/7

Research Article

The Effect of Toxicity Stress on The Germination, Growth and Yield of *Pennisetum glaucum* (Var. Super Sosat)

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Received: 7th December, 2023 **Accepted:** 28th December, 2023 **Published:** 31st December, 2023

ABSTRACT

The performance of the *Pennisetum glaucum* subjected to various concentrations of spent engine oil (0, 10mL, 20mL and 30mL) was the aim of this study. Twelve pots were used for the experiment arranged in a Randomized Complete Block Design with three replicate each and a control. The data of each parameter (germination percentage, leaf length, leaf number, stem width, plant height and fruit weight) was subjected to analysis of variance using Duncan's New Multiple Range Test for mean separation. All the parameters considered were significantly affected by the increase in concentrations of spent engine oil in comparison to the control. Germination percentage was poor for 20mL and 30mL concentrations of spent engine oil (40% and 25% respectively) whereas 100% germination was observed for control and 10mL concentrations, though seedling emergence was faster in control than 10mL concentration of spent engine oil. The plant height, stem width, leaves number and fruit quality were observed to performed better in control and 10mL concentration of spent oil while in 20mL and 30mL concentrations, all parameters observed were poor in comparison to control. The heavy metals (Cu, Fe, Ni, Pb and Zn) accumulation also increased with increased concentrations of spent engine oil applied which obviously was responsible for the toxicity effects such as wilting, chlorosis, stunted growth and poor fruits harvest observed. Therefore indiscriminate disposal of spent engine oil is a threat to the overall performance of *P. glaucum* and need to be checkmated to eliminate such negative impact on *P. glaucum* production.

Keywords: Concentrations; Germination; Heavy metals; *Pennisetum glaucum*; Super Sosat; Yield

Citation: Buah, J.D., Okeseni, O. and Musa, D. D. (2023). The Effect of Toxicity Stress on The Germination, Growth and Yield of *Pennisetum glaucum* (Var. Super Sosat). *Sahel Journal of Life Sciences FUDMA*, 1(1):124-129. DOI: *https://doi.org/10.33003/sajols-2023-0101-013*

NTRODUCTION

Millets are among the major cereal crops in the developing world especially in the semi-arid tropical regions of Africa and Asia where they are used both as human food and livestock feed (Zarihun, 2016). Pearl millet (*Pennisetum glaucum)* being a C4 plant, is the major coarse grain crop of the world (Gangaiah, 2012).They are identified by their small grain sizes and are considered as the 6th most important world cereal and also a fundamental crop in the dry lands of Sub-Saharan Africa, including the Sahel region (Basavaraj *et al.,* 2010).

Pearl millet originates from Africa and spread to Asia, the Americas and Oceania where it is cultivated predominantly as forage and mulch component of minimum tillage-based cropping systems (Ajeigbe *et al*., 2019). It provides staple food for the poor in a short period in the relatively arid part of the country, it is also used as feed for poultry and green fodder or dry for cattle (Gangaiah, 2012).

Pearl millet is grown globally in 29 million ha in more than 40 countries (Gangaiah, 2012). Its cultivation is mainly confined to semi-arid and arid climates of tropical and sub-tropical regions of South Asia (primarily India), Africa and Latin America. In Africa, it is cultivated in Nigeria, Niger, Mali, Chad, Tanzania, Sudan, Senegal and Burkina Faso (Gangaiah, 2012). Pearl millet is grown on over 260,000 km^2 of land worldwide and accounts for about 50% of the total world production of millets (Millet Consultative Group on International Agricultural Research, 2012). There are diverse groups of millet typical of different parts of the world (FAOSTAT, 2015).

