Original Research Article

Effects of Tin mine Tailings on the Growth and Development of Common Bean (*Phaseolus vulgaris* L.) in the Jos, Nigeria

ABSTRACT

Aims: To study the effects of mine tailings on the growth and yield of two genotypes of common bean (*Phaseolus vulgaris* L.)

Study design: The experiment was laid in a Randomized Complete Block Design (RCBD) with four treatments, two blocks and each block was replicated three times.

Place and Duration of Study: University of Jos botanical garden Jos, Plateau State, Nigeria during the rainy season in a field experiment in 2014.

Methodology: The mine tailings combinations include four different additions mine tailings soil {(T_0) 0 kg as control, (T_1) 2 kg, (T_2) 3 kg, (T_3) 4 kg} and the respective mine tailings soils were added to 6.3 kg of normal soil. Two common bean accessions were used (Cranberry-G1 and Pinto-G2), which gave the total of eight treatment combinations (T_0G_1, T_0G_2, T_1G_1, T_1G_2, T_2G_1, T_2G_2, T_3G_1, T_3G_2).

Results: The control recorded significant higher mean plant height (cm), number of leaves and number of trifoliate leaves, number of pods and number of seeds per pod in both genotypes for all the different weeks after planting (WAP). A significant decrease in plant height, number of trifoliate leaves, number of leaves per plant, number of pods and number of seeds per pod in both genotypes were observed with increased levels of mine tailings. There was a significant increase in time to 50 % flowering and 50% pod production (*P = 0.01*) over the control which increased with increasing levels of mine tailings. The genotypes exhibited no significant difference (*P = 0.05*) for most traits accessed, except for number of pod per plant. It is evident from the findings that Cranberry is more tolerant to heavy metals contamination in soil, perhaps may be more suitable for planting in such mining soils.

Conclusion: The study showed that inclusion of mine tailings had detrimental effect on both the growth and yield of common bean.

Keywords: Tin-mine spoils, Plant growth, Phaseolus Vulgaris L., genotypes.

1. INTRODUCTION

Alexander [1] reported that about 4 % of the total land (325 km^2) in the Jos plateau (8600 km^2) has been degraded by the Open cast method of mining resulting in the deposition of large volumes of tailings on the soil among other things. Mining activities are well known for their deleterious effects on the environment, due to the deposition of large volumes of tailings on the soil [2, 3]. Mining activities particularly the old method of mining exposes the top soil to heavy metals, which are

often washed into farming areas and causes environmental degradation, such as destruction of landscapes, soil degradation, thereby tampering with plant growth [4].

Adepetu [5] earlier on reported that competitive land use in the Jos Plateau is putting pressure on the local farmers forcing them to grow crops on these mine spoils. Thus It would also be interesting to study the soil-crop relationship on these soils so as to understand the challenges faced by the local farmer.

Soil characteristics of Tin mine tailings are generally low fertility and unfavourable physical conditions that results in very low productivity because ex-mining land have very low capability to provide plants with necessary nutrients for growth. Attempts to utilize the tailings for agricultural use through experiments and trials have been made by the Tin Mine spoil researchers among others. These included forest tree planting, growing of agricultural crops and improvement of the soil by several methods to elevate the fertility status and create a more favourable condition for plant growth [6].

Whereas, heavy metals such as Copper (Cu) and Zinc (Zn) are essential for normal plant growth and development, elevated concentrations of both essential and non-essential heavy metals in the soil can lead to toxicity symptoms and growth inhibition in most plants [7]. Excessive concentration of heavy metals in plants can cause oxidative stress and stomatal resistance [8,9], thereby affecting the normal physiological processes in plants. It can also affect photosynthesis and chlorophyll florescence processes [10]. Copper can inhibit photosynthesis and reproductive processes; lead reduces chlorophyll production, arsenic interferes with metabolic processes, while zinc and tin stimulate the growth of leaves and shoots; ultimately plant growth becomes limited or impossible [11,12,13]. Studies on the performance of cultivated plants around the mining areas in Jos will be of importance, especially for common bean *Phaseolus vulgaris* since it is widely cultivated around the mining areas in Jos. Therefore, the objective of the study was to determine the effect of different levels of mine tailings on the growth and development of the common bean *(Phaseolus vulgaris* L.).

2. MATERIALS AND METHODS

The research was carried out at the Botanical Garden of Department of Plant Science and Biotechnology, University of Jos, Nigeria during the rainy season of 2014. For the present study two *Phaseolus* cultivars viz., Cranberry and Pinto were procured from Angwang Rukubu market in Jos.

