# Effect of Plant Spacing in the Nursery on the Production of Planting Materials for Field Establishment of Vetiver Grass

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## Summary

*A study was conducted between June and October, 2001, at the Teaching and Research Farm of the University of Ibadan (7° 24' N, 3° 54' E), Nigeria, to evaluate the effect of plant spacing in the nursery on the growth of vetiver grass (*Vetiveria zizanioides *L.) so as to determine the optimum plant spacing in the nursery for the production of planting materials for field establishment. Four spacings, 20 x 30 cm$^2$, 15 x 40 cm$^2$, 20 x 40 cm$^2$ and 40 x 40 cm$^2$, were replicated four times and laid out in a randomized complete block design. Treatment plots measured 4 m x 4 m. Per stand, two vetiver tillers were planted on flat seedbeds. Parameters assessed included plant height, dry matter yield and tiller production. Shoot, root and total plant dry matter and tiller count were measured at 16 weeks after planting (WAP). Spacing had no effect (P< 0.05) on plant height but impacted very significantly (P< 0.01) on root, shoot and total plant dry matter production, which increased with wider spacing. In a spatial context, dry matter yield per hectare was least in the widest spacing. Spacing had no effect (P< 0.05) on number of tillers produced per planted tiller (multiplication rate) but it had a very significant effect (P< 0.01) on the number of tillers produced per unit area. The closest spacings, 20 x 30 cm$^2$ and 15 x 40 cm$^2$, which gave the highest number of tillers per hectare (203.3 x 10$^4$ and 196.7 x 10$^4$, respectively), were recommended for production of planting materials in the nursery.*

## Résumé

### Etude de l'influence des écartements en pépinière sur la production du matériel de plantation de Vétiver

*Une étude a été réalisée entre juin et octobre 2001 à la station de recherche de l'Université d'Ibadan (7° 24' N, 3° 54' E) au Nigeria pour déterminer les écartements en pépinière assurant la meilleure croissance du vétiver (*Vetiveria zizanioides *L.) et permettant de produire du bon matériel destiné à la plantation en champs. L'essai a été effectué en quatre répétitions, un dispositif en blocs (des billons plats mesurant 4 x 4 m$^2$) aléatoires complets avec quatre écartements (20 x 30 cm$^2$, 15 x 40 cm$^2$, 20 x 40 cm$^2$ et 40 x 40 cm$^2$). Le vétiver a été planté à raison de deux talles par poquet. Les paramètres étudiés, (la taille des plants, la production en matière sèche et le nombre de talles), ont été évalués 16 semaines après plantation (SAP). Les résultats obtenus montrent que l'écartement n'a pas un effet significatif (P< 0,05) sur la taille des plants. Par contre, un effet très significatif (P< 0,01) des écartements a été observé sur le nombre de racines, le nombre de talles ainsi que la matière sèche totale. Cette différence significative augmente avec la taille des écartements. De plus, il a été constaté que la quantité de matière sèche produite par hectare était inversement proportionnelle à la taille des écartements. En outre, il a été observé que les écartements n'avaient pas d'effets significatifs (P< 0,05) sur le nombre de talles produit par talles plantés alors qu'ils influençaient significativement (P< 0,01) le nombre de talles produit par unité de surface. Les plus petits écartements (20 x 30 cm$^2$ et 15 x 40 cm$^2$), qui ont produit le plus grand nombre de talles (respectivement 203,3 x 10$^4$ et 196,7 x 10$^4$ talles) par hectare sont à recommander en pépinière pour la production du matériel de plantation de vétiver.*


## Introduction

Of Africa's total land area of three billion hectares, 60% or 1.8 billion hectares suffers the risk of accelerated erosion due to various types of soil abuse especially when appropriate soil and water conservation measures are not taken (7). Though there are as yet no quantitative estimates on a national scale of the extent of erosion in Nigeria, the fact of its occurrence, growing spread and intensity is not, by any means, in

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doubt. Nigeria currently accounts for 15% of Africa's population and has a relatively high population density of 228 per square kilometer as against the world's average of 75 per square kilometer (12). Its population growth rate of 2.8% is high compared to the world's average of 1.3% (13).