Most of the arable lands world over is prone to one or more of the abiotic stresses, which cause yield losses of up to 70% in many crops (Ajeigbe *et al*., 2019). Extreme temperature, water stress (drought and flood), salinity, and heavy metal stress are some of the major environmental factors that affect growth, development, and yield of crop plants (Achuba and Peretiemo, 2007)

Spent engine oil is a common and toxic environmental contaminant not naturally found in the environment but large amounts are disposed into the environment when motor oil is changed and disposed into gutters, water drains, open vacant plots and farmlands, a common practice by motor and generator mechanics. Oil in the soil affects the biological, physical, chemical and microbiological components of the soil in various ways (Agbogidi and Ejemeta, 2005), hence, affecting the growth, development, productivity and yield of plants. Traditionally, farmers have device means to enrich soil fertility in field close to the homestead through regular application of household waste, crop residues, and animal manure yet the continual disposal of spent oil frustrates the these process as a result of poor crop yield (Achuba and Peretiemo, 2007). The increasing contamination of soil with heavy metals due to irregular disposal of spent oil has become one of the important reasons for the loss in crop productivity despite the development of several high yielding millet varieties (Pradeep and Guha, 2011). Though several high yielding millet varieties are available in the sub-region, there is little information on their response to effluent from spent engine oil. Therefore, this study was carried out to evaluate the effects of spent engine oil on the germination and growth performance of pearl millet (super sosat variety).

MATERIALS AND METHODS

Study Area

The study was carried out in the Botanical Garden in Federal University of Dutsin-Ma, Katsina State Nigeria. The Botanical Garden lies between latitude 12.4723°'N. and longitude 7.4879°'E.

Experimental Design

The Millet variety used for this study was super sosat. The seeds of millet were bought from Agro store and taken to the Department of Biological Science for identification and authentication. The spent engine oil used for the experiment was collected from a mechanic workshop. Viable seeds were sown in pots containing sandy loamy soil with punctured holes to avoid water logging. Twelve (12) plastic pots of three replicates were prepared and labelled. The pots were irrigated with different concentrations of spent engine oil. Three different concentrations of spent engine oil were applied at 10mL, 20mL and 30mL each with a control (0) and mixed adequately in the soil. The experiment was arranged in a completely randomized design, ten viable seeds of millet were sown separately in each of the pots and were thinned down to three per pot after total germination percentage was recorded.

Data collection: The following parameters were taken and recorded

Germination percentage: Average seed germination in the five replicates was determined and the percentage of germination was calculated as follows:

$$\text{Percentage seed germination} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seed planted}} \text{ x } 100$$

= Average number of seeds that germinated x 100

Plant height: Three tagged plants of each treatment were used in determining the plant height using a measuring rule. The height (cm) was determined every two weeks by measuring the length of shoot from the soil surface to the apex of the plant.

Leaf number: The leaves of each plant were counted visually and recorded. Leaves from the tagged plant from each treatment were counted every two weeks.

Leaf length*:* Three leaves were selected for measurements every two weeks. The length of the selected leaves was taken with the aid of a thread and 30 cm plastic meter rule.

Stem width: The stem girth was determined using a thread rolled over the middle of the plant stem once and then stretched over a 30 cm meter rule.

Fruit weight: The mature fruits of millet was determined using a weighing balance (g)

Heavy Metal Analysis

The Fe, Mg and Zn level was determined by using atomic absorption spectrophotometer (Thermo Fisher. Model CE 3000 Series AA System) as described by Radhouane, (2008).

Data Analysis

The data collected was subjected to analysis of variance (ANOVA), where treatments are significant Duncan's New Multiple Range Test (DNMRT) was used for mean separation.

RESULTS

The results obtained in this study as presented in Table 1 revealed that 100% seed germination of *P. glaucum* was recorded for control and 10mL while 20mL and 30 mL had poor germination percentage (40% and 25% respectively) with delayed seedling emergence compared to the control pot. The Highest number of leaves was observed in the control and gradual decline in leaf number as concentrations of spent engine oil increased was observed as presented in Table 2. The control had the highest leaf length at 12 weeks after planting (65.25cm) while gradual decline in leaf length was observed with increasing spent oil at 30mL (23.65cm) and significantly different at P<0.05 (Table 3). The stem width was highest in control (8.95cm) at the maturity of *P. glaucum* (12-WAP) while the stem width decreases with increasing concentrations of spent oil, although control and 10mL are statistically not significant at P<0.05 but statistically different from 20mL and 30mL concentration of spent oil as presented in Table 4.

