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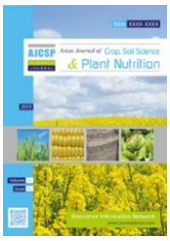

# Effect of NPK fertilizer on root, shoot and tiller increment of vetiver (*Vetiveria zizanioides* (L.) Nash)

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***ABSTRACT***

*In this study clumps with two tillers were planted with two treatment $T_1$ (control or without fertilizer) and $T_2$ (with NPK fertilizer). The survival percentage of vetiver clumps was found 96.354±0.354 in control and 97.916±1.802 for NPK fertilizer after 3 months. After 13 months (92.187±1.562) % and (93.750±3.125) % survivability were found in control and NPK fertilizer respectively. After 3 months average tiller increment (nos) were found 2.677±0.252 and 5.877±0.434 respectively in control and with NPK fertilizer. After 13 months the average tiller increment (nos) was found 14.522±0.691 and 21.288 ± 0.477 in control and NPK fertilizer. After 3 months observed value of 't' by independent t-test was 11.022 and P-value is 0.000. After 13 months observed value of 't' by independent t-test was 13.958 and P-value is 0.000. So at 5% significance level, there was a very highly significant difference between control and NPK fertilizer after 3 and 13 months in tiller increment. The average initial root and shoot lengths were 22.022±0.601 cm and 76.755±9.1499 cm during planting time in control. On the other hand, the average initial root and shoot lengths were 22.722±3.548 cm and 65.66±14.611 cm for NPK fertilizer. After 13 months the average root lengths in control and NPK fertilizer were measured 23.123±1.272 cm and 24.422±3.106 cm. The observed value of 't' by independent t-test was 0.669 and P-value was 0.540. The shoot length was measured 143.103±20.378 cm in control and 176.633±24.075 cm in NPK fertilizer. The observed value of independent 't' test was 1.841 and P-value was 0.139. So at 5% significance level there was no significant difference of root and shoots growth in control and NPK fertilizer. After 13 months the mean increment of root and shoot were calculated 1.101 cm and 66.348 cm in control. In NPK fertilizer the mean increment of root and shoot length was calculated 1.7 cm and 110.973 cm.*

***Key Words:*** *NPK, Vetiver grass, Clump, Tiller, Root length and Shoot length.*

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## I. Introduction

Vetiver (*Vetiveria zizanioides* (L.) Nash) is a perennial tussak grass belonging to the family Poaceae. It is tall (1-2m) and fast growing. The massive and complex root system is long (3-4 m) that can