The experimental design employed was a randomized complete block design (CRBD). The treatments include four different additions of mine tailings soil {(T_0) 0 kg as control, (T_1) 2 kg, (T_2) 3 kg, (T_3) 4 kg} to 6.3 kg of normal soil. Two common bean accessions (Cranberry-G1 and Pinto-G2) were planted, which gave the total of eight treatment combinations (T_0G_1, T_0G_2, T_1G_1, T_1G_2, T_2G_1, T_2G_2, T_3G_1, T_3G_2) and each treatment combinations were replicated thrice on each row in each block. The plot was designed to have 8 blocks, each block having 3 rows for the 3 replicates of seed (*Phaseolus vulgaris* L.). The plot was measured to be 5.0 m × 5.0 m. Each block was measured to be 2.50 m × 2.50 m with rows of 2.0 m long.

Three seeds of common bean genotypes were sown into polythene bag containing the amended soils at a depth of 2-5 cm and later thinned to two per pot at 2 weeks after planting. A viability test was carried out before planting by exposing 20 soaked seeds of the genotypes to light and the date of germination and the percentage viability was recorded.

The mine tailings soil was collected from the mine site situated along the Golf Course Rayfield in Jos, and analyzed at Federal College of Land Resources, Kuru, Jos, Plateau State Nigeria to determine the soil mineral contents and pH.

Plant characters which include plant height (cm), number of leaves, number of trifoliate leaves, days to 50 % flower, days to 50 % pod production, number of pod per plant and number of seeds per pod were determined at 4, 6, and 8 weeks after planting (WAP). The data collected were subjected to analysis of variance (ANOVA) using SPSS (version 21) and the means were separated using least significant difference (LSD).

3. RESULTS AND DISCUSSION

RESULTS

The effect of genotype on plant height, number of leaves, number of trifoliate and under different levels of mine tailings at different weeks of growth after planting is shown in Table 1. Generally, Cranberry recorded higher plant height, number of trifoliate leaves and number of leaves compared to Pinto, even though the difference was not significant ($P \geq 0.05$).

With regards to the effect of Mine tailings on growth characters, the control recorded significantly higher mean plant height (cm), number of leaves and number of trifoliate leaves for all the different WAP. A significant decrease in plant height,

number of trifoliate leaves, number of leaves was observed with increase in levels of mine tailings (Figure 1, 2 and 3). A notable observation was that at 4 WAP, the 2 kg mine tailings produced a significantly higher plant height and number of trifoliate leaves compared to the control (*P* = *.001*). A significant (*P* = *.05*) interaction was also recorded between the genotypes and mine tailings levels with respect to plant height at WAP (Table 1).

Table 1: Effect of genotypes and mine tailings on plant height, number of leaves and number of trifoliate leaf of Common bean (*Phaseolus vulgaris*) at different WAP.

Character	Genotype	Weeks after plant (WAP)		
		4 WAP	6 WAP	8 WAS
Plant height (cm)	Cranberry(G_1)	16.1[a]	25.1[a]	42.9[a]
	Pinto(G_2)	15.7[a]	23.6[a]	41.8[a]
	$L.S.D_{0.05}$	0.9	4.1	2.5
Number of leaves	Cranberry (G_1)	25.2[a]	34.8[a]	40.8[a]
	Pinto (G_2)	23.4[a]	32.5[a]	38.1[a]
	$L.S.D_{0.05}$	2.2	3.1	5.6
Number of trifoliate leaf	Cran berry(G1)	7.1[a]	15.9[a]	27.3[a]
	Pinto(G2)	7.4[a]	14.0[a]	26.0[a]
	L.S.D (0.05)	1.6	3.1	1.4

WAP = Weeks After Planting, G = Genotype, Means followed by the same letter within the same column and character are not significantly different at 5% level of probability.