The effect of the spent engine oil on the plant height of *P. glaucum* shows that control has the highest height at 12 weeks after planting (130.51cm). Gradual decline in plant height with increasing spent oil was observed with the lowest plant height at 30mL (80.01cm) and is significantly different at P<0.05 as presented in table 5. The fruits weight of the matured *P. glaucum* harvested at 12-WAP shows that the control had the highest weight of (146.35g) from replicate 3, while 10mL had 145.15g from replicate 1 and 4 respectively. The control and 10mL pots were not significantly different statistically at P<0.05. The highest fruit weight of 20mL and 30mL concentration of spent oil (131.8g and 105.5g respectively) in replicate 2 and 4 were less in weight compared to control and 10mL (Table 6). The percentage concentrations of heavy metals analyzed from *P. glaucum* samples under spent engine oil, Copper had the highest concentration and then Zinc (861.082 and 671.34 respectively) while the least concentration was nikel with 0.022 concentrations as presented in Figure 1.

Table 1. Percentage Seed Germination of *Pennisetum glaucum* (Var.Super Sosat)

Treatment	Replicate 1 (%)	Replicate 2 (%)	Replicate 3 (%)
Control	100	100	100
10mL	100	100	100
20mL	45	45	45
30mL	25	25	25

Table 2. The effect of spent engine oil on leaf numbers of millet *Pennisetum glaucum* (super Sosat)

TRT	WAP-1	WAP-2	WAP-3	WAP-4	WAP-5	WAP-6	WAP-7	WAP-8	WAP-9	WAP-10	WAP-11	WAP-12
Control	2.0±0.0^{a}	3.0±0.0^{a}	4.11±1.41^{a}	6.03±1.41^{a}	7.0±1.41^{a}	8.0±0.00^{a}	10.0±1.14^{a}	11.0±1.41^{a}	12.0±1.41^{a}	13.0±0.00^{a}	13.0±1.41^{a}	14.0±1.41^{a}
10mL	1.0±0.0^{b}	3.0±0.0^{a}	3.0±0.00^{b}	5.0±0.00^{b}	6.0±1.41^{b}	7.0±0.00^{b}	8.0±1.41^{b}	9.0±1.41^{b}	11.0±0.00^{b}	12.0±1.41^{b}	13.0±1.41^{a}	14.0±0.00^{a}
20mL	1.0±0.0^{c}	2.0±0.0^{b}	3.0±1.41^{b}	4.0±1.41^{c}	5.0±0.00^{c}	6.0±1.41^{c}	7.0±1.41^{c}	8.0±1.41^{c}	9.0±1.41^{d}	9.0±0.00^{c}	10.0±0.00^{b}	11.0±0.00^{c}
30mL	0.±0.0^{d}	1.0±0.0^{c}	2.0±1.41^{c}	2.0±1.41^{d}	3.0±0.00^{d}	4.0±1.41^{d}	4.0±1.41^{d}	5.0±1.41^{d}	5.0±1.41^{c}	7.0±0.00^{d}	8.0±0.00^{c}	9.0±0.00^{d}

Mean followed by same the same letter (s) within the same column are not significantly different at P<0.005

Key: mL=Millimeter, WAP=Week after planting, TRT=Treatment

Table 3. The effect of spent engine oil on the leaf length (cm) of millet *Pennisetum glaucum* (super Sosat)