penetrate the deeper layers of the soil. Vetiver is an ancient Old World grass and cultivated in at least 70 countries in the world (NRC, 1993). The genus *Vetiveria* is comprised of 11 species. Among these 11 species, five species are endemic to Australia, two are found in Africa, one is found in Southeast Asia and one is endemic to Mauritius and neighbouring island of Rodrigues in the Indian Ocean (Rahman et al., 1996). *Vetiveria lawsonii* is found in southern India and *Vetiveria zizanioides* are found in northeastern India and Bangladesh. *Vetiveria zizanioides* L. Nash is the only species that exists in Bangladesh (Rahman et al., 1996). The generic name, *Vetiveria*, is derived from a Tamil word; 'vettiver' means to root that is dug up and the species name *zizanioides*, means by the riverside. That is vetiver is commonly found along with the waterways (NRC, 1993). Vetiver grass is commonly found all over Bangladesh except littoral forest of Sundarbans, greater Sylhet, Chittagong, and Chittagong Hill Tracts districts as well as under the shades of the Sal (*Shorea robusta*) forest of Tangail, Mymensing and Gazipur near the sandy banks of the river Brahmaputra in the district of Mymensing, Jamalpur and Sherpur. It is cultivated in Nawabganj for thatching material. In Bangladesh, the grass grows quite well on hillocks and undulating lands, fallow lands, dikes of crop fields, marshy habitats, river side's and low lying areas, where it never grows inside forest under shade. If it is introduced inside open forest patches, vetiver can thrive and establish very well. The root of vetiver grows very fast. It grows downwards without any competition of neighboring crops. Tillers, culm branches and culm cuttings can do its multiplication (Moula and Rhman, 2008). Moula and Rahman (2009) also reported that the wild varieties of vetiver grass can be propagated from fertile seed. It grows in low, bogs and hillsides. Vetiver can survive in broad environmental conditions and grow with annual rainfall ranges from 200 to 5,000 mm (Rahman et al., 1996). It can tolerate adverse climatic change. It can survive with temperature ranging from $0^0$C to $50^0$C. Vetiver is suitable for growing on different types of soil (NRC, 1993). It is suitable for both highly acidic (pH 4) and alkaline (pH 8) soil (Rahman et al., 1996). It is generally pest and disease resistant. Vetiver bears both xerophytic and hydrophytic characteristics. It can tolerate drought, flood, windstorm, grazing animals, long periods of waterlogging and other forces of nature except freezing. It cannot grow in saline area (Islam, 2000). It has multiple uses, such as forage, firewood thatch and roofing materials, fencing materials, shedding materials, raw materials in cottage industries and herbal medicine (Kirtikar and Basu, 1986). It is also used for soil conservation and in perfume industry (Bor, 1960). It is also used in the recovery of degraded areas, especially in erosion control due to the presence of small rhizomes, and thin-matted root. The root reaches in deep and allows the plant to remain adhered to the soil aggregates and thus resistance to drought and runoff (Mickovski et al., 2005). Vetiver roots have tremendous diversity concerning pattern of growth, orientation and thickness of roots, as well as for the occurrence of secondary roots. The root system of the vetiver grass is very much impressive. The roots of vetiver grass are fibrous and can reach up to 3 m deep and thus being able to stabilize the soil. Protection of slope and embankment from erosion has become an important issue. The construction of strong structures requires large capital, integrated designing, high maintenance cost. Moreover, strong structural measures have negative impact on the environment. Plantation of vetiver system along the slopes is an alternative solution.

Vetiver grass can establish a full-stop to bank erosion caused by rapid drawdown. It is also a sustainable and innovative solution for the protection of banks (Verhagen et al., 2008) at the same time its an economically attractive and eco-friendly solution and has aesthetic value. Vetiver grass has unique morphological, physiological and ecological characteristics that highlight its adaptability to a wide range of environmental and soil conditions. The strength of vetiver rooted soil is 87% higher than that of soil without root (Islam and Arifuzzaman, 2010). The angle of internal friction of rooted sand ($46.79^0$) is 2.5% higher than that of bare rooted sand ($45.63^0$) which indicates that vetiver rooted soil able to absorb high natural force than soil without root. Further, it can go for large deformation before failure (Islam et al., 2016). These properties of vetiver rooted soil protect the embankments against cyclonic tidal surge and slope failure (Islam and Arifuzzaman, 2010). Growth, yield and quality of Vetiver are highly dependent on soil and climatic conditions, as well as agronomic practices, adopted (Maffei, 2002). The growth of vetiver grass would be increased by using higher lime and fertilizer (Yoon, 2002). Vetiver plants showed differences in growth and biomass within the ecotype when the fertilizers were applied (Suntanakanit et al., 2000). Vetiver needs moderate rates of N and P early in the establishment phase (1 to 2 years, depending on growing conditions) (Truong and Creighton, 1994).

Although in some parts of the world an extensive work has been done on the effect of different fertilizer on vetiver growth with tiller, root and shoot using different fertilizer, but there is no reported

work in this respect in our country. So, the present study has been undertaken to know the effect of NPK on the growth of vetiver grass including the survivability of clumps as well as increment of tiller, root and shoot.

## II. Materials and Methods

### Study area

The experiment was set up at the office campus of the Plantation Trial Unit Division, Bangladesh Forest Research Institute, Ruapatali, Barisal for 13 months from July 19, 2018 to September 1, 2019. It is situated at Ward NO 25, Barisal City Corporation. The latitude and longitude of the location are 22.7010° N; 90.3535° E. The Barisal lies on 10m above sea level. Barisal has a tropical climate. In winter, there is much less rainfall in Barisal than in summer. The average annual temperature is 25.9°C. The annual rainfall is 2184 mm (climate-data.org). The soil characteristic of the study is given in Table 01 and the location is shown in Figure 01.

