Effect of FYM, NPK and Algal fertilizers on the Growth and Biomass of Vetiver Grass [*Vetiveria zizanioides L.Nass*]

Dhirendra Kumar, Kumar Nikhil

Abstract— **Vetiver grass (Vetiveria zizanioides) is a warm season perennial grass grown as a phyto-remediation tool for soil, water, control/check soil erosion on overburden dumps slopes during rainy season and recently proposed as a plant material source for biofuel production. However, limited information exists on Vetiver grass fertility management practices in cropping systems. Therefore, the effects of nitrogen, phosphorus and potassium (NPK) fertilizer in the form of Suphala (15:15:15), Farm yard manure (FYM) and dry algae as algal bio-fertilizer as individual dose and in combination of thereafter. This individual fertilization and combination makes it six different treatments and control with five replications each respectively. Each replication under all the six treatments including control, two numbers of Vetiver grass each were planted in all the 30 pots for this experiment to study the increment in height, culm numbers, root length, root:shoot ratio, fresh and dry above and below ground biomass (FAGB, FBGB, DAGB and DBGB) after 39 and 65days respectively and data analysed.**

***Index Terms*— Farm Yard Manure (FYM), Nitrogen, Phosphorus, Potassium (NPK) based fertilizer, Algal bio-fertilizer, *Vetiveria zizanioides*, Growth and Biomass**

I. INTRODUCTION

With the development of industrialization mineral and metal mining and requirement of more or more energy coal mining is upcoming to meet the demand of increasing population development (Nikhil, et.al., 2002 and Singh, et.al., 1998). Due to this continuous degradation of soil quality and ultimately land use (Nikhil, et.al., 1998). The mining resultant huge overburden dump requires biological reclamation (Nikhil, 1999 and Nikhil, et.al., 2001) to sustain the land use and bulk density of the soil to maintain soil fertility (Nikhil, et.al., 1998). Use of chemical fertilizer and pesticides has affected the agricultural soil nearby mining affected areas (Nikhil & Loveson, 1998). Further, use of organic, bio fertilizers and inorganic fertilizer for the growth of certain species used for bio-reclamation/ phyto-remediation of mining affected/contaminated land is matter of concerned (Nikhil, 2001). In connection with this use of algae as a bio-fertilizers is the main objective of this experiment. Moreover, taking the vetiver grass for this experiment, grown for 65days in pot with 7 different treatments including control and five replications each. The increment of height and culm numbers after 39 and 65days were recorded. The increments in shoot and root length with their ratio after 69 days were recorded along with the fresh and dry above and below ground biomass were also recorded. Selection of appropriate plant species is very important to ensure a self-sustaining vegetation cover (Wong, 2003). In the present study, species of vetiver grass [Vetiveria zizanioides (L.) Nash] of native grass commonly found in the Jharkhand. Vetiver grass is a fast-growing plant that tolerates various extreme environments, including soil pH values between 3.0 and 10.5 and temperature from -10 to 48^{0}C (Dalton etal., 1996; Wong, 2003). It also effectively controls erosion of soil by water (Truong and Baker, 1998). The previous studies have shown that vetiver grass can grow well in soils contaminated with multiple elements at high concentrations such as those found at coal,cadmium, and gold mining sites (Truong and Baker 1998; Nikhil, et.al., 2004; Nikhil, 2004; Dhirendra and Nikhil, 2016; Roongtanakiat and Chairoj, 2002). It can attain a very good height (2-3 m) and produces large biomass, capacity to absorb contaminants, its tolerance and practical field application. As for vetiver, although researches in Australia, China and Thailand have established its tolerance to high level of heavy metals in the soil and its effectiveness in phyto-remediation work in contaminated land but vetiver has not been studied specifically on lead contamination alone and on a lead mine area.

Adding of inorganic and organic fertilizers for the successful establishment of the vetiver grass in wasteland soils is the prime objective of our experiment. The addition of amendments provides the release of nutrient such as N, P, K to support plant growth (Wong, 2003; Chiu et al., 2006). Cow manure, poultry manure and pig manure were found to be effective in reducing lead availability to plants, leading to lower uptake of lead (Scialdone et al., 1980; Wong and Lau,1985; Ye et al., 1999). In addition, fertilizers are an essential ingredient for successful restoration of mine wastes (Bradshaw and Chadwick, 1980).

