Production Potential of Vetiver (*Vetiveria zizanioides* L.) as Affected by Different Planting Methods and Spacings

N. D. N. Priyadarshani, M. K. T. K. Amarasinghe, S. Subasinghe, I. R. Palihakkara and H. K. M. S Kumarasinghe

Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Sri Lanka

Abstract

Present study was undertaken to find out suitable planting method and spacing combination in order to enhance the biomass production, harvestable root yield and oil content of Vetiver. Experiment on production potential of Vetiver (*Vetiveria zizanioides* L.) under different planting methods was carried out using three different planting methods (*i.e.* ridge and furrow system, planting pits and beds). It was followed a Randomized Complete Block Design with five replicates. Experiment on growth and production potential of Vetiver (*Vetiveria zizanioides* L.) under different spacing combinations was carried out in Two Way Parallel Row Design using fifteen different spacing combinations and four replicates. Results of these studies revealed that different planting methods as well as spacing combinations had significant impact on biomass production, un-harvestable root yield as well as oil yield of Vetiver. Significantly higher ($P<0.05$) growth and yield parameters were recorded in both ridge and furrow system followed by bed method with compared to pit method. Spacing of 80 × 60 cm^2 resulted in significant ($P<0.05$) increase in all the growth and yield parameters. Thus, Vetiver planted in ridge and furrow system with 80 × 60 cm^2 could be used to enhance biomass production, root oil content as well as harvestable root yield of Vetiver.

Keywords: *Oil yield, Planting method, Spacing combination, Un-harvestable root yield*

INTRODUCTION

Vetiver (*Vetiveria zizanioides* L.) is a valuable medicinal and aromatic plant used in both indigenous medicine and perfumery industry. The root system of Vetiver is consisting of long fibrous roots and rootlets which grow more than 2m depth but about 80% of the roots can be found in the first 30-35 cm (Peyron, 1989). Even after the careful harvesting, 40% of the roots remain in the soil resulted in poor root yield with highly damaged roots. Damaged roots are easily attacked by the fungus resulting drastical reduction of quality of roots and root oil. On the other hand, cost of labour and time consuming for harvesting is also increased and thereby increase the cost of production. Therefore, use of proper planting system and spacing are vital factors for the crops grown especially for their roots to facilitate easy root harvesting because spacing and planting method had direct impact on the biomass production, oil content *etc.* of the crops (Vinod kumar and Meenu sood, 2011; Saini *et al.*, 2002). Although, some researchers found suitable planting method and optimum spacing of Vetiver for soil conservation purposes, there are no such studies conducted for improvement of production potential of Vetiver. Therefore, the objective of this study was to find out suitable planting method and spacing combination in order to enhance the production potential of root yield, oil content and harvestable root yield of Vetiver.

MATERIALS AND METHODS

Two separate field experiments were conducted at Medicinal plant garden, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Matara, Sri Lanka (14° 40' 29'' N and 39°25' 29''E). Soil type of the experimental field was Red Yellow Podsolic (According to the USDA soil Taxonomy) (Mapa *et. al.*, 1999). Climatic data such as average annual temperature (°C), annual rainfall (mm), average annual relative humidity (%) and average number of rainy days/year of the

experimental site for the year 2008 and 2009, were (29 °C, 29 °C), (204 mm, 199 mm), (79%, 77%) and (16.8, 15.3), respectively (Department of Agric. Engineering, Faculty of Agriculture, University of Ruhuna, Sri Lanka).

Experiment-I:Production potential of Vetiver (*Vetiveria zizanioides* L.) under different planting methods

In order to study the effect of planting method on growth, root yield as well as oil yield of Vetiver, an experiment was conducted as Randomized Complete Block Design with five replicates. Experimental treatments were included three different planting methods [*i.e.* ridge and furrow system (T_1), planting pits (T_2) and beds (T_3)]. Ridge and furrow system was constructed to a 30 cm height and size of planting pit was 30×30×30 cm^3. Planting beds were prepared as 1×3 m^2 and 30 cm in height. Four months old Vetiver tillers were planted in different planting methods using 80×30 cm^2 spacing (Maffei, 2002). In ridge and furrow planting system, ridges were used to plant the Vetiver tillers keeping a tiller per planting point.