Given its relatively high population growth rate its land resources are increasingly under pressure to produce substantial amounts of food to sustain the growing population. This profoundly increases the probability of land overuse and the tendency for poor soil management. Given the high erodibility of Nigerian soils (1, 2, 3) poor soil management will ultimately result in accelerated soil erosion. A large proportion of plant nutrients for arable crop growth are contained in the top soil, hence, soil erosion constrains soil fertility and impoverishes the soil's physical structure. Soil erosion impacts negatively on crop yield, environmental quality and socio-economic development of developing nations (4). To curb physical land degradation and maintain soil productivity on a sustainable basis, the use of vegetative soil and moisture conservation measures that are cheap, replicable, sustainable and effective are required. According to the World Bank (20), strips of vetiver grass (*Vetiveria zizanioides* L.*)* as a phytoremedy to soil erosion have demonstrated superiority over other measures in a wide range of climatic environments. Vetiver grass is a tropical plant (3) belonging to the family *Graminae* (*Poaceae*), subfamily *Panicoideae* (*Andropogonidae*), tribe *Andropogoneae*, subtribe *Sorghinae* (6). It grows in a wide range of climatic environments (18) but grows luxuriantly in areas with an annual rainfall of 1,000 to 2,000 mm at temperatures ranging from 21 $^{o}$C to 44.5 $^{o}$C (19). Of the 12 and about a 100 cultivars of vetiver grass (6), it is the cultivated variety of *Vetiveria zizanioides* that is recommended for soil and water conservation (20). This specie appears in a dense clump of about 30 cm diameter and grows fast through tillering. The culm can grow to a height of about 3 m and the roots to a depth of more than 3 m (4). Once planted in a hedge row, the culms form a dense hedge which acts as a filter against runoff and soil wash. The network of its roots increases the resistance of the soil to erosion because the roots increase the soil's shear strength by 30 - 40% (17).

Though Nigeria is one of several countries in the tropics that the cultivated *Vetiveria zizanioides* is known to exist (19), its potential for soil conservation had not been recognized (14). The vetiver technology is now being introduced in Nigeria. However, the use of the grass in the field for soil conservation is being constrained by its low availability (2). There is, therefore, the urgent need to raise planting materials in nurseries for intending users. Nursery plants are sufficiently developed for field establishment at 16 weeks after planting (22). Plant spacing is known to impact on growth and production of tillers in vetiver grass in the nursery (10, 22). Depending on soil and climate, intra- and inter-row spacings of 15 - 40 cm and 30 - 40 cm, respectively, have been adopted in nurseries (4). This study was carried out to determine the optimum plant spacing in the nursery for the production of planting materials in the humid region of Nigeria for field establishment.

## Material and methods

The study was conducted at the Teaching and Research Farm of the University of Ibadan, Nigeria, from June to October 2001. Ibadan is located at 7° 24' N and 3° 54' E with an altitude of 122 m above sea level. The weather data covering the duration of the study are presented in Table 1.

**Table 1**

**Weather data for Ibadan, Nigeria, for the months of June to October 2001**

| Month | Total rainfall | Total evaporation | Mean wind speed | Solar radiation | Temperature (°C) | | | Relative humidity (%) | | | Rainy days* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mm) | (mm) | (km/h) | (MJ/m$^2$/day) | Min | Max | Mean | Min | Max | Mean | |
| Jun | 260.5 | 92.3 | 1.8 | 12.11 | 22.1 | 28.7 | 25.4 | 79 | 99 | 89 | 22 |
| Jul | 242.1 | 89.7 | 1.8 | 11.95 | 21.6 | 28.4 | 25.0 | 75 | 99 | 87 | 16 |
| Aug | 251.7 | 88.9 | 1.8 | 10.35 | 21.4 | 27.8 | 24.6 | 77 | 99 | 88 | 14 |
| Sept | 236.2 | 116.9 | 1.9 | 13.11 | 22.1 | 29.5 | 25.8 | 72 | 99 | 85 | 20 |
| Oct | 103.8 | 135.8 | 1.8 | 15.35 | 22.1 | 30.8 | 26.4 | 64 | 99 | 81 | 9 |

Rainy day = rainfall > 0.2 mm

Source: Agroclimatology Unit of the International Centre for Tropical Agriculture, Ibadan.

According to the local classification system of Smyth and Montgomery (15) the soil used for the study belongs to the Iwo series. USDA classified it as an Oxic Paleustalf (16). The physico-chemical properties of the soil are presented in table 2.