The beneficial effects of use of algae as a bio-fertilizer is reported on a number of crops such as barley, oats, tomato, radish, cotton, sugarcane, maize, chilli and lettuce, wheat (Sahu, et.al., 2012).When Vigna mungo (L.) Hepper commonly known as black gram seeds were treated with biofertilizer, Azotobacter sp., it showed better and significant result compared to untreated control in terms of both morphological (such as number of leaves, breadth of leaves, total length of plant, shoot and root length) and biological parameters including chlorophyll content, carbohydrate content, protein content (Amit and Bhalerao, 2015). Giant Kelp (an algal species) is also used as a fertilizer with a combination of other fertilizer which provides high value of nutrients needed by the plants. This is commonly practiced in pacific coast of North America. Kelp fertilizer comes in

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liquid, soluble powder and solid forms. It provides all the major nutrients including 2.5 lbs. of potassium which is a major plant nutrient. BGA also increases the yield, weight and oil content and inducing resistance to *Tikka* disease in ground nut plant. Dry algae is an organic material which act as humus for the soil which helps in binding the soil, hold nutrient inside it and supply to plants by capillary action for a longer duration, increases the water holding capacity of soil and increase the inter molecular space between soil molecule due to which proper aeration is supplied to root system and hence makes it more beneficial to use as bio fertilizer in comparison to chemical fertilizers (Saurabh and Nikhil, 2014; Vyomendra & Nikhil, 2016**a** and Vyomendra & Nikhil, 2016**b**).

Hence, the main objective of the present study was to evaluate the effects of NPK, FYM and Algae fertilizers on the vetiver grass (V. zizanioides) and hoped that this research would aid in establishing suitable application dosage of these materials for amending the mine affected soil.

Vetiver roots have tremendous diversity with respect to pattern of growth, orientation and thickness of roots, as well as for occurrence of secondary roots. Growth, yield and quality of Vetiver are highly depending on soil and climatic conditions as well as agronomic practices adopted (Maffei, 2002).Vetiver growth increased with higher lime and fertilizer rates (Yoon, 2002). Vetiver plant showed differences in growth and biomass within the ecotype when the fertilizers were applied (Sompong et al., 2000). Vetiver requires moderate rates of N and P early in the establishment phase (1 to 2 years, depending on growing conditions) (Truong and Creighton, 1994). Several scientists (Truong and Creighton, 1994; Sompong et al., 2000) conducted research on impact of fertilizer on growth and biomass production.

II. Experimental Layout

A. Methodology

A pot trial was designed to test the effect of NPK, FYM and Algae fertilizer on the growth of V. zizanioides. CSIR-CIMFR garden soil 8kgeach was filled in earthen pots (12inches in diameter, 18 inches in height) which had four pieces of holes at the bottom to help in the percolation of water fromthe soil filled. Plants were selected, pruned (shoots were 20 cm and roots were 5 cm in length) and then transplanted into the pots (2 plants/pot) containing sixtreatments with control. There were five replicates for each treatment (**Fig.1**). After 65 days, the plants wereharvested, were washed thoroughly with tap water, rinsed with de-ionized water and divided into shoots and roots. They were oven-dried at 60^0C for 48 h to a constant weight and the dry weight yield was recorded.

Figure.1.Pot experiment, dry algae, algae grown in water and vetiver grass

B. Site Details

Experiment was conducted at the garden of CSIR-CIMFR, Dhanbad, Jharkhand, India during January to March, 2016 (**Fig.2**). The climate of this place is moderate during the experiment. During these three months, an average temperature ranging from 10^0C to 28^0C with rainfall ranging from 2cm to 6.5cm followed by dry weather conditions. The pH of the garden soil was 6.2 with water holding capacity 33 %, 0.50 to 0.75 kg per hectare organic carbon, 39 kg per hectare available phosphorous, 180 kg per hectare available nitrogen and 296 kg per hectare available potassium respectively.

Figure.2: Site detail

C. Procedure Adopted

The experiment was having six treatments with Algae (T1), FYM (T2), NPK (T3), Algae + FYM (T4), Algae + NPK (T5), NPK + FYM (T6) and Control (C) respectively with five replicates each. Soil analysis were done with the prescribed ICAR- New Delhi soil testing standards.