TRT	WAP-1	WAP-2	WAP-3	WAP-4	WAP-5	WAP-6	WAP-7	WAP-8	WAP-9	WAP-10	WAP-11	WAP-12
Control	0.3±0.02a	0.9±0.14a	5.9±0.14a	7.9±0.49a	20.0±1.41a	31.5±0.91a	40.8±0.28a	44.0±1.41a	50.4±0.14a	55.2±3.46a	61.6±0.91a	65.3±1.76a
10mL	0.3±0.05a	0.8±0.14a	4.1±0.14a	6.9±0.28a	24.8±1.76a	28.0±0.99a	30.0±1.41b	32.8±1.13b	48.9±1.27b	50.4±1.06a	54.0±1.414a	56.8±1.76b
20mL	0.3±0.03a	0.8±0.07a	4.9±0.42a	5.0±1.41a	20.5±0.71a	25±8.83a	28.9±2.12c	30.5±0.70c	40.3±0.56c	41.6±1.90b	41.5±0.33b	42.8±0.778c
30mL	0.1±0.07a	0.7±0.14b	2.6±0.56a	5.0±1.34b	10.8±0.35b	15.2±0.28c	20.8±1.06d	20.3±1.76d	26.0±0.63d	21.2±0.99c	21.9±0.49c	23.7±0.354d

Means followed by the same letter (s) within the same column are not significantly different at P<0.05 Key: mL = Milliliter; WAP = Week After Planting; TRT = Treatment

Table 4. The effect of spent engine oil on the Stem width (cm) of millet *Pennisetum glaucum* (super Sosat)

TRT	WAP-1	WAP-2	WAP-3	WAP-4	WAP-5	WAP-6	WAP-7	WAP-8	WAP-9	WAP-10	WAP-11	WAP-12
Control	0.45±0.14^{a}	0.65±0.07^{a}	4.05±1.34^{a}	5.15±0.21^{a}	5.65±0.07^{a}	6.35±0.07^{a}	6.90±0.07^{a}	7.00±0.14^{a}	7.21±2.69^{a}	7.31±0.35^{a}	7.51±0.42^{a}	8.95±0.14^{a}
10mL	0.35±0.07^{b}	0.60±0.07^{a}	3.55±0.63^{b}	4.6±0.57^{a}	4.80±0.14^{b}	5.25±0.21^{b}	5.70±0.49^{b}	6.50±0.78^{b}	7.00±1.13^{a}	7.11±0.28^{a}	7.33±0.42^{a}	8.50±0.28^{a}
20mL	0.2±0.00^{c}	0.65±0.07^{b}	2.0±0.00^{c}	3.55±0.78^{b}	3.70±0.07^{c}	3.90±0.07^{c}	4.00±0.42^{c}	4.51±1.41^{c}	4.61±0.71^{b}	4.61±0.28^{b}	4.71±63^{b}	5.25±0.35^{b}
30mL	0.10±0.07^{c}	0.150±0.07^{b}	0.20±0.71^{d}	0.65±0.92^{b}	0.90±0.21^{d}	1.10±0.21^{d}	2.10±0.14^{d}	2.90±0.49^{d}	3.60±0.57^{c}	4.01±0.21^{b}	4.21±0.35^{b}	5.15±0.07^{b}

Means followed by the same letter (s) within the same column are not significantly different at P<0.05; Key: mL = Milliliter; WAP = Week After Planting; TRT = Treatment.