Experiment-II:Production potential of Vetiver (*Vetiveria zizanioides* L.) under different spacing combinations

A field experiment was carried out to find the most suitable spacing for growth, root yield and oil yield of Vetiver using ridge and furrow system. Experimental field was ploughed to 30 cm depth to facilitate proper root penetration. Sand was added to the field to a top soil: sand (1:2) on a volume basis as a growing media for the proper root development (Priyadarshani *et al.*, 2010). Height of a ridge was 30 cm and ridges were used to plant the 4 month old Vetiver tillers keeping a tiller per planting point. The experiment was carried out using fifteen different treatment combinations with four replicates. Three different between row spacings (60, 80 and 100 cm) and five different within row spacings (30, 40, 50, 60 and 70cm) were employed for the Two Way Parallel Row Design.

Fifteen different treatment combinations used for the experiment were T_1: 30×60 cm^2; T_2: 30×80 cm^2; T_3: 30×100 cm^2; T_4: 40×60 cm^2; T_5: 40×80 cm^2; T_6: 40×100 cm^2; T_7: 50×60 cm^2; T_8: 50×80 cm^2; T_9: 50×100 cm^2; T_{10}: 60×60 cm^2; T_{11}: 60×80 cm^2; T_{12}: 60×100 cm^2; T_{13}: 70×60 cm^2; T_{14}: 70×80 cm^2; T_{15}: 70×100 cm^2. For both experiments, irrigation was carried out at two day intervals up to four weeks after planting for better establishment and survival. Thereafter, plants were exposed to rain fed conditions and weeding was carried out at monthly intervals. Harvesting was done at 6 and 9 months after planting. Data on growth and yield parameters such as number of leaves, number of tillers, dry weight of shoot and root, unharvestable root yield, ratio of unharvestable root yield in relation to total root production from each spacing combinations and oil content were taken. Steam distillation procedure was carried out for oil distillation (Maffei, 2002). The data analyses were carried out using SAS software (SAS version 6.12) and Duncan Multiple Range Test (DMRT) was employed for mean separation.

RESULTS

Experiment I

Different planting methods had significant ($P<0.05$) effect on biomass production and oil content of Vetiver. Significantly higher root dry weights (46 g and 74.6 g) (Figure 1a), shoot dry weights (153.4 g and 256 g) (Figure 1b), number of leaves (110 and 162) (Figure 1c), number of tillers (14 and 23) (Figure 1d) and oil content (1.2% and 1.53%) (Figure 1f) were observed in Vetiver planted in ridge and furrow system (T_1) at 6 and 9 months after planting, respectively followed by bed method for same parameters with compared to Vetiver planted in pit method (T_2). Vetiver planted in both beds and ridge and furrow system, root yield (dry weight) was nearly double than yield recorded in pit method (Figure 1a). Also significantly higher ($P< 0.05$) un-harvestable root yield (dry weights) was recorded in Vetiver planted in pits (T_2) (12.31g and 20.55g) compared to other planting methods of ridge and furrow system (T_1) (7.7g and 12.4g) and

ıd 13.82g) respectively at 6 and 9 months after planting (Figure 1e). Results
ɾe was a positive relationship between the oil yield and harvestable root yield
to the overall results of the experiment, Vetiver planted in ridge and furrow
ɜr biomass production and higher oil content compared to other planting

ı the effect of plant spacings on root dry weight, shoot dry weight, number of
ers and oil yield in Vetiver revealed that spacing of 80 × 60 cm^2 resulted in
ncrease in all the growth and yield parameters. At this spacing maximum root
), shoot dry weight (860.63 g), number of leaves (531) and number of tillers
ıt 9 months after planting (Figure 2a, 2b, 2c, 2d and 2e). There were no
:s ($P \geq 0.05$) in un-harvestable root yield: total roots among all spacing
· value for un-harvestable root yield: total roots was recorded from Vetiver
spacing compare to all spacing combinations.

