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Effect of vermicompost on growth of crysophogan zizanioides on manganese mine dump of Central India

The utilization of crysophogan zizanioides in the management of mine-site dumps opens a new doorway for carbon sequestration and mitigation of soil erosion. Crysophogan zizanioides, a.k.a vetiver grass, is a densely tufted grass from Poaceae family of giant grasses. These grasses are known for its tolerance to extremely high levels of heavy metals and can grow in tropical and temperate regions around the world. Hence, the present study attempts to utilize the barren manganese dumps around the Dongri Buzurg mine area in central India as a carbon sink patch by vegetating vetiver grass. It was found that the nutrient content of the hangwall and footwall of the existing dump was lacking in N (29.33kg/acre) and P (58.73 kg/acre) for sustaining the potential growth of plant species, also the organic carbon content was found to be around 0.10% which should ideally be around 1.12%. As the dump requires longer roots compared to its shoots, for providing stability and control of soil erosion, the study focuses on this aspect of vetiver growth. It was observed that as the percentage vermicompost increases than shoot/root (S/R) ratio decreases. The study on the control sample indicated a ratio of 3.33 over a period of 60 days indicating poor root growth without any vermicompost supplement on the other hand a 50% vermicompost sample indicated a ratio of 1.24 over the same period of time. This study developed an empirical formula using statistical analysis tools to determine the optimum S/R ratio at different per cent vermicompost.

Keywords: Manganese waste dump, vetiver grass, vermicompost, low-cost soil improvement techniques

1.0 Introduction

Climate change is a serious threat looming large over the humanity which is undeniably a man-made disaster. The Paris agreement of 2015 has emphasized on maintaining the temperature below 2°C of pre-industrial era. The aim could not be achieved without carbon capture or sequestration as carbon dioxide which is the main constituent of global warming is increasing at an alarming rate. Research related to carbon sequestration has got major boost in the European Union with different technologies being developed that directly capture atmospheric carbon dioxide. While in India, low-cost techniques like nature-based solutions are more appropriate as the financial constraint is one of the major hurdles. Use of vetiver grass technology is one such nature-based solution that can be applied for carbon sequestration. Conversion of fallow land to perennial vegetation like grasses can contribute majorly for carbon sequestration and in turn play their role in conserving the balance of carbon dioxide in nature (Powlson et al., 2011). Vetivers have proved themselves to be more c-sequestrating than members of their own family species (Singh munnu et al., 2014). There is also scope for economic utilization of vetiver along with its eminent environmental benefits mainly using the vetiver aromatic oil due to its medicinal value (Prakasa Rao et al., 2008, Sujatha S et al., 2011, Yaseen mohod et al., 2014). Apart from the economic benefits, vetivers are also crucial for restoration of soil quality that had been damaged due to introduction of heavy metals (Das Padmini et al., 2010, Singh et al., 2015, Dousset Slyve et al., 2016)

Vetiver grasses can grow on marginal soils, saline soil as well as sandy soil, waterlogged and sloping geographic landscape (R.K. Lal.,2012). Acknowledging these properties of the vetiver, the overburden dump of Dongri Buzurg mine in Central India can be used for the plantation of vetivers. The mine is located at an area of low rainfall and has not been very fertile for tree species. Taking these factors under consideration, crysophogan zizanioides can prove to be an effective tool for carbon sequestration under the prevailing conditions. Chrysophogan zizanoides like all other species of vetiver grass; are tropical plant native to India and has high adaptability to difficult environmental conditions. The grass has a potential to grow up to a height of 1.5 to 2m and root length up to 3 to 4m (Niknahad et al., 2014). Researchers have found vetiver grasses to be fast growing, low-cost, highly resistant to drastic climatic changes, fire and pests, and tolerant to different types of soil, pH ranges and high concentrations of pollutants. In this

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particular study, the soil of manganese dump where the experiment is supposed to be conducted is high on silica content due to presence of mica schist and does not support growth of vegetation. Moreover, the erosion of slopes due to runoff can be prevented by vegetating it with vetiver grass (Rahardjob H et al.,2014). Considering the nature of the soil under this study; vermicompost was found to be a suitable supplement which was available in the local vicinity and was therefore used in this study.