### Seedling Collection

Vetiver clumps were collected from a homestead at Zia Sarak, Ward No. 24, Barisal City Corporation. These clumps were developed during the site development work of the home and grown up automatically. Clumps were collected on July 18, 2018 by uprooting the rhizome and transported to the experimental site. On July 19, 2018 the tillers were separated and measured the root length and shoot length of each tiller by measuring tape. The length of root and shoot of every individual tiller were recorded.

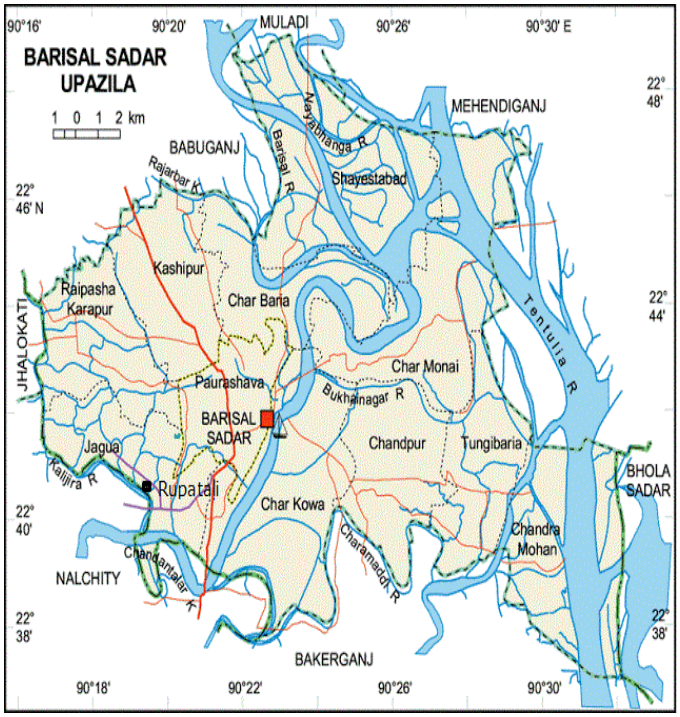


**Figure 01. Map showing experimental sites Barisal sadar upazila, Barisal (Source: Google map).**

### Site preparation

Soil was tilled up to a depth of 30 cm by country made spade to prepare the land. *Cynodon* and other grasses were removed from the experimental field after second tillage. Before the last tillage, chemical fertilizers (NPK as Urea, MP and TSP) were mixed at the rate of 30, 40 and 40 $kg.h^{-1}$respectively. After the final tillage, laddering was done with a locally made ladder. Then the site was prepared for planting the clumps.

### Planting bed preparation

The planting bed was prepared a size of 142.24 cm x 60.96 cm. A 20.32 cm drain was prepared around the beds for drainage of water and other maintenance and observation purposes.

**Table 01. General characteristics of soils of Barisal sadar upazilla, Barisal**

| Soil characteristics | Quantity |
|---|---|
| Texture | Clay |
| pH | 6.2-6.9 |
| ECe ($dSm^{-1}$) | 0.8-1.3 |
| Organic matter (%) | 2.36-3.01 |
| Total nitrogen (%) | 0.106-0.183 |
| Phosphorus (microgram/gram) | 3.60-5.70 |
| Potassium (milieq/100gm) | 0.20-0.27 |
| Sulphar (microgram/gram) | 28.80-83.90 |
| Zinc (microgram/gram) | 0.32-0.54 |
| Boron (microgram/gram) | 1.08-1.47 |
| Calcium (milieq/100gm) | 12.00-16.00 |
| Magnesium (milieq/100gm) | 3.25-3.75 |
| Copper(microgram/gram) | 4.22-6.42 |
| Iron (microgram/gram) | 77.20-170.80 |
| Manganese (microgram/gram) | 6.68-14.40 |

Source: (Land and soil resource use guideline (SRDI, 2009), Barisal Sadar Upazila, District Barisal(In Bengali).

**Planting design and layout**

Clumps were planted with Randomized Complete Block Design (RCBD) with two treatments. Each treatment was replicated (defined as block) three times. Two tillers per clump were planted with 20.32 cm × 20.32 cm spacing.