The land was ploughed and harrowed prior to planting in order to obtain a seedbed with fine tilth. Inorganic fertilizer, NPK 15-15-15, was applied to the soil at the rate of 30 kg N.ha$^{-1}$ after ploughing and was worked into the soil during harrowing.

**Table 2**

**Physico-chemical properties of the soil used for the study**

| Parameter | Remark |
|---|---|
| pH (KCl; 1:1) | 6.0 |
| Organic carbon (%) | 1.54 |
| Organic matter (%) | 2.79 |
| Total nitrogen ($g.kg^{-1}$) | 5.88 |
| Available phosphorus ($mg.kg^{-1}$) | 16.48 |
| Exchangeable potassium ($Cmol.kg^{-1}$) | 5.71 |
| Fine sand ($g.kg^{-1}$) | 42 |
| Coarse sand ($g.kg^{-1}$) | 782 |
| Silt ($g.kg^{-1}$) | 100 |
| Clay ($g.kg^{-1}$) | 76 |
| Texture | loamy sand |
| Bulk density ($mg.m^{-3}$) | 1.53 |
| Total porosity | 0.42 |

Four plant spacings constituted the treatments, viz, 20 x 30 $cm^2$, 15 x 40 $cm^2$, 20 x 40 $cm^2$ and 40 x 40 $cm^2$, corresponding to plant populations of 166,667; 166,667; 125,000 and 62,500 per hectare, respectively. Even though the first and second spacings have the same number of plants per hectare, the justification for the inclusion of both is based on the observation of Yoon (22) that both intra- and inter-row spacings influence plant growth and production of tillers in vetiver grass. The first and second values describing each spacing indicate the intra- and inter-row spacings, respectively (for instance, the intra- and inter-row spacings in the first treatment are 20 cm and 30 cm, respectively). The treatments were replicated four times and laid out in a randomized complete block design. Treatment plots measured 4 x 4 $m^2$ with an inter-plot spacing of 1 m.

For planting material, four month old tillers were obtained from a vetiver nursery 0.5 m away from the location of the experiment. They were topped at 20 cm and roots cut at 15 cm and planted at two tillers per stand as recommended by Hanping (9) for good establishment of vetiver grass in the humid tropics. Planting was done at the beginning of the rainy season in order to minimize moisture stress and irrigation requirement. Weeding was done twice at four and ten weeks after planting (WAP).

Parameters assessed were plant height, tiller production and dry matter yield. Plant height measurements of 10 randomly selected plants (excluding border row plants) from each treatment plot were taken biweekly until 16 WAP, the age at which plants are sufficiently mature for field establishment (22). At 16 WAP, a count of the number of tillers produced per planted tiller was conducted. Ten plants from each plot were randomly selected and dug out for root length measurement and dry matter analysis. The selection excluded border rows. The roots of dug-up plants were washed under a gently running tap and severed from the shoots. The dry matter yield of roots and shoots was obtained by oven drying at 65 $^oC$ for three days, which enabled computations of dry matter yield per plant and per hectare, respectively.

Data were subjected to analysis of variance following the specifications of Gomez and Gomez (8) and means were separated using the Duncan multiple range test (DMRT).

## Results and discussion

There were no significant differences in plant height among spacings for the period of evaluation (Table 3).

Thus, spacing did not impact on plant height. Plant height at 16 WAP ranged from 100.2 cm to 105.7 cm.

On the contrary, significant differences were found in dry matter yield. Both shoot and root dry weights increased with spacing (Table 4).

For shoot dry weight at 16 WAP, the widest spacing of 40 x 40 $cm^2$ gave the highest shoot dry weight. The 20 x 30 $cm^2$ spacing had the lowest shoot dry weight of 12.92 $g.plant^{-1}$, which was, however, not significantly different ($P< 0.01$) from that of the 15 x 40 $cm^2$ spacing, which had 14.32 $g.plant^{-1}$. The 20 x 40 $cm^2$ spacing had a higher value, though not significantly, than the 15 x 40 $cm^2$. For dry root weight, the widest spacing (40 x 40 $cm^2$) maintained its superiority over the 20 x 30 $cm^2$ and 15 x 40 $cm^2$ spacings but unlike in shoot