450 kgof Ammonium sulphate (20.5%N) /ha; 350 kg. of calcium super phosphate(15.5%P2O5) /ha and 75 kg of Potassium sulphate (48% K2O) /ha with 10T/ha for FYM and Algae-fertilizers as a recommended dose [in 1ha=$2.24x10^6$ kg soil]. Here in one pot 8kg of soil has been taken for this experiment. Therefore, inorganic fertilizer like NPK and organic fertilizer like FYM and Algae fertilizers were calculated accordingly.

The increment of height and culm numbers after 39 and 65days were recorded. The increments in shoot and root lengthwith their ratio after 69 days were recorded along with the fresh and dry above and below ground biomass were also recorded. The root/shoot ratio is a highly representative indicator of environmental stress that is encountered by plants (Chiu et al., 2006). It was calculated as follows:

$$\text{Root/shoot ratio} \equiv \frac{\text{Dry wt. of root}}{\text{Dry wt. of shoot}}$$

D. Data Analysis and Statistic Analysis

All analysis was performed using software Microsoft Excel including variance analysisand multiple comparisons.

III. Results

A. Growth performance

1. Height

The vetiver grass grown for this experiment shown the maximum growth as increament in height after 65 days in T4 (Algae+FYM) of 32.15cm followed by 27.48cm in T5 (Algae+NPK), 21cm in T6 (NPK+FYM), 20.86cm in T1(Algae), 19.59cm in T2 (FYM), 17.55cm in T3 (NPK), 14.9 cm in control (C). The same trend was noted after 39 days also. Whereas, in initial days the height of all the vetiver grass planted in all the pots were found to be 15cm each.

Treatments	Height (cm) of Vetiver grass		
	0 day	39days	65 days
C	15	6.5	14.9
T1	15	15.72	20.86

T2	15	17.66	19.59
T3	15	15.78	17.55
T4	15	28.1	32.15
T5	15	23.22	27.48
T6	15	17.08	21

Table.1: Height (cm) of Vetiver grass after 0, 39 and 65 days of growth

2. Culm

The vetiver grass grown for this experiment shown the maximum growth as increament in culm number after 65 days in T4 (Algae+FYM) of 8.33 followed by 5.25 in T5 (Algae+NPK), 4.5in T1(Algae), 3.4 in T6 (NPK+FYM), 3.33 in T2 (FYM), 3.13 in T3 (NPK), 3.0 in control (C). The same trend was not been noted after 39 days. Whereas, in initial days the culm numbers of all the vetiver grass planted in all the pots were found to be 1.

Treatments	Culm number of Vetiver grass		
	0 day	39days	65 days
C	1	1.5	3
T1	1	2.4	4.5
T2	1	2	3.33
T3	1	2.42	3.13
T4	1	2.5	8.33
T5	1	3	5.25
T6	1	2.78	3.4

Table.2: Culm number of Vetiver grass after 0, 39 and 65 days of growth

B. Root:Shoot Length Ratio

The vetiver grass grown for this experiment shown the maximum root shoot length and their ratio as increments in root and shoot length after 65 days. A maximum of root length were achieved during 65 days of vetiver grass i.e., 32.15 in T4 followed by 27.48 in T5, 21 in T6, 20.86 in T1, 19.59 in T2, 17.55 in T3 and 14.9cm in control. Whereas in shoot length attained by vetiver grass was found maximum of 46.75gms in T4 followed by 44.04 in T5, 41.92 in T1, 33.15 in T6, 32.32 in T2, 31.75 in T3 and 21.4gms in Control respectively.

Further, the root:shoot length ratio was noted maximum in T1 as 2.01:1 followed by 1.81:1 in T3, 1.65:1 in T2, 1.60:1 in T5, 1.58:1 in T6, 1.45:1 in T4 and 1.44:1 in C.