present study reported that root fresh weight of 5560 kg/ha could be achieved
ɔlants on ridge and furrow system and harvested at 9 months after planting
f fertilizer. An average yield of 4,000-5,000 kg of fresh roots per hectare has
ifferent areas of South India (Chadha, 1995). He further revealed that a higher
ɔts, up to 7,600 kg/ha can be obtained under successful cultivation. In the
urther observed that Vetiver planted in pits were more resistant to harvesting
ıer root damage with compared to other treatments. This may badly affect the
ıt. These findings are in agreement with the findings reported by Lavania and
reported that it is desirable to identify proper planting method, because
ıce little or no oil. It was also observed that thicker bast area and high
ɾ roots in the Vetiver planted at the ridge and furrow system and beds than the
wever, in pit method high amount of secondary and tertiary roots were
ɔw and Barang (2002) observed that the essential oil is produced in the bast
ıed on account of secondary thickening. They further reported that primary
y to produce higher concentration of essential oil of good quality. Secondary
h primary roots will have little bast region, and the tertiary fibrous roots
ɔn, and are therefore not likely to produce good quality and sufficient quantity
hese may be the reasons to yield high amount of oil from the Vetiver planted
w system as well as beds compared to Vetiver planted in pits.
:d in beds and ridges provided loose soil texture for root growth, as well as
t harvesting. In pit method, growth media or soil become compact with time
ricted root growth as well as poor drainage and aeration conditions. This may
growth, root yield as well as significantly higher ($P \leq 0.05$) un-harvested yield
· planted in pits compared to ridge and furrow system and planting beds in this
dition is essential for proper growth and development of roots (Montagu *et al.*,
ɔarable with the findings of the present study. Soil compaction reduces root
educes shoot growth mainly due to restricting the volume of soil explored by
ıence the less availability of water and nutrients to the plant (Montagu *et al.*,

ıigher ($P \leq 0.05$) dry weights of shoot and roots, number of leaves and number
ɜd in Vetiver planted at 80×60 cm^2 (T_{11}) spacing compared to other spacings
after planting. Results of this study further revealed that, closer spacing
ılly within row spacing (such as 60×30 cm^2, 80×30 cm^2, 100×30 cm^2 and
plant spacing combinations (such as 100×50 cm^2, 100×60 cm^2, 80×70 cm^2

and 100×70 cm^2) have no positive impact on yield improvement of Vetiver. Spacing of 50×100 cm^2 (T_9), 60×100 cm^2 (T_{12}), 70×80 cm^2 (T_{14}) and 70×100 cm^2 (T_{15}) resulted in low yield compared to the yield from 80×60 cm^2. Generally, optimum plant spacing enables plant to capture solar radiation which in turn increases the photosynthesis of the plants and ultimately increase the biomass production of Vetiver. Wider spacing creates less competition for nutrients and sunlight. Unnecessarily wider spacing helps to waste the content and quality of the yield due to problems with weeds, soil erosion *etc.* and also waste the labour, time, natural resources as well as economic returns. Selection of particular plant spacing on a given locality is one of the most important long term decisions in the cultivation of Vetiver and may be the critical factor for sustained the productivity. This may be the reason to decline growth and yield reported in the wider and narrow spacing combinations. A density of approximately 40,000 plants/ha is considered optimal and is obtained by planting at intervals of 80 cm between the rows while the cuttings in the rows are planted at 30 cm intervals (Maffi, 2002). However, in the present study 80×30 cm^2 recorded relatively low growth and yield. This may be due to the competition for nutrients, sunlight and space *etc.* Kramer and Boyer (1995) reported that the size of root systems is usually reduced when they are grown in competition with other plants possibly due to competition for nutrients and water. It was observed in the present study that narrow spacing and wider spacing produced low oil yield compared to 80×60 cm^2 spacing. These spacing produced low root yield with more slender roots and this may be due to the competition effect. Slender roots produce low oil content. This may be the reason for the poor oil yield associated with narrow spacing and wider spacing. All spacing combinations had no significant difference for un-harvestable root yield in relation to their total root production. It was varied between 12-14% and Un-harvested root yield in relation to the total root production in Vetiver planted in the spacing of 80×60 cm^2 (T_{11}) was 13.7%. According to the findings of this study, it is evident that un-harvestable root yield is not depending on the spacing. It may depend on the type of the growing media and soil moisture content as well as planting method used. Increasing of un-harvestable root yield is not a good feature in a crop grown for roots. However, literature says that even after careful harvesting, 40% of the roots remain in the soil yielding highly damaged roots and poor root yield (Maffei *et al.*, 1995). Therefore, 80×60 cm^2 (T_{11}) spacing could be used to get satisfactory harvestable yield. Also ridge and furrow system was the most promising planting method in the sense of the harvestable root yield, oil yield as well as it facilitate the mechanical harvesting.