Vermicompost is a well-known additive for improvement of physical, chemical and biological properties soil. The whole process of vermicomposting is an environment friendly process to decompose organic waste. Researchers have found adequate growth of vegetation even in unfavourable conditions (K. A. Gopinath et al., 2010, Afroja Nasrin et al., 2019, Manuel Blouin., et al 2019) .Vermicompost is effective in enhancing the root formation, elongation of stem and production of biomass in plants. Due to its organic nature, vermicompost has higher amount nitrogen levels ranging from 3% to 4% of total mass and phosphorous of about 2.25% to 4.5%, potassium concentration ranging from 1.85-2.25%, which is beneficial for soil microbes like 'nitrogen fixing bacteria' and mycorrhizal fungi essential for growth of plants. Vermicompost is scientifically proven as one of the most effective soil ameliorators available at reasonable cost for enhancing plant growth microbial population required for N_2-fxing bacteria increases by application of vermicompost. The increased activities by the bacteria improve the availability of soil phosphorous and nitrogen.

The main focus of this study is on the S/R length ratio, as this ratio would help to demonstrate the growth in initial phases of the vetiver growth. This ratio is particularly important for sandy soil for its stability (Mohammad S. Islam et al., 2016). To study this, control pot experiments have been carried out and for a period of two months, the shoot length and root length was recorded. Using statistical tools like SPSS, an empirical relation is developed in order to find the relationship between increasing vermicompost percentage and S/R ratio. Previous studies indicated linear responses between productivity and use of various fertilizers, but as our main area of interest are overburden dumps, root length inevitably becomes the main focus of our study. The study is basically an indication of feasibility of vetiver growth if applied on the mine site. As on the mine site, regular reapplication of vermicompost and careful crafting of conditions are a difficult part, therefore this pot experiment is conducted for a period of 60 d in order to check the impact of vermicompost on the vetiver root growth in the initial harsh conditions of the mine and also establishing the correct amount of vermicompost for generating near unity S/R ratio.

2.0 Material and methods

The pot experiments were conducted with the dump soil from mines and vermicompost from Cow Research Institute (CRI). The whole experiment began on the 1st of April, 2021 and it ended on 1st of June, 2021. Vetivers are found to be tolerant for a wide range of temperature variations ranging from 15°C to 45°C, though optimal soil temperature determined through various experiments for root growth is 25°C (Seshu lavania, 2019). The soil temperature was at an average of 22.5°C during the pot study, with a minimum of 5°C and going up by a max of 32.6°C. The experiment was conducted maintaining strict routine of shading and sunlight conditioning. Watering was done at an interval of 12 hr, applied in volumetric measurement of 500 cm^3 to each of the pot. The vermicompost that was applied was obtained from CRI, an independent research organization which applied the cow products in use for agriculture.

2.1 Design of experiments

The pot experiments that started on 1st of April 2021 which includes 5 control experiment in the pot along with 30 pots of different vermicompost mixture proportion with the dump soil. The proportion is mixed in volume in order to replicate the same condition if applied practically on the field. The proportions are made in additive volume ratios in contrast to substitutive volume replacement method. The proportional mixing is described in Table 1.

The experiments were conducted for pots with 10%, 20%, 30%, 40%, 50% vermicompost as an additive volume with respect to dump soil sample. These experiments were planned and conducted as per Table 2.

2.1.1 Parameters of the experiment

There were 3 main components in the pot experiment, which are mentioned below.

1. Soil sample collected from dump of Dongri Buzurg manganese mine at 15 cm and 30 cm depth.

Table 1: Sample volume proportion mixing

Pot No.	Dump Soil (in cm^3)	Vermicompost (in cm^3)
Control sample	4000	0
1	4000	400
2	4000	800
3	4000	1200
4	4000	1600
5	4000	2000

Table 2: Experimentation chart

Pot no.	Vermicompost in %	Days	Root length	Shoot length	Shoot/ root ratio
0	0	10,20,30,40,50,60	XX	XX	XX
1	10	10,20,30,40,50,60	XX	XX	XX
2	20	10,20,30,40,50,60	XX	XX	XX
3	30	10,20,30,40,50,60	XX	XX	XX
4	40	10,20,30,40,50,60	XX	XX	XX
5	50	10,20,30,40,50,60	XX	XX	XX