Treatments	Length (cm) of Vetiver grass		
	Root	Shoot	Root-Shoot Ratio
C	14.9	21.4	1.44:1
T1	20.86	41.92	2.01:1
T2	19.59	32.32	1.65:1
T3	17.55	31.75	1.81:1
T4	32.15	46.75	1.45:1
T5	27.48	44.04	1.60:1
T6	21	33.15	1.58:1

Table.3: Root:Shoot Length and ratio of Vetiver grass after 65 days of growth

C. Root:Shoot Dry Biomass Ratio

The vetiver grass grown for this experiment shown the maximum root shoot dry biomass and their ratio as increments in root and shoot dry biomass after 65 days. A maximum of root dry biomass were achieved during 65 days of vetiver grass i.e., 2.1gms in T4 followed by 1.48 in T5, 1.24 in T1, 1.1 in T6, 1.02 in T2, 0.86 in T3 and 0.04gms in control respectively. Whereas in shoot dry biomass attained by vetiver grass was found maximum of 2.59gms in T4 followed by 2.02 in T5, 1.36 in T1, 1.26 in T6, 1.04 in T2, 1.04 in T3 and 0.13gms in Control respectively.

Further, the root:shoot dry biomass ratio was noted maximum in C as 3.25:1 followed by 1.36:1 in T5, 1.23:1 in T4, 1.19:1 in T3, 1.15:1 in T6, 1.09:1 in T1 and 1.02:1 in T2 respectively.

Treatments	Dry Biomass (gms) of Vetiver grass		
	Root	Shoot	Root:Shoot Ratio
C	0.04	0.13	3.25:1
T1	1.24	1.36	1.09:1
T2	1.02	1.04	1.02:1
T3	0.86	1.02	1.19:1
T4	2.1	2.59	1.23:1
T5	1.48	2.02	1.36:1
T6	1.1	1.26	1.15:1

Table.4: Root:Shoot Dry Biomass and ratio of Vetiver grass after 65 days of growth

3. DISCUSSION

The present study demonstrated that the application dosage of Algae+FYM together has more significant growth rates followed by Algae+NPK., Algae, FYM, NPK single doses alone over control treatments. This was significantly noted in height and culm numbers after 39 and 65 days of vetiver grass growth.These could enhance growth in vetiver. Similar results were reported by Ye et.al. (1999); adding inorganic fertilizer alone did not significantly improve the growth of (Shu et al., 2001; Saurabh and Nikhil, 2014; Vyomendra & Nikhil, 2016**a** and Vyomendra & Nikhil, 2016**b**).

Effect of different fertilizer mixtures on biomass production of Vetiver showed significantly higher fresh and dry weight of root and shoot, root and shoot length with their ratio, height, culms numbers after 0, 39 and 65 days were compared to other treatments.

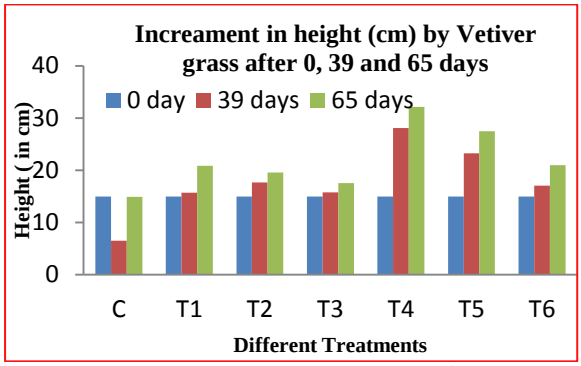

Figure.3: Increment in Height (cm) of Vetiver grass after 0, 39, 65 days

There were increasing trends in root and shoot dry weights, number of leaves and culm number with Algae, FYM, NPK and combinations (**Figure.3,4,5 and6**).

Both Algae, FYM and inorganic fertilizer treatments had significant effect on the shoot and root dry weights and culm numbers. Similar results have also been reported by Wong and Ho (1991) on amending soils with composts. NPK fertilizers are more efficient than the organic manures in supplying N, P and K in the short run, while the compost had an advantage in supplying other macro and micro nutrient elements not contained in NPK fertilizer in the long term as well as in slow releasing nature. Rotkittikhun et al., 2007 and Adholeya and Prakash, 2004 showed the suitability of application of high proportions of compost with lower doses

of inorganic fertilizer for higher biomass production of field crops such as Java citronella and sunflower.