CONCLUSIONS

Vetiver plant on ridge and furrow system with the spacing of 80×60 cm^2 can be recommended to ensure higher growth, higher harvestable root yield as well as higher oil yield. However, further studies need to be carried out to find the effect of different soil moisture contents and different soil types on the harvestable root yield of Vetiver.

Acknowledgements

This work was supported by a grant from Ministry of Indigenous Medicine and the authors are grateful for the financial support.

REFERENCES

Chadha YR (1995) *The wealth of India*, A dictionary of Indian raw materials and industrial products, Raw materials vol. x-: sp-w, publications and information directorate, CSIR, New Delhi. pp. 451-456.

Chomchalow N and Barang M (2002) Proceedings of the Second International Conference on Vetiver: Vetiver and the Environment, Office of the Royal Development Projects Board, Bangkok. pp. 495-497.

Hunter J T, Ruffner HP, Volschenk CG and Le Roux DJ (1995) Partial defoliation of *Vitis vinifera L.* Effect on root growth, canopy efficiency, grape composition and wine quality, *American journal of enology and viticulture*, vol-46, pp.306-314.

Kramer PJ and Boyer JS (1995) *Water Relations of Plants and Soils*, Academic Press, San Diago, pp. 330-336.

Lavania UC and Kumar S (1998) Genomic manipulation in Vetiver to realize non-seeding eco-friendly cultivars for soil water conservation and essential oil production, Proceedings of the First International Conference on Vetiver, Office of the Royal Development Projects Board, Bangkok, pp.137-140.

Maffei M (2002) *Vetiveria* (the genus *Vetiveria*), Taylor and Francis publishers, London, p.191.

Maffei M, Scannerini S, Berta G and Mucciarelli M (1995) Photosynthetic enzyme activities in *Vetiveria zizanioides* cultivated in temperate climates, *Biochemical Systematics and Ecology*, pp. 27-32.

Mapa RB, Somsiri S and Nagarajah S (1999) Soils of the wet zone of Sri Lanka, Soil Science Society of Sri Lanka, pp. 23-92.

Montagu KD, Conroy JP and Atwell BJ (2001) The position of localized soil compaction determines root and subsequent shoot growth responses, *Journal of Experimental Botany*, Vol. 52, No. 364, pp. 2127-2133.

Priyadarshani NDN, Amarasinghe MKTK, Subasinghe S, Palihakkara IR and Kumarasinghe HKMS (2010) Effect of Potting Mixture on Plant Growth, Yield and Oil Quality of Vetiver (*Vetiveria zizanioides* L), *Tropical Agricultural Research and Extension*, Vol 13(4), pp. 110-111.

Peyron L (1989) Vetiver in perfumery, Quintessenza, Taylor and Francis publishers, London, pp. 4-14.

Richards D (1983) The grape root system, *Journal of horticultural sciences*, vol -54, pp. 127-128.