2. Vermicompost collected from the local CRI unit

3. The plastic pot. The plastic pots act as a vessel for the experimentation with 4 holes in the bottom with half inch diameter as an outlet for gravitational water. Ambient conditions like soil temperature, water loss per 12 hr, relative humidity in the atmosphere and soil temperature were all averaged over the period of time and tabulated in the Table 3, as a reference condition for the final growth of the vetiver.

2.1.2 Properties of material

Soil sample: Soil samples have been taken from the waste dump of Dongri Buzurg manganese mine. Mine development activities over the years have created dumps and the same are stacked on the earmarked dumping sites within the lease hold area of mines. Presently, Dongri Buzurg mine accommodates a total of five dumps within the lease hold area. The details of which along with their volume is presented in the Table 4 (Moil.nic.in).

Out of the five dumps, one dump is located towards the hangwall side (southern part) of the lease area. This is an old and matured dump and currently no dumping activity is being carried out with a bottom MRL of 340 and top MRL of 405 giving it a height of 65 meters. The dump slope is about 40-45°. The dump mainly comprises both hangwall waste rock/rejects (orthogneiss, felspathoid, quartz, mica schist) and footwall waste rock/rejects (mica schist). Size of waste rock material varies from fine to medium silt to medium to coarse sand, and large boulders. The dump tops are covered by weathered rock derived from underlying metamorphic rock. The soil from this dump is used for our study as can be seen in Figs.1 and 2. The properties of this dump soil is analyzed at laboratory by MOIL and results are tabulated below in Table 5.

The properties of dump soil indicate a sandy, low nitrogen, low organic carbon content soil and low potassium

Table 3: Average condition of during the period of the experiment

Average ambient temperature in degree celsius	Average soil temperature in degree celsius	Water loss in grams for 12 hours	Relative humidity
33.5	22.5	28.76%	53.2%

Table 4: Dump volume in and around mine

Name of dump	Volume in m^3
North dump	32,47,738
South dump	38,21,396
West dump	1,45,42,490
In area of 60.22 Ha (south)	1,05,75,156
In area of 60.22 Ha (north)	42,65,950
Total	3,64,52,730

Fig.1 Right side picture of the north dump from where the soil sample is collected

Table 5: Properties of waste dump soil

	Parameter	Unit	Result	Limit	Method reference
1	Texture	-	Sandy	-	IS 1498
2	Bulk density	gm/cc	1.34	-	IS 2720-part 4
3	Water retention capacity	%	41.22	-	Method of manual
4	Permanent wilting coefficient	%	15	9-21	By calculation
5	Electrical conductivity	mS/cm	0.109	<1	Method of manual
6	Available organic matter	%	0.19	0.71-1.05	IS 2720-part 22
7	Available nitrogen as N	Kg/acre	29.33	114-170	Method of manual
8	Available potassium as KS	Kg/acre	58.63	73-97	Method of manual
9	Available phosphorous as PO_4	Kg/acre	221.99	17-27	Method of manual

Fig.2 Left side picture of the north dump from where the soil is collected

soil. Vermicompost is expected to supplement these deficiencies in the soil. Increasing the soil organic carbon pool to above the critical level to 1.12% from the current 0.12% to restore the original fertility of the soil (Rattan Lal, 2015).

Vermicompost: It is an end-product of the breakdown of organic matter by earthworms, rich in nutrients and is recommended for long term sustainable farming without negatively impacting the land and underground water quality. Vermicompost has higher levels of nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous, soluble potassium and calcium derived from the wastes. Vermicompost stimulates the growth of a wide range of plant species of different horticultural crops due to several direct and indirect beneficial effects (Arancon et al., 2005).

Vermicomposting is an effective biological method and converts eco-friendly organic substances into a powerful fertilizer for sustaining plant growth. Thus, stimulating the microbial activity of soil and increasing the availability of oxygen while at the same time maintaining normal soil temperature.