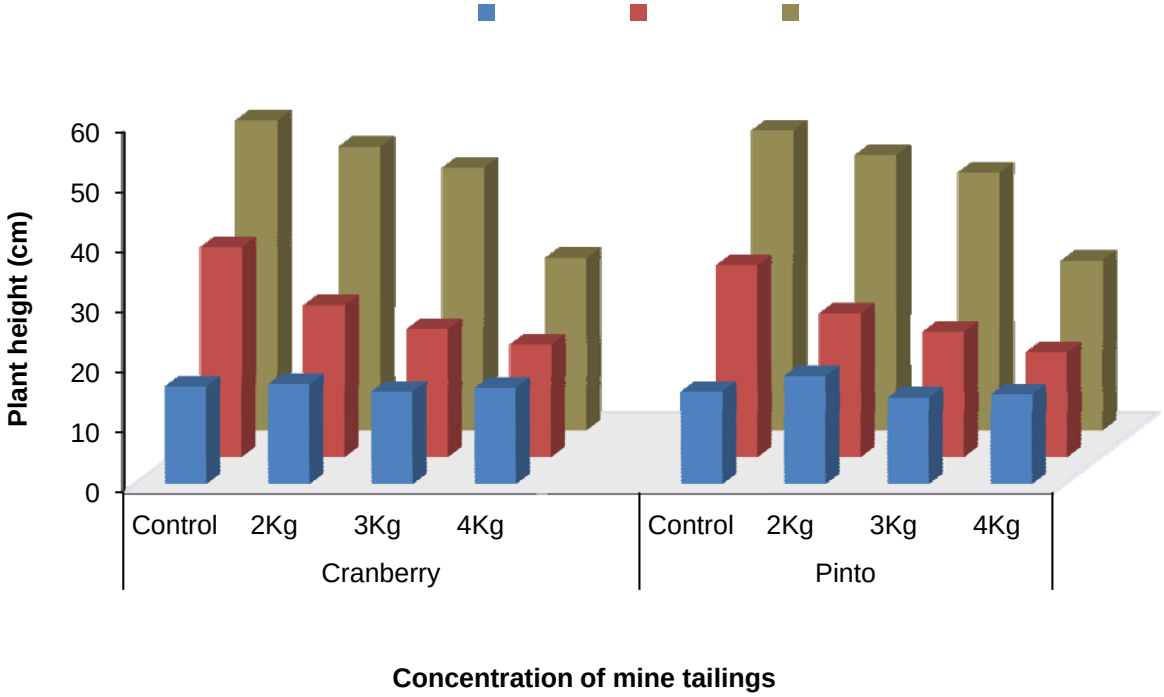

Figure 1. Changes in the plant height of *P. vulgaris* grown under different concentrations of mine tailings at 4, 6, and 8 weeks after planting (WAP).

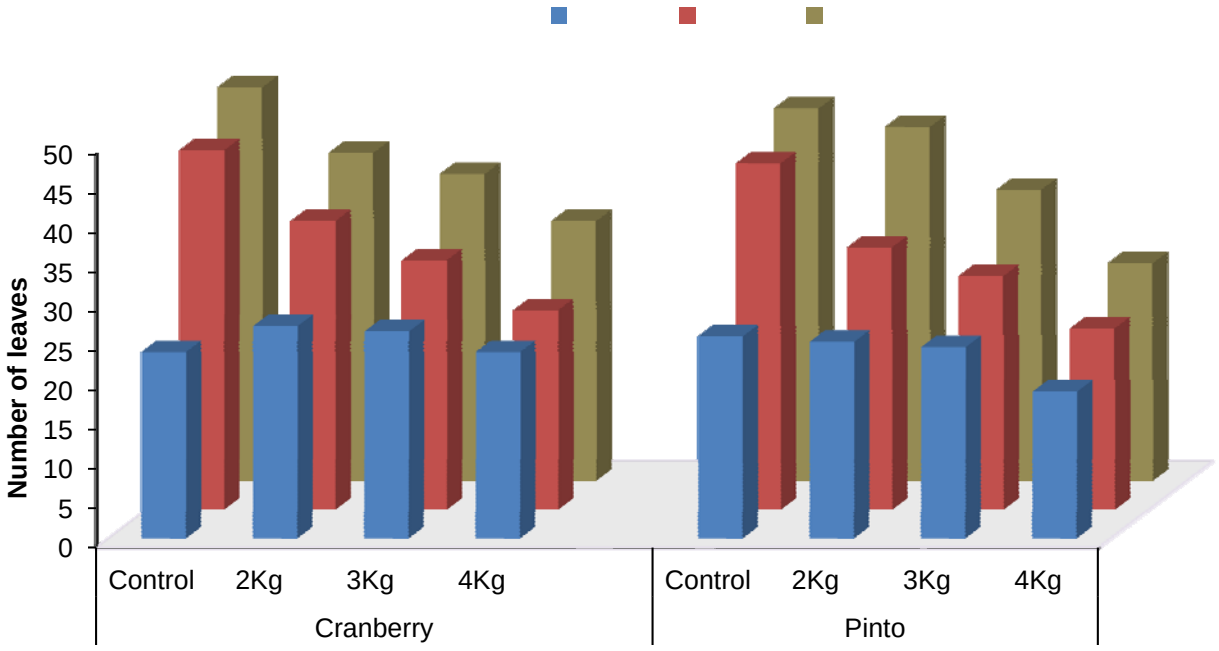

Figure 2. Changes in the number of leaves of *P. vulgaris* grown under different concentrations ofMine Tailings at 4, 6, and 8 weeks after planting (WAP)