**Table 3**

**Effect of plant spacing on plant height (cm) of vetiver grass**

| Spacing | Weeks after planting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (cm) | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| 20 x 30 | 35 1a | 47.3a | 62.1a | 73.4a | 85.1a | 92.0a | 97.0a | 100.2a |
| 15 x 40 | 34.3a | 46.0a | 63.0a | 75.1a | 83.1a | 91.5a | 96.5a | 103.4a |
| 20 x 40 | 36.8a | 45.9a | 65.4a | 77.5a | 86.3a | 93.3a | 98.3a | 104.1a |
| 40 x 40 | 33.2a | 48.5a | 67.1a | 80.0a | 89.2a | 93.9a | 98.9a | 105.7a |
| cv (%) | 8.5 | 8.0 | 7.8 | 9.2 | 7.7 | 6.6 | 4.3 | 5.9 |

Means followed by the same alphabet in a column are not significantly different (P= 0.05)

**Table 4**

**Effect of plant spacing on dry matter yield of vetiver grass at 16 weeks after planting**

| Spacing | Dry matter (DM) yield | | | |
|---|---|---|---|---|
| (cm) | Shoot | Root | Total plant | Total DM |
| | g.plant$^{-1}$ | g.plant$^{-1}$ | g.plant$^{-1}$ | kg.ha$^{-1}$ |
| 20 x 30 | $12.92_{c}$ | $6.24_{b}$ | $19.16_{c}$ | $3193.3^{a}$ |
| 15 x 40 | $14.32_{bc}$ | $6.60_{b}$ | $20.92_{bc}$ | $3486.7^{a}$ |
| 20 x 40 | $20.32_{b}$ | $7.50_{ab}$ | $27.82_{b}$ | $3477.5^{a}$ |
| 40 x 40 | $28.57_{a}$ | $9.30_{a}$ | $37.80_{a}$ | $2362.5^{b}$ |
| cv (%) | 13.5 | 9.7 | 9.8 | 12.7 |
| LSD (P= 0.01) | 7.8 | 2.3 | 7.9 | - |
| LSD (P= 0.05) | - | | | 79.6 |

Means followed by different subscripts and superscripts in a column are significantly different at P= 0.01 and P= 0.05, respectively.

dry weight, it did not differ significantly from the 20 x 40 cm$^2$ spacing.

Given that shoot dry weight ranged twice to thrice that of root dry weight, it contributed more to total plant dry weight, hence, the differences among treatments for total plant dry weight followed a similar trend as that of the shoot dry weight. The values increased with spacing, though there were no significant differences between the 20 x 30 cm$^2$ and 15 x 40 cm$^2$ and between 15 x 40 cm$^2$ and 40 x 40 cm$^2$ spacings, respectively. The results for dry matter yield indicate that wider spacing produces higher dry matter per clump as has been reported by the Vetiver Information Network (19) when intra-row spacings of 15 and 30 cm were compared. The total plant dry matter was multiplied by the number of stands per hectare to obtain the dry matter yield per hectare. There were no significant differences (P< 0.05) among the closest spacings for dry matter yield. The closest spacings had higher dry matter yield than the widest spacing. Whereas the effect of spacing on dry matter yield of individual plants was highly significant (P< 0.01) its effect on dry matter yield per unit area was only significant at 5% probability level.

Spacing had no effect on the multiplication rate of individual tillers but impacted on the number of tillers produced per unit area (Table 5).

The multiplication rate ranged from 5.9 to 6.4. Xuhu (21) reported a range of 3.48 to 6.15 in vetiver grass. On a unit area basis, number of tillers per hectare drastically decreased with spacing. The two closest spacings, 15 x 40 cm$^2$ and 20 x 30 cm$^2$, produced the highest number of tillers per hectare. That spacing influenced total plant dry matter but had no effect on

**Table 5**

**Effect of plant spacing on tiller production in vetiver grass at 16 weeks after planting**

| Spacing | Number of tillers | |
|---|---|---|
| (cm) | Tillers/planted tiller | Tillers/ha (x 10$^4$) |
| 20 x 30 | 6.1a | 203.3a |
| 15 x 40 | 5.9a | 196.7a |
| 20 x 40 | 6.4a | 160.0b |
| 40 x 40 | 6.3a | 78.8c |
| cv (%) | 3.5 | 2.9 |
| LSD (< 0.01) | - | 13.9 |

number of tillers per planted tiller at 16 WAP, indicates that the higher dry matter produced in wider spacings was not utilized in tiller production.