During this research, majority of the studies that were considered for referencing compared the effect of composts on plant growth generally on vegetative plants (Xio Deng et al., 2017 and Tahir lawan et al., 2018). However, none of them focused on growth of grasses in stated harsh conditions impacted by the application of vermicompost. The composition of the applied vermicompost is tabulated in Table 6.

Experimental pot: To conduct the experiments, a set of 35 pots was taken. The capacity of each is measured as 4000 cm^3. The pot is left unfilled from 3 cm from the top. Pot experiments are considered to be low-cost and easy-to-use technique for studies of soil evaporation and plant transpiration in controlled environments. On similar pattern

TABLE 6: COMPOSITION OF VERMICOMPOST

	Parameter	Unit	Result
1	pH	—	7.83
2	EC	mS/cm	0.96
3	N	%	2.73
4	P	%	0.10
5	K	%	1.12
6	Mg	%	3.68
7	Ca	%	3.13

Fig.3 Size of experimental pots

the pot experiment was performed over a period of 2 months and the performance of vetiver grass assessed. The size of the pot is depicted in Fig.3.

Water quantity available in the area: Water is the most important parameter for vetiver growth, not only in terms of quantity but in terms of quality also. The mine receives a mean rainfall of 735mm i.e., as a result of 10 years of moving average. The rainfall data of the study area is tabulated in Table 7. Vetiver grass can survive over a wide range of

TABLE 7: RAINFALL DATA OF DONGRI BUZURG MINE OF CENTRAL INDIA

	Year	Total annual rainfall (mm)
1	2007	875.2
2	2008	657.32
3	2009	392.78
4	2010	968.72
5	2011	864.32
6	2012	963.19
7	2013	144.15
8	2014	824.61
9	2015	785.70
10	2016	767
11	2017	581.81
12	2018	712.07
13	2019	682.57
14	2020	797.66
Average over the years//mean		715.51244

rainfall from 300-2200 mm (TVNI, Paul Throng, 2008). Therefore, the quantity of water is not a constraint. In the context of the control pot, 500 cm^3 of tap water was applied after every 12 hr, with a loss of 35% by weight.

2.2 Statistical Analysis (ANOVA)

For the purpose of testing the relationship between percentage vermicompost and S/R ratio and between percentage vermicompost and root length (cm) regression analysis has been applied taking percentage vermicompost as independent variable and S/R ratio as dependent variable in the first case and root length (cm) as dependent variable in the second case. A linear regression has been studied between the independent and dependent variables using following linear equation model

$$Y = a + bx \quad \text{... (1)}$$

Where X is percentage vermicompost being independent variable and Y = S/R ratio in the first case and root length in later relationship. Also, in order to study the significance of the model one-way ANOVA test has been applied using SPSS ver. 20 where the sig. value i.e. p-value is compared to the alpha value of 0.05. If p-value is less than the alpha value of 0.05 the relationship between dependent and independent variable is said to be significant and vice-versa.

3.0 Result and discussion

After 60d of plantation, vetiver formed a canopy, with leaf angles varying from 45° to approximately 125°. The experiment yielded results as per Table 1. The results are tabulated under the section 3.1 with the parameters mentioned in Table 1. The analysis of those growth parameters is analyzed under section 3.2 using ANOVA.

3.1 Growth parameters over the entire period of 60d

Growth parameters such as root length, shoot length and S/R ratio was assessed after every 10d by plugging out the plant from the experimental pot as depicted in the Fig. 4. The plant growth for control sample is analyzed separately and is tabulated in Table 8. The analysis of the control sample indicated a base reference as the rest 30 pots are an indication of improvement of growth after amelioration of the dump soil. The Table 9 provides the complete result for 60d of plantation under the conditions mentioned in Table 3.

The growth is significantly increasing after 30% of vermicompost amelioration, but 40% to 50% shows a saturated growth curve. The individual growth graph from Figs.5 to 10 asserts the above statements. Figs. 11 to 17 depict the actual experiment photographs of growth and development of vetiver.