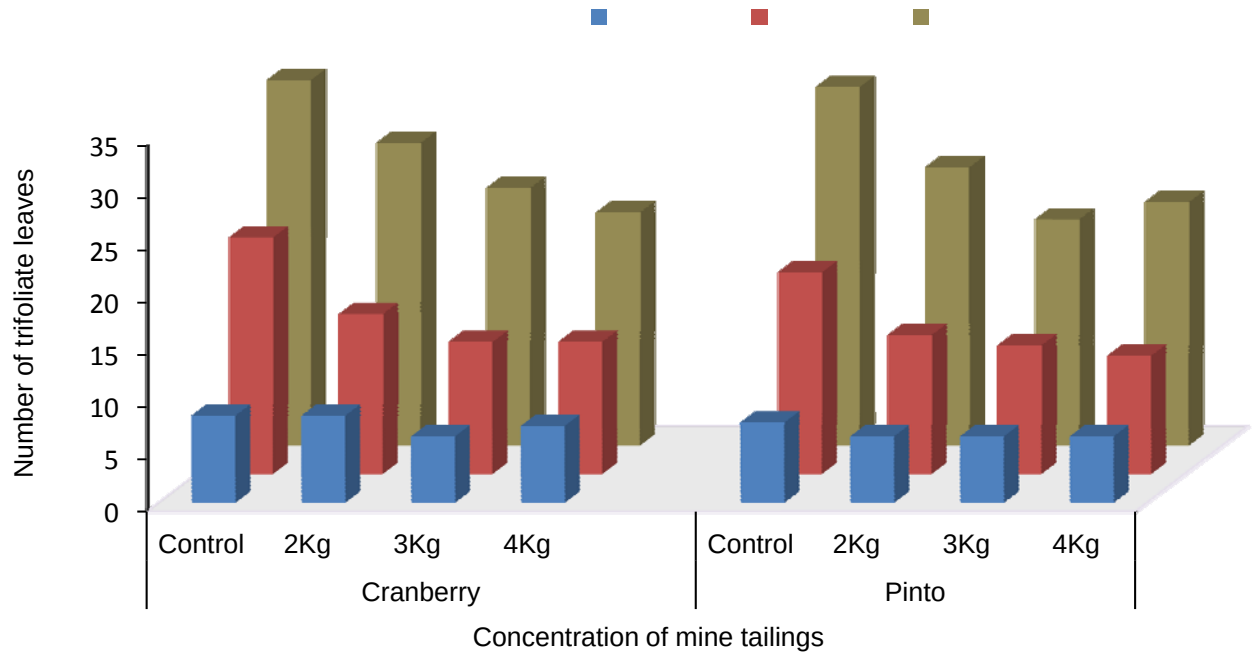

Figure 3. Changes in the number of trifoliate leaves of *P. vulgaris* grown under different concentrations of Mine Tailings at 4, 6, and 8 weeks after planting (WAP)

The effect of genotypes on yield characters (Table 2) showed that although Pinto took longer days to 50% flower and for 50% pod production compared to cranberry even, the difference was not statistically significant (*P = .05*). On the other hand Cranberry recorded higher number of pod and seeds per pod than Pinto, but the variation was only significant for number of pods per plant.

Table 2. Effect of genotypes and mine tailings levels on yield characters of Common bean (*Phaseolus vulgaris)* at harvest.

Treatments	Days to 50 % Flowering	Days to 50 % Pod Production	Number of pod/plant	Number of seed/pod
Genotypes				
Cranberry(G_1)	48.8^a	63.6^a	9.3^a	8.4^a
Pinto(G_2)	49.8^a	64.3^a	6.9^b	8.1^a
L.S.D$_{0.05}$	1.5	1.4	2.3	2.3
Mine Tailings				
Control (T_0)	42.5^d	56.5^d	12.3^a	9.7^a
2Kg mine tailings (T_1)	47.3^c	62.0^c	8.8^b	8.8^a
3kg mine tailings (T_2)	52.5^b	66.3^b	8.5^b	8.5^a
4kg mine tailings (T_3)	54.8^a	70.8^a	6.1^c	6.2^b
L.S.D$_{0.05}$	1.5	1.4	2.3	2.3

Means followed by the same letter within the same column and treatment are not significantly different at 5% level of probability

There was a significant increase in days to 50 % flower and 50 % pod production (*P = .01*) under increasing concentration of mine tailings. It was also observed that variations in the two characters across the two genotypes were more pronounced at higher levels of mine tailings and tend to decrease with decreased in levels of mine tailings (Figure 4).