As spacing influenced dry matter production but had no effect on plant height, it is suggested that wider plant spacing afforded better plant vigour. This is corroborated by the report of Intaphan *et al.* (10) that wider spacing in vetiver grass enhanced plant vigour.

## Conclusion

The results obtained show that individual plants fare better at wider spacing, but closer spacing produces higher number of tillers per unit area. Among the spacings tested, the two closest spacings, 15 x 40 cm$^2$ and 20 x 30 cm$^2$, are recommended for the production of planting materials in the nursery because from the results obtained, they yielded the highest tiller production per unit area and is suitable for rapid multiplication of vetiver grass.

## Literature


1. Aina P.O., Lal R. & Taylor G.S., 1976, Soil and crop management in relation to soil erosion in the rainforest of western Nigeria. Soil Cons. Soc. Am. Special publ., Ankeny, Iowa, p. 75 - 82.
2. Babalola O., 2000, Soil management and conservation in Nigeria, *in*: University of Ibadan, Ibadan, Nigeria, Agronomy in Nigeria, p. 216 - 222.
3. Chaipattana Network Webmaster, 1996,http://www.chaipat.or.th/vetiver/vetiver_e.html
4. Greenfield J.C., 1989, Vetiver grass (*Vetiveria* spp.), The ideal plant for vegetative soil and moisture conservation. World Bank, 58 p.
5. Lal R., 1976, Soil erosion problems on an alfisol in western Nigeria and their control. IITA monograph #1, Ibadan, Nigeria.
6. Mekonnen A., 2000, Handbook on vetiver grass technology: from propagation to utilization, for Ethiopia. http://www.vetiver.com/ETH-handbook.htm.
7. FAO, 1990, The Conservation and rehabilitation of african lands: An International Scheme. Publication Nº. Arc 9014. FAO, Rome
8. Gomez K.A. & Gomez A.A., 1984, Statistical procedures for agricultural research. 2nd ed. John Wiley & Sons. 680 pp.
9. Hanping X., 1997, Observations and experiments on the multiplication, cultivation, and management of vetiver grass conducted in China in the 1950's. The Vetiver Newsletter, 18, 18 - 22.
10. Intaphan P., Boonches S. & Vathatum S., 1997, Study of optimum rows and different plant spacings of vetiver grass for soil erosion control on sloping land. The Vetiver Network, 17, 39.
11. Juliard C.L., 2000, Best practices - establishing a natural vetiver diffusion program: example of Madagascar, a country eroding into the sea. The Vetiver Network, 21, 29 - 35.
12. Population Reference Bureau, 2003a, Country Fact Sheets. http://www.prb.org/pdf/Nigeria_Eng.pdf
13. Population Reference Bureau, 2003b, 2002, World Population Data Sheet, http://www.prb.org/pdf/WorldPopulationDS02_Eng.pdf
14. Randev H.S., 1995, Vetiver grass technology in Nigeria, *in*: Grimshaw, R.G. & Helfer L. (eds). Vetiver grass for soil and water conservation, land rehabilitation and embankment stabilization. World Bank Tech. Paper, 273, 145 - 146.
15. Smyth A.J. & Montgomery R.F., 1962, Soils and land use in central western Nigeria. Govt. of western Nigeria Press, 265 pp.
16. Soil Survey Staff, 1975, Soil Taxonomy: A basic system of soil classification for making and interpreting soil surveys. USDA Agric. Handbook, 436 pp.
17. The Vetiver Network, 2003, http://www.vetiver.com/TVN_frontage_english.htm
18. Truong P., 2001, Vetiver Grass Technology: A tool against environmental degradation and desertification in Iberia. http://www.inpeco.pt/eng/environment/vetiver/vetiver.html
19. Vetiver Information Network, 1992, Vetiver newsletter. #8. World Bank, 22 p.
20. World Bank, 1990, Vetiver Grass: The hedge against erosion. 3rd ed. Washington, DC. 78 p.
21. Xuhu C., 1997, Effects of applying fertilizer to vetiver grass for erosion control. Vetiver Newsletter, 17, 22 - 26.
22. Yoon P.K., 1993, A look-see at vetiver grass in Malaysia, Part 2: Establishment and management of quality vetiver hedgerows. Vetiver Information Network. 53 pp.



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