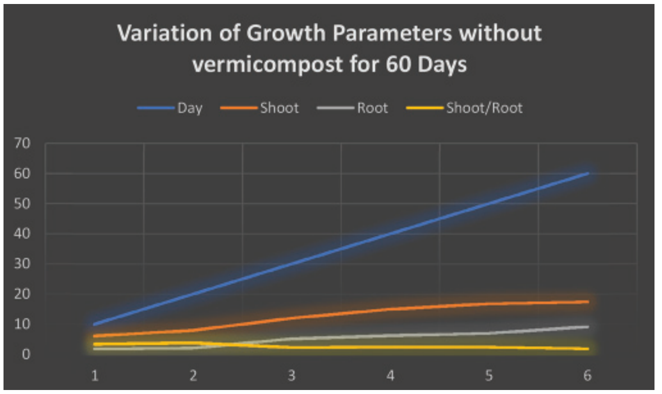

Fig.4 variation of growth parameters without vermicompost for 60 days

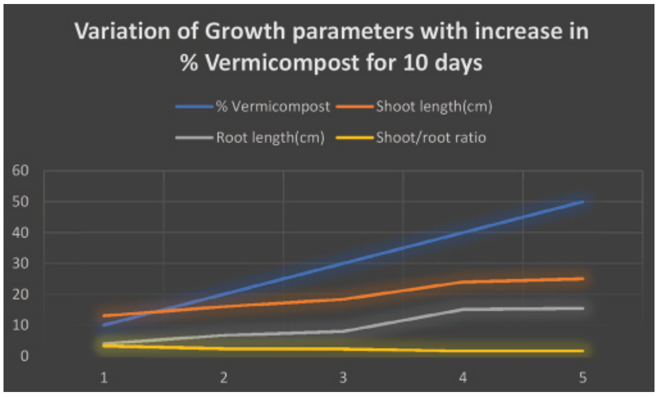

Fig.5 Growth variation of parameters with increasing % vermicompost after 10 days

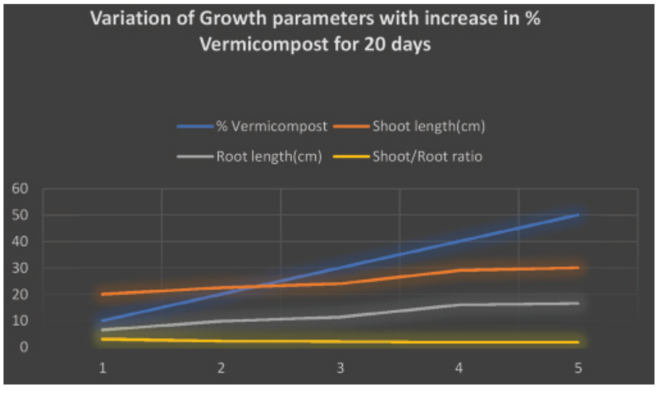

Fig.6 Growth variation of parameters with increasing % vermicompost after 20 days

Table 8: Control experiment results

	At 10 days	At 20 days	At 30 days	At 40 days	At 50 days	At 60 days
Shoot length	6.1	8	12	15	16.8	17.4
Root length	1.8	2.1	5.2	6.2	7	9.2
Shoot/root ratio	3.338	3.810	2.307	2.42	2.4	1.891

Table 9: Growth parameters at different parameters

After 10 days	At 10% Vermicompost	At 20% Vermicompost	At 30% Vermicompost	At 40% Vermicompost	At 50% Vermicompost
Shoot length	13.2	16	18.4	24	25
Root length	4.0	6.7	8	15.1	15.4
Shoot/root	3.256	2.388	2.3	1.589	1.6233
After 20 days					
Shoot length	20	22.5	24	29	30
Root length	6.5	9.8	11.4	16	16.5
Shoot/root	3.076	2.269	2.105	1.8125	1.818
After 30 days					
Shoot length	22	29.4	35	39.6	41
Root length	11	20	21	26	33
Shoot/root	2	1.47	1.666	1.522	1.2424
After 40 days					
Shoot length	32	45	52	57	62
Root length	13	17	27.9	38.6	44.5
Shoot/root	2.461	2.647	1.863	1.4766	1.392
After 50 days					
Shoot length	34	50.2	63	70	72.5
Root length	17.5	26.1	34.3	55.3	63
Shoot/root	1.942	1.923	1.836	1.266	1.111
After 60 days					
Shoot length	36	51.1	64.7	71.2	76
Root length	21	39.2	45.9	60.6	66.4
Shoot/root	1.714	1.303	1.410	1.174	1.144