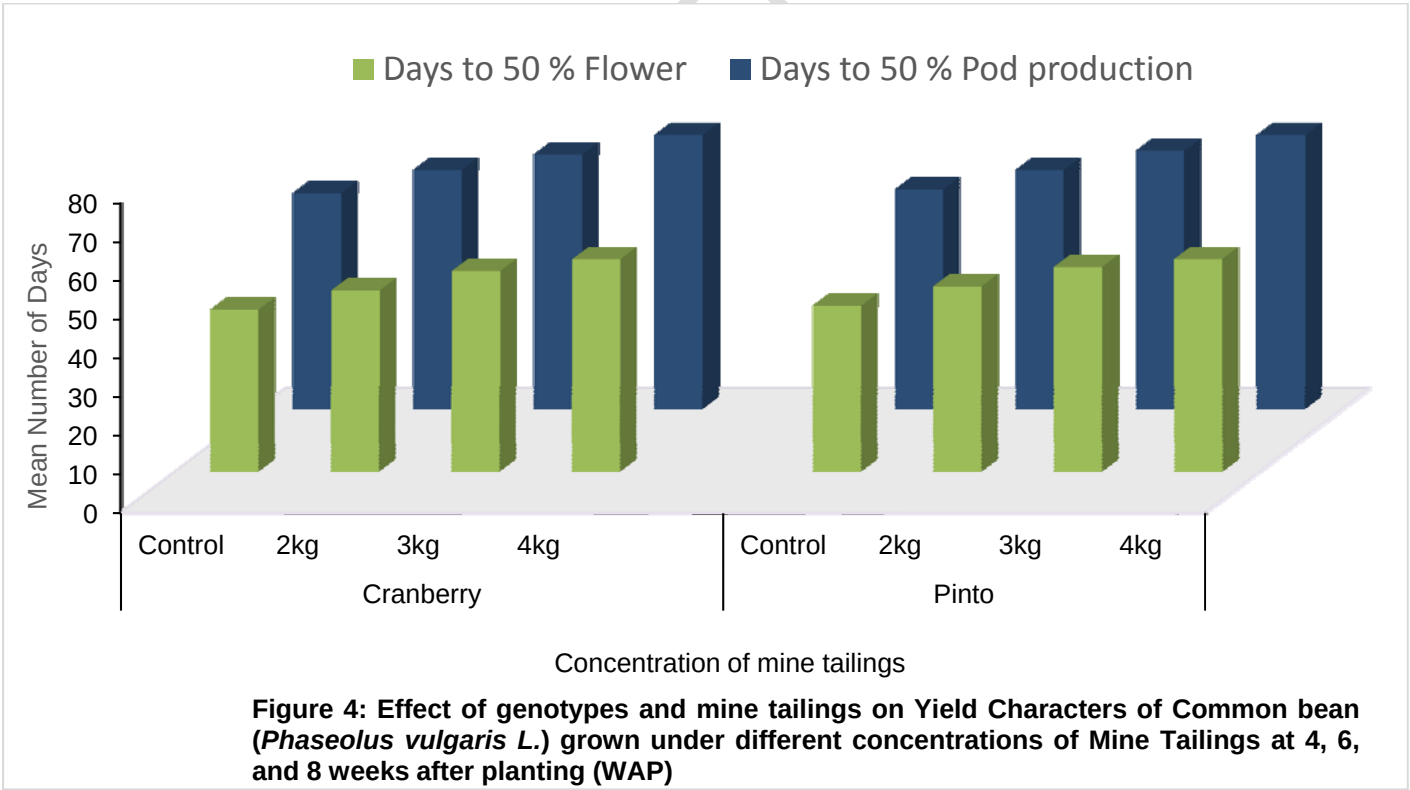

Figure 4: Effect of genotypes and mine tailings on Yield Characters of Common bean (*Phaseolus vulgaris L.*) grown under different concentrations of Mine Tailings at 4, 6, and 8 weeks after planting (WAP)

Along with the delay in flower and pod production time, significant decrease was recorded for number of pods and number of seeds per pod in both genotypes with increased levels of mine tailings (Figure 5).