Treatment 1 ($T_1$): Control (without fertilizer).
Treatment 2 ($T_2$): With NPK fertilizer.

| | | |
|---|---|---|
| Block 1 | $T_1$ | $T_2$ |
| Block 2 | $T_2$ | $T_1$ |
| Block3 | $T_1$ | $T_2$ |

**Out planting the seedlings**

Vetiver clumps with double tiller were planted on July 19, 2018 with 20.32 cm × 20.32 cm spacing. In each line, 8 clumps were planted. In each bed, there were 4 lines. Thus a total of 32 (4× 8) clumps were planted in each bed defined as replication or block.

**Maintenance of the experimental plot**

The experimental plot was maintained by weeding and watering and protected from animal grazing up to 13 months (August 30, 2019)(Figure 02).

**Figure 02. The experimental plantation of vetiver (left), a single clump of vetiver (right)**

**Data collection and analysis**

After 3 months (October 21, 2018) and after 13 months (September 1, 2019) data on survival of the clumps and number of tiller in each clump were collected to find out the increment of tiller number. After 3 months data were collected at standing position. After 13 months (September 1, 2019) finally, data were collected on tiller number, root and shoot growth by uprooting the clumps and washing with water by counting tiller and measuring root and shoot length. The measuring tape was used for measurement. Data were computed and analyzed through an Excel spreadsheet and SPSS statistical programme as stated elsewhere.

## III. Results and Discussion

Survival percentage of vetiver clumps was found 96.354± 0.354 for $T_1$ (without fertilizer) and 97.916± 1.802 for $T_2$ (with NPK fertilizer) after 3 months (Table 02). After 13 months (92.187± 1.562) % and (93.750±3.125) % survivability was found in $T_1$ and $T_2$ respectively (Table 02). Moula and Rahman (2008) found 96.79% survivability after 12 months. Xia (2003) in his two month period of study found 81% survivability. In the present study, the survival percentage was higher than Xia (2003) and lowers than Moula and Rahman (2008). These differences may be due to different climatic conditions and management practices.

**Table 02. Survival of clumps of vetiver after 3 and 13 months**

| Treatment | Survival after 3 months (%) (Mean ±SD) | Survival after 13 months (%) (Mean ±SD) |
|---|---|---|
| $T_1$ (without fertilizer) | 96.354± 0.354 | 92.187± 1.562 |
| $T_2$ ( with NPK fertilizer) | 97.916± 1.802 | 93.750± 3.125 |

In this study clumps with two tillers were planted. After 3 months average tiller increment (nos) were found 2.677± 0.252 and 5.877±0.434 respectively in $T_1$ and $T_2$ (Table 03). After 13 months the average tiller increment (nos) was found 14.522±0.691 and 21.288±0.477 respectively in $T_1$ and $T_2$ (Table 03). After 3 months CV value was higher in $T_1$ (9.413) than $T_2$ (7.384) (Table 03). CV value was also higher in $T_1$ (4.756) than $T_2$ (2.239) after 13 months (Table 03). So the increment of tiller after 3 months and 13 months in $T_2$ was more homogeneous than $T_1$. After 3 months observed value of 't' by independent t test is 11.022 and P value was 0.000 (less than 0.05). After 13 months observed value of 't' by independent t test was 13.958 and P value was 0.000 (less than 0.05). So at 5% significance level, there was very highly significant difference between $T_1$ and $T_2$ after 3 and 13 months in tiller increment. Xia (2003) in his two months study found the net increment of tiller 1.30 whereas Moula and Rahman (2008) were found 16.99 after 12 month study using same dose of NPK. Yoon (1993) found the net increment of tiller as 6.2 nos and 5.2 nos for the single and triple tillers. Kumar and Nikhil (2016) in their pot experiment found 1.5 nos (tiller increment 0.5) and 3 nos (tiller increment 2.0) tiller after 39 and 65 days in control where initial planting tiller was 1. Using NPK they found 2.42 nos and 3.13 nos after 39 and 65 days respectively (tiller increment were 1.42 and 2.13). The tiller increment was higher than Xia (2003), Moula and Rahman (2008) and Kumar and Nikhil (2016) may be due the longer experimental time.