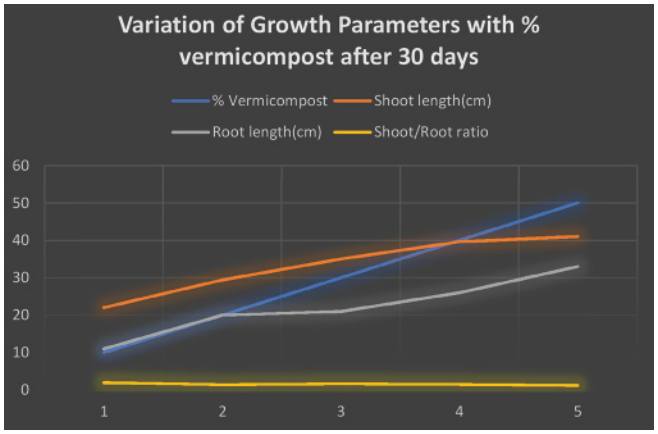

Fig.7 Growth variation of parameters with increasing % vermicompost after 30 days

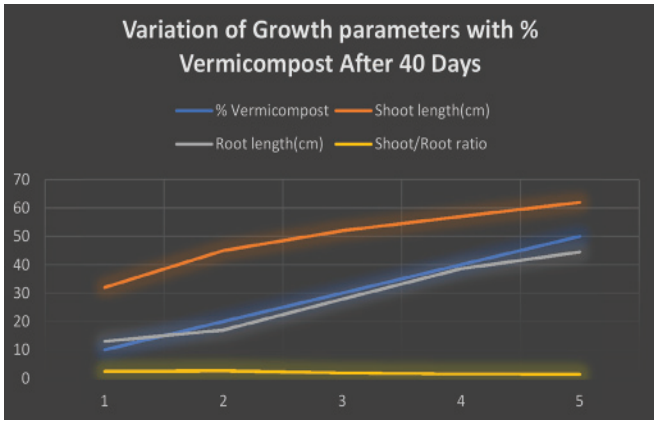

Fig.8 Growth variation of parameters with increasing % vermicompost after 40 days

3.2 Analysis of variance (ANOVA)

3.2.1 Relationship between percentage vermicompost and S/R ratio

An attempt is made to study the relationship between % vermicompost and S/R ratio over 6 different durations i.e., 10d, 20d, 30d, 40 d, 50d and 60d period after plantation and following correlations have been obtained, tabulated in the Table 10.

The above table shows the Pearson correlation between % vermicompost and S/R ratio. The correlation co-efficient obtained is -0.673 which states that there is a negative moderate relationship between percentage vermicompost and S/R ratio. This indicates that with an increase in percentage vermicompost the value of S/R ratio tends to decrease. A model summary is also prepared and presented in the Table 11.

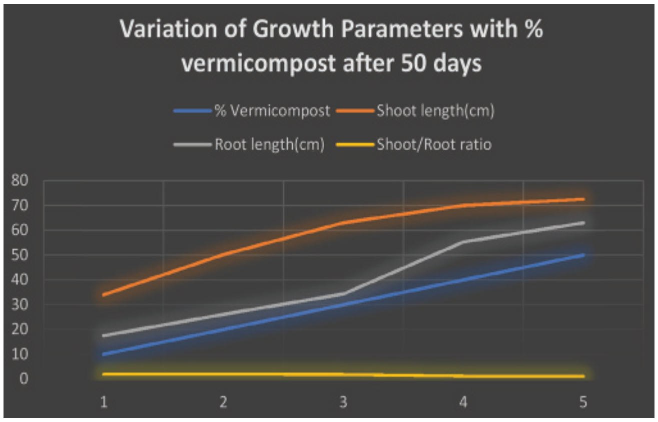

Fig.9 Growth variation of parameters with increasing % vermicompost after 50 days