Table 5. The effect of spent engine oil on Plant Height (cm) of millet *Pennisetum glaucum* (super Sosat)

TRT	WAP-1	WAP-2	WAP-3	WAP-4	WAP-5	WAP-6	WAP-7	WAP-8	WAP-9	WAP-10	WAP-11	WAP-12
Control	5.0±0.00^{a}	14.5±0.71^{a}	19.7±0.42^{a}	25.5±3.54^{a}	44.0±1.41^{a}	54.5±1.27^{a}	65.35±0.92^{a}	78.5±3.53^{a}	88±1.41^{a}	95±7.071^{a}	110.5±4.95^{a}	130.51±2.12^{a}
10 mL	4.8±0.28^{b}	12.0±1.41^{b}	17.0±0.28^{b}	25.5±0.71^{a}	43.0±0.00^{a}	53.9±0.28^{a}	65.05±1.20^{a}	77.8±3.96^{a}	88.5±3.54^{a}	95.5±2.12^{a}	109.5±5.66^{a}	129.52±2.48^{a}
20 mL	3.4±0.07^{c}	10.1±0.35^{c}	14.8±0.42^{c}	22.5±0.71^{b}	30.6±0.57^{b}	50.2±2.54^{b}	55.9±0.56^{b}	63.85±0.49^{b}	69.0±1.41^{b}	69.95±1.49^{b}	75.8±3.96^{b}	80.52±2.12^{b}
30 mL	2.9±0.14^{d}	9.5±0.71d	10.5±0.71^{d}	18.5±2.12^{c}	24.0±1.41^{c}	30.65±0.49^{c}	40.65±0.35^{c}	51.45±0..77^{c}	56.5±2.12^{c}	68.5±0.78^{b}	74.5±0.42^{b}	80.01±2.84^{b}

Means followed by the same letter (s) within the same column are not significantly different at P<0.05Key: mL = Milliliter; WAP = Week After Planting; TRT = Treatment.

Table 6. Fruit Weight (g) of *Pennisetum glaucum* (Var.Super Sosat)

Treatment	Replicate 1(g)	Replicate 2 (g)	Replicate 3(g)	Replicate 4(g)
Control	145.45±1.17[a]	145.95±0.78[q]	146.35±1.48[a]	145.05±2.19[a]
10mL	145.15±2.00[a]	144.95±2.60[a]	145.05±1.03[b]	145.15±3.61[a]
20mL	130.75±1.45[b]	131.80±1.90[b]	131.55±1.08[c]	130.65±3.93[b]
30mL	105.20±2.47[c]	105.00±1.52[c]	104.50±2.45[d]	105.50±2.51[c]

Means followed by the same letter (s) within the same column are not significantly different at P<0.05
Key: mL = Milliliter

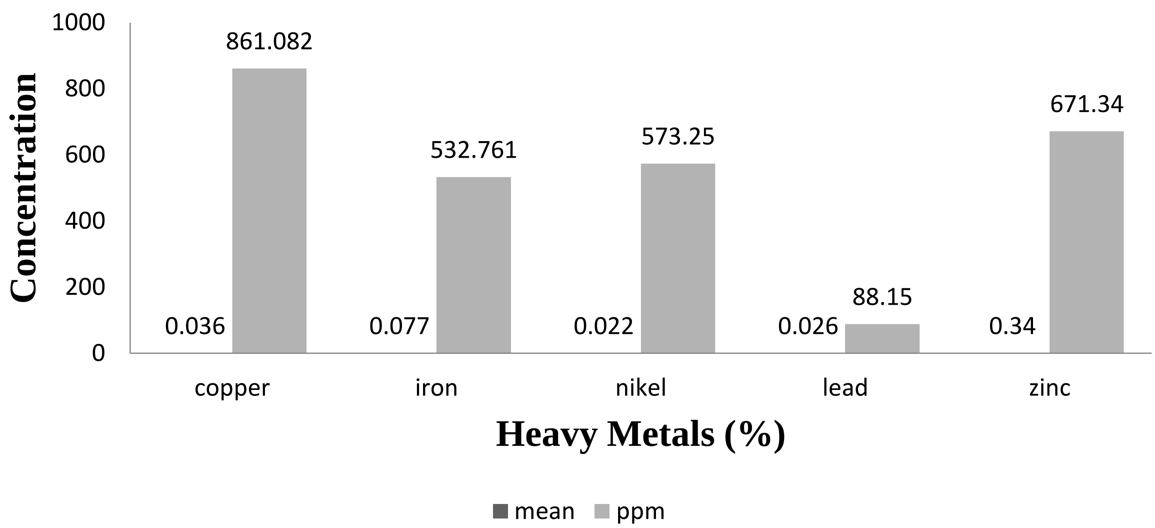

Figure 1. Percentage concentration of heavy metals in *Pennisetum glaucum* (var.Super Sosat