**Table 03. Tiller increment after 3 months and after 13 months**

| Treatment | Tiller increment after 3 months | | Tiller increment after 13 months | |
|---|---|---|---|---|
| | (Mean ±SD) | CV Value | (Mean ±SD) | CV Value |
| $T_1$ (without fertilizer) | 2.677± 0.252 | 9.413 | 14.522 ± 0.691 | 4.756 |
| $T_2$ ( with NPK fertilizer) | 5.877 ± 0.434 | 7.384 | 21.288 ± 0.477 | 2.239 |

In the present study the average initial root and shoot length were 22.022±0.601cm and 76.755±9.1499 cm during planting time in $T_1$ (Table 04). On the other hand, the average initial root and shoot length were 22.722±3.54 cm and 65.66±14.611cm (Table 04). After 13 months average roots length in $T_1$ and $T_2$ were measured 23.123±1.272 cm and 24.422±3.106 cm (Table 04) respectively. Here CV value was higher in $T_2$ (12.718) than $T_1$ (5.500). So the root growth in $T_1$ was more homogenous than $T_2$. The observed value of 't' by independent t test was 0.669 and P value was 0.540 (greater than 0.05). The shoot length was measured 143.103±20.378 cm in $T_1$ and 176.633±24.03cm in $T_2$. Here CV value in $T_1$ (14.240) was higher than in $T_2$ (13.630). So the shoot growth in $T_2$ was more homogenous than $T_1$. The observed value of the independent 't' test was 1.841 and P value was 0.139 (greater than 0.05). So at 5% significance level there was no significant

difference of root and shoots growth between $T_1$ and $T_2$. After 13 months the mean increment of root and shoot were calculated 1.101 cm and 66.348 cm in $T_1$. In $T_2$ the mean increment of root and shoot length were calculated 1.7 cm and 110.973 cm. Kumar and Nikhil (2016) found root and shoot length 14.9 cm (increment 9.9 cm) and 21.4 cm (increment 6.9 cm) respectively after 39 and 65 days in control. They reported 17.55 cm (increment 12.55 cm) and 31.75 cm (increment 16.75 cm) root and shoot length using NPK (40.0 ka ammonium sulphate containing 20.5% N/ha, 350.0 kg of calcium super phosphate containing 15.5% $P_2O_5$/ha and: 75 kg of Potassium sulphate containing 48% $K_2O$) after 39 and 65 days. The increment of root both in control and NPK fertilizer by Kumar and Nikhil (2016) was higher than the present study. On the other hand increment of shoot both in control and with fertilizer (NPK) was lower than the present study. These differences may be due to pot experiment vs field experiment and management practices.

**Table 04. Root length and shoot length increment after 13 months**

| Treatment | Initial root length ( cm) (Mean ± SD) | Initial shoot length (cm) (Mean ±SD) | Root length after 13 months | | | Shoot length after 13 months | | |
|---|---|---|---|---|---|---|---|---|
| | | | (Mean ±SD) | CV Value | Average root increment (cm) | (Mean ±SD) | CV Value | Average shoot increment (cm) |
| $T_1$ | 22.022 ± 0.601 | 76.755± 9.1499 | 23.123 ± 1.272 | 5.500 | 1.101 | 143.103± 20.378 | 14.240 | 66.348 |
| $T_2$ | 22.722 ± 3.548 | 65.66 ± 14.611 | 24.422 ± 3.106 | 12.718 | 1.7 | 176.633± 24.075 | 13.630 | 110.973 |

## V. Conclusion

The survivability of clumps as well as the increment of tiller root and shoot using NPK fertilizer was higher than control (without fertilizer). The productivity or biomass of vetiver grass depends on the survivability of the clumps, increment of tiller, root length and shoot length. Considering the increment of tiller in the present study we concluded to use NPK fertilizer for the mass propagation of vetiver grass. Bangladesh is highly a flood-prone region. Erosion, problems and flood control embankments are continuously being damaged by floods, devastation cyclone, tidal surges causing damage to lives and properties of the peoples. There is a great potential for the use of vetiver grass for the protection of coastal and river embankments by planting vetiver grass using NPK fertilizer.

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**APA**
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**Chicago**
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**Harvard**
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**Vancouver**
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