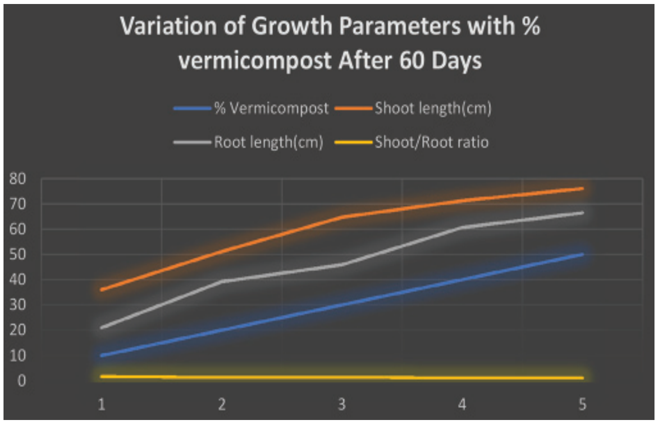

Fig.10 Growth variation of parameters with increasing % vermicompost after 60 days

Fig.11 Plantation of the experiments

TABLE 10

		S/R ratio	% Vermicompost
Pearson correlation	S/R ratio	1.000	–.673
	% Vermicompost	–.673	1.000
Sig. (1-tailed)	S/R ratio	.	.000
	% Vermicompost	.000	.
N	S/R ratio	30	30
	% Vermicompost	30	30

TABLE 11

Model	R	R Square	Adjusted R Square	Std. Error of the estimate
1	-.673[a]	.453	.434	.41323

a. Predictors: (Constant), % Vermicompost

The above R square value obtained from the above model summary table is 0.453 which indicates that percentage vermicompost impact 45.3% on S/R ratio i.e., the value of S/R ratio depends 45.3% on percentage vermicompost and remaining 54.7% on other factors. However, the correlation value obtained is -0.673 which indicates the model is moderately strong.

Fig.12 On site growth after 20 days

Fig.13 On site growth after 30 days

Fig.14 On site growth after 50 days

Fig.15 On site growth after 60 days

Fig.16 Measurement of the parameters

In order to study the significant impact of percentage vermicompost on S/R ratio, ANOVA test has been applied, The F-value i.e. ANOVA value obtained is 23.218 and the sig. value i.e. p-value obtained is 0.000 which is less than the alpha value of 0.05 (F=23.218, P<0.05), which indicates a significant impact of the two variables. Hence, it is concluded that there is significant impact of percentage vermicompost on S/R ratio. The summary of the results is tabulated in the Table 12.

Further the analysis indicates the beta co-efficient of -0.026 for the independent variable % vermicompost with the sig. value i.e. p-value of 0.000. Since, the p-value obtained is less than the alpha value of 0.05, the relationship is said to be significant and the linear equation formed to determine the value S/R ratio is as follows:

S/R ratio = 2.599–0.026* (percentage vermicompost) (2)

The table of coefficients and sigma relations is given in Table 13. From the above equation 2, the amount of vermicompost for a desired S/R ratio can be tabulated and is given in Table 14.

From Table 14, it is evident that a % vermicompost of 61.5% is required to achieve a ratio of 1 at the earliest, which is not economical given the volume of the dump where it had to be applied. Therefore, an optimal % is worked out in the Table 15 at 50% vermicompost application, an additional 11.5% would cost 57,000/- more. The increase is not necessary as the ratio is satisfactory and a growth of generally 75 cm is expected of vetiver at fertile condition.

TABLE 12

	Model	Sum of squares	Df square	Mean	F	Sig.
1	Regression	3.965	1	3.965	23.218	.000[b]
	Residual	4.781	28	.171		
	Total	8.746	29			

a. Dependent Variable: S/R ratio
b. Predictors: (Constant), % Vermicompost

TABLE 13

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	2.599	.177		14.688	.000
	% Vermicompost	-.026	.005	-.673	-4.819	.000

a. Dependent Variable: S/R ratio

TABLE 14: PERCENTAGE VERMICOMPOST FOR DESIRED S/R RATIO

	Desired S/R ratio in 2 months	% Vermicompost required
1	1.00	61.500
2	0.90	65.346
3	0.80	69.192
4	0.70	73.038
5	0.60	76.884
6	0.50	80.730
7	0.40	84.576