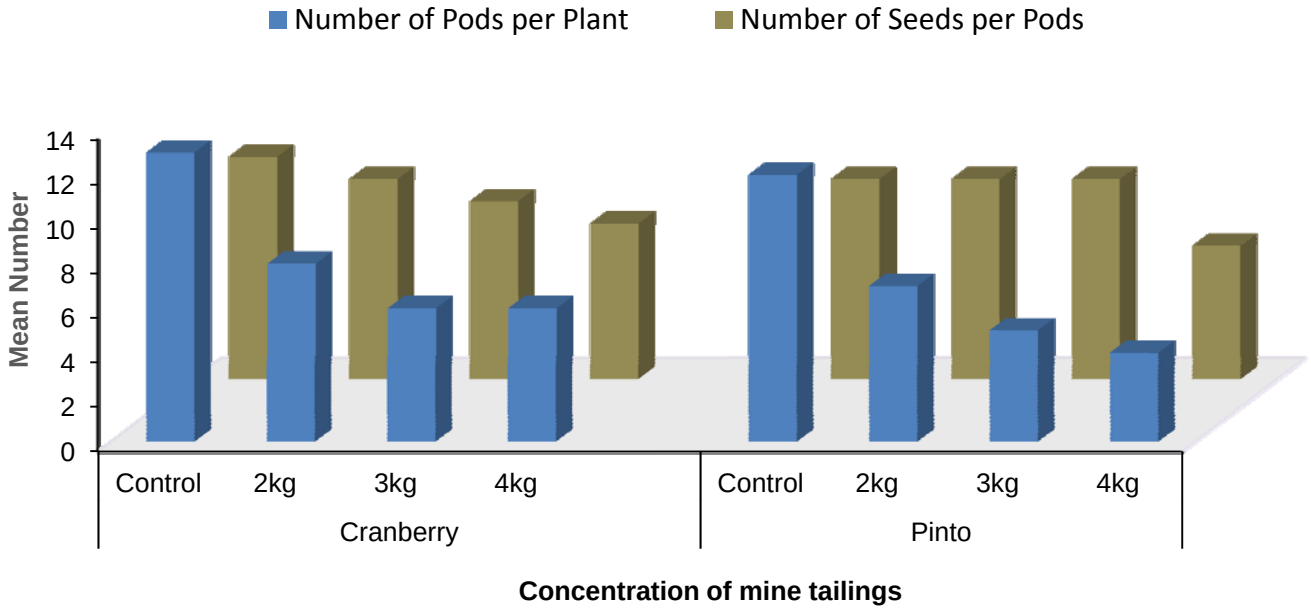

Figure 5: Effect of Mine tailings on Yield Characters of Common bean (*Phaseolus vulgaris*)grown under different concentrations of Mine Tailings at 4, 6, and 8 weeks after planting (WAP).

4. DISCUSSION

In the present study, exposure to mine tailings affected different parameters in common beans. The results revealed that growth parameters such as plant height, number of trifoliate leaves, number of leaves, decreased drastically with increase in levels of mine tailings compared to the control.

The result further revealed that higher concentrations of mine tailings leads to delay in flowering, delay in pod production, and decrease in number of pods per plant and number of seeds per pod. These indicate that the yield of common bean is affected by increase in the concentration of mine tailings. This result is in agreement with the earlier report of Gardea-Torresdey *et al.* [10] who observed that heavy metals at high concentrations when taken in by plant can inhibit photosynthesis and reproductive processes there by affecting their final yield.

The high significant difference observed between the levels of mine tailings in respect to most of the characters assessed indicates that mine tailings have great effects on the growth and productivity of common bean. Earlier researchers [7,14] have reported that elevated concentrations of both essential and nonessential metals in the soil can lead to toxicity symptoms and growth inhibition in most plants. Atafar *et al*. [14] carried out a research on soybean, and reported that high concentration of lead affect its early growth. They also reported that arsenic (As) has adverse effects on plant growth.

4. CONCLUSION

The present result showed that mine tailings has effect on the growth and productivity of the common bean. This Study shows that mining tailings at high concentration have direct effects on the growth and yield of common beans. Although, the study showed that the Cranberry (G1) tolerated high levels of mine tailings than Pinto (G2), growing plants in metal-polluted sites should be discourage, as it can lead to high accumulation of some metals that will be detrimental to the health of the consumers.

COMPETING INTERESTS

None

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