DISCUSSION

The result has shown that spent engine oil has a negative impact on the production of *Pennisetum glaucum*. Percentage seed germination was observed to be slow for pots containing 20mL and 30mL of applied spent engine oil with only 45 and 25 percent seed germination recorded in comparison to the control and 10mL pots that had 100% seed germination, this is similar with the report of Joshua *et al.* (2016). The leaf numbers decreased as concentration of spent oil increased with control and 10mL spent oil pot having the highest number of leaves (Table 2); that is significantly different from 20mL and 30mL with the lowest leaf numbers at 12 weeks after planting. This finding is in agreement with Odjegba and Atebe (2007) who reported that toxicity stress has effect on the leaves of plants and reduce their photosynthetic activities and fruit yield. The leaf length average of *Pennisetum glaucum* was significantly high for control (65.25cm) and decreased with increasing spent oil presence with 10mL, 20mL and 30mL having average length of 56.75cm, 42.75cm and 23.65cm respectively, this finding is in agreement with Joshua *et al.* (2016) who assayed decline in leaf length of crops as stress factor increases. The stem width was not significantly different between the control and 10ml pots (8.95±0.14 and 8.50±0.28 respectively) in contrast to 20mL and 30mL that were not significantly different but less in width comparison to control. This finding is in agreement with the report of Agbogidi *et al.* (2007). The average plant height of *P. glaucum* at maturity (12WAP) was high in the control and 10mL spent oil concentration (130.51±2.12 and 129.52±2.48) compared to 20mL and 30mL which is lesser (80.52±2.12 and 80.01±±2.84). This finding agrees with Agbogidi *et al.* (2007) who stated that poor performance of the plants exposed to spent oil at the seedling stage of growth (Table 5) indicates that the plant has less resistant to pollution by spent oil at tender age and slows down its overall development. The fruit weight was higher for control and 10ml and significantly different from 20mL and 30mL due to increased concentration of spent oil. The concentration of heavy metals (Cu, Fe, Ni, Pb, and Zn) analyzed reveals that copper (Cu) was the highest and lead (Pb) was the least (Figure 1), this high concentrations of toxic heavy metals and polycyclic aromatic hydrocarbon has been reported to be present in spent oil is responsible for obstructing efficient growth observed in this study. High level of Pb and Cu affects the chlorophyll content of the plant and could lead to the interference of the oil on the ability of the plant to absorb mineral nutrients like magnesium, iron, boron, and manganese essential for chlorophyll synthesis (Kent, 2000). Such interferences slows down photosynthetic activity accompanied by reduction of chlorophyll, stunted growth and eventual plant death. The reduced leaf length, width and height of the plants due to the spent oil can aggravate the photosynthesis level in the plant with resultant poor output of the plant. All these can lead to poor yield of the plant and food shortage. This suggest that the level of pollution (above 10mL) from spent oil has adverse effect on the morphological characters *P. glaucum* and on the survival of plants to oil pollution, which agrees with Agbogidi *et al*. (2007).

CONCLUSION

The results of this study have shown that spent engine oil has negative effects on the morphological features and grain yield of *Pennisetum glaucum* (var. super sosat). This is attributed to the distortion of growth parameters such as germination, leave length, leaf number, stem width and plant heights which are necessary for optimal performance of the crop exposed to spent engine oil compared to the yield recorded in the control sample.

Funding: This research received no external funding

Conflicts of Interest: The authors declare there is no conflict of interest

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