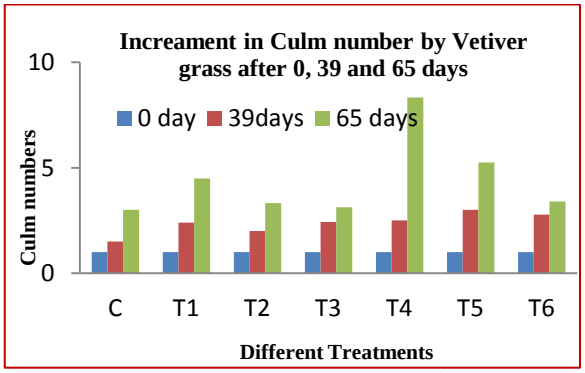

Figure.4: Increment in Culm numbers of Vetiver grass after 0, 39, 65 days

Application of kitchen garbage, municipal and industrial waste compost have great effects on plant growth and yield as well as promote the soil physical and chemical properties (Guisquiani et al., 1995; Wong and Ho, 1991; Remison, 2005).Increased plant yield may also be due to increased soil aggregate stability which might have favored the beneficial microbes which in turn could have contributed to improve biomass production (Basso and Ritchie, 2005; Bwenya and Terokun, 2001; Saurabh and Nikhil, 2014; Vyomendra & Nikhil, 2016**a** and Vyomendra & Nikhil, 2016**b**).

Similar findings, organic manure alone or in combination with NPK fertilizers significantly, increased biomass production and oil yield of Sunflower than control were also reported (Tiwari and Parihar, 1992; Ramesh et al., 1999; Gorttappeh et al., 2000; Saeed et al., 2002). This has been noted in moong bean also (Saurabh and Nikhil, 2014; Vyomendra & Nikhil, 2016**a** and Vyomendra & Nikhil, 2016**b).**

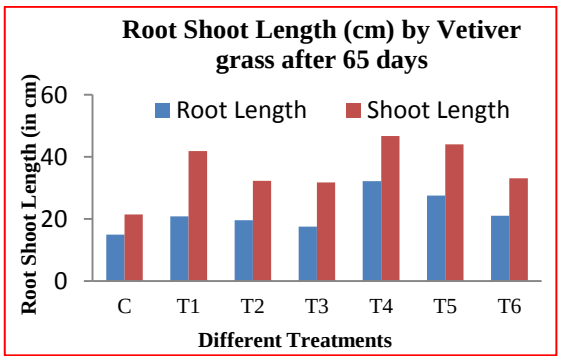

Figure.5: Increment in Root Shoot length Vetiver grass and its ratio after 65 days

Vetiver is used to plant in reclaimed bare sloping fields, two In this study, T5 improved the growth of vetiver by using Algae+NPK. To sum up, the results of this experiment indicate that treatments T4 and T5 were better than T1, but in contrast, treatments not using FYM and algae, the effect isn't desirable (Saurabh and Nikhil, 2014; Vyomendra & Nikhil, 2016**a** and Vyomendra & Nikhil, 2016**b).**

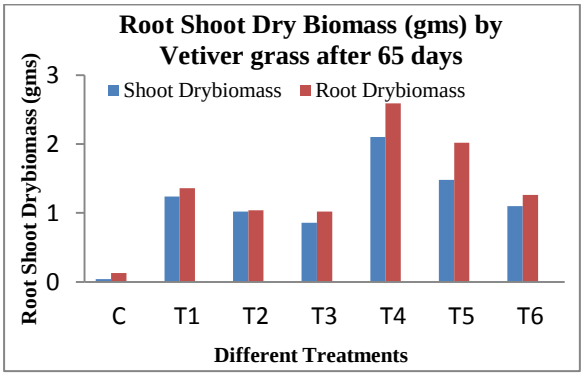

Figure.6: Increment in Root Shoot drybiomass of Vetiver grass and its ratio after 65 days

4. CONCLUSION

V. zizanioides are good choices for phyto-stabilization of wasteland soil. The applications of Algae, NPK, FYM fertilizer to increase nutrients for plant growth, soil amended with 450 kg of Ammonium sulphate (20.5%N) /ha; 350 kg. of calcium super phosphate(15.5%P2O5) /ha and 75 kg of Potassium sulphate (48% K2O) /ha with 10T/ha for FYM and Algae-fertilizers as a recommended dose [in 1ha=$2.24x10^6$ kg soil].

Due to its unique physical and morphological characteristics, its tolerance to environmental extremes and low risk of becoming an invasive plant species, Vetiver grass may have production potential in the India as a plant material source for biofuel production or carbon sequestration. Plant height and total plant fresh weight were significantly different between Algae+FYM dose and Algae+NPK. Therefore, our results indicate that Vetiver grass may successfully be cultured organic carbon as a FYM and algae combined dose for fertility.

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