Table 15: Cost comparison over increase in percentage vermicompost for actual site

	Volume of Dump(m^3)	Surface area of dump(m^2)	Depth of application of vermicompost	Cost of vermicompost at 50%	Cost of vermicompost at 61.5%
1	32,47,738	85,467.78	0.18	1,57,890	2,14,915
				Difference	57,025

Table 16

		% Vermicompost	Root length (cm)
% Vermicompost	Pearson correlation	1	.567**
	Sig. (2-tailed)		.001
	N	30	30
Root length (cm)	Pearson correlation	.567**	1
	Sig. (2-tailed)	.001	
	N	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

3.2.2 Relationship between percentage vermicompost and root length (cm)

Similarly, another attempt is made to study the relationship between percentage vermicompost and root length over 6 different durations i.e., 10d, 20d, 30d, 40d, 50d and 60d period after plantation, following correlations has been obtained, and tabulated in the Table 16:

The above table shows the pearson correlation between % vermicompost and root length. The correlation co-efficient obtained is 0.567 which states that there is positive moderate relationship between percentage vermicompost and root length (cm). This indicates that with an increase in % vermicompost the value of root length will also increase moderately. A model summary is also prepared and presented in the Table 17.

Table 17

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.567[a]	.322	.297	15.04143

a. Predictors: (Constant), % Vermicompost

The above R square value obtained from the above model summary table is 0.322 which indicates that % vermicompost impacts 32.2% on root length i.e., the root length depends 32.2% on percentage vermicompost and remaining 67.8% on other factors. However, the correlation value obtained is 0.567 which indicates the model is moderately strong. The summary of the results are tabulated in Table 18;

Further on the analysis indicates the beta co-efficient of 0.707 for the independent variable percentage vermicompost with the sig. value i.e. p-value of 0.001. Since, the p-value obtained is less than the alpha value of 0.05, the relationship is said to be significant and the linear equation formed to determine the value of root length is as follows:

Root length = 5.137 + 0.707* (percentage ermicompost)

Table 18

Model	Sum of Squares	Df	Mean Square	F	Sig.	
1	Regression	3001.923	1	3001.923	13.268	.001[b]
	Residual	6334.851	28	226.245		
	Total	9336.774	29			

a. Dependent variable: Root length (cm)
b. Predictors: (constant), % vermicompost

Table 19

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.137	6.440		.798	.432
	% Vermicompost	.707	.194	.567	3.643	.001

a. Dependent Variable: Root Length (cm)

(3) The table of coefficients and sigma relations is given in Table 19;

4.0 Conclusions

As the vegetation is to be done mainly on the dumps, which are sandy in texture, therefore, the root length is more significant. With control studies, after 30d only 5.8cm of root length was observed while on the same period with 10% vermicompost addition, significant increase of root length, i.e., more than 47.75% was noticed. The significant finding in this study is the S/R ratio variation with the vermicompost addition. As the ratio decreases with increase in percentage vermicompost and thus making it clear that to achieve higher proportion of early root growth, it would be requiring higher percentage of vermicompost. Both the equation can give a fair idea of percentage vermicompost required for achieving S/R ratio as 1, within the stipulated study time and under the given conditions. With all site-specific condition of the dump soil and its characteristics, this paper would like to suggest a vermicompost per cent of 50%. As that would be economical for field application and would provide a S/R ratio of about 1.2. However, an addition of 61.5% of vermicompost in dump soil would be able to provide a S/R ratio equals to 1, but that would not be advisable from the economic point of view for the entire volume of surface area of matured dumps as well as it would be difficult for the miners to calculate the exact percentage for achieving the S/R ratio equals to 1. It is obvious that application of vermicompost in dump soil of Dongri Buzurg manganese mine would be required in the initial phase only for obtaining desired S/R and once it is achieved, any re-application of vermicompost would not be required for further growth of the vetiver grass. The above study would definitely help the mine operator for development of green environment along with other commercial benefits.

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