Saini SS, Jagmohan K and Gill BS (2002) Effect of planting methods and row spacings on the growth and development of Japanese Mint (*Mentha arvensis* L.) *Indian Perfumer,* vol 46(4): pp. 361-364

Vinod kumar and Meenu sood (2011) Effect of transplanting time, spacing and fertilizers on herbage and oil yield of *Mentha piperita* L. *International Journal of Farm Sciences*, vol 1(2), pp.68-74

Figures

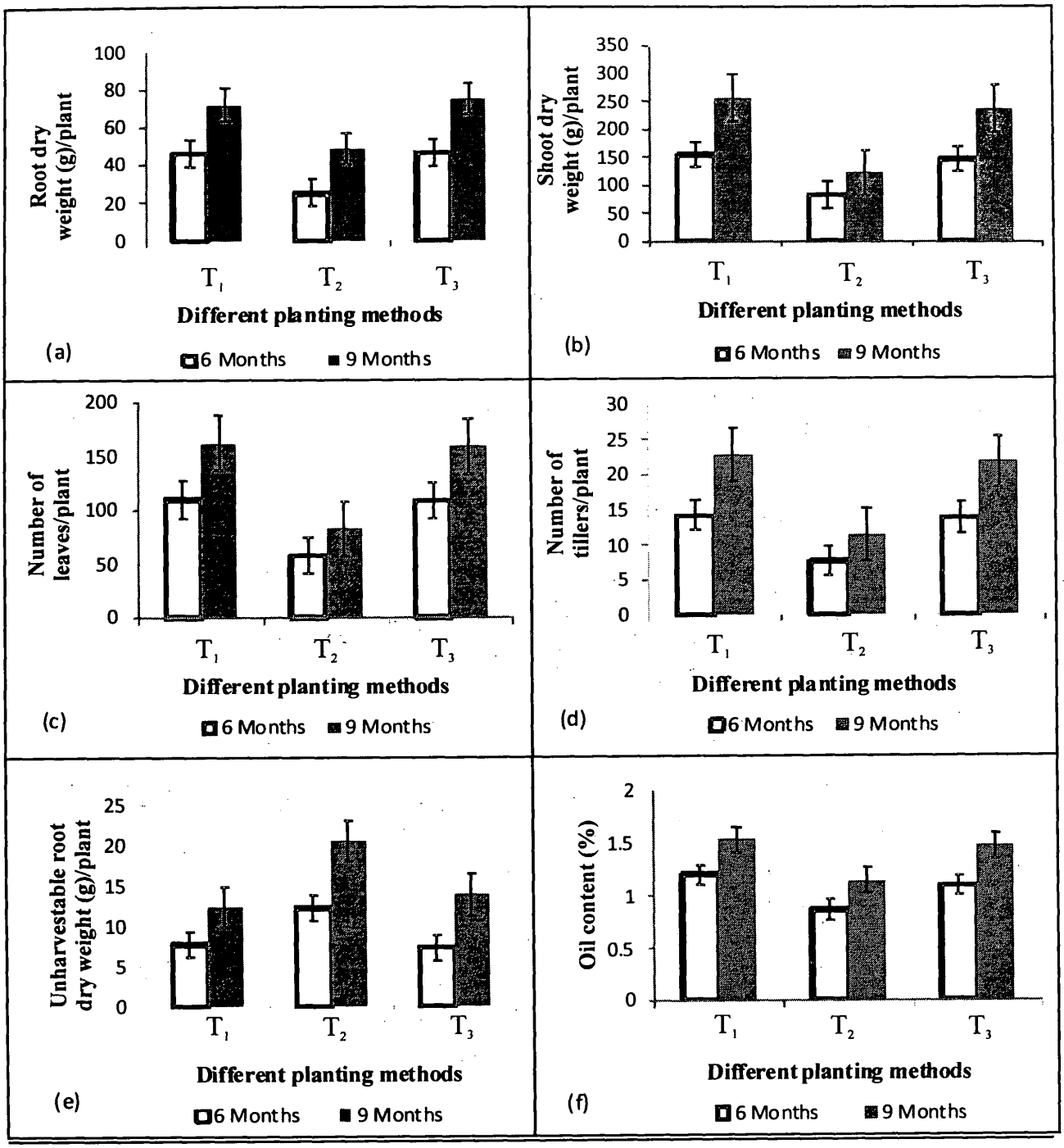

Figure 1: Changes in root dry weight (a), shoot dry weight (b), number of leaves (c), number of tillers (d), un-harvestable root dry weight (e) and oil content (f) of Vetiver with different planting methods at 6 and 9 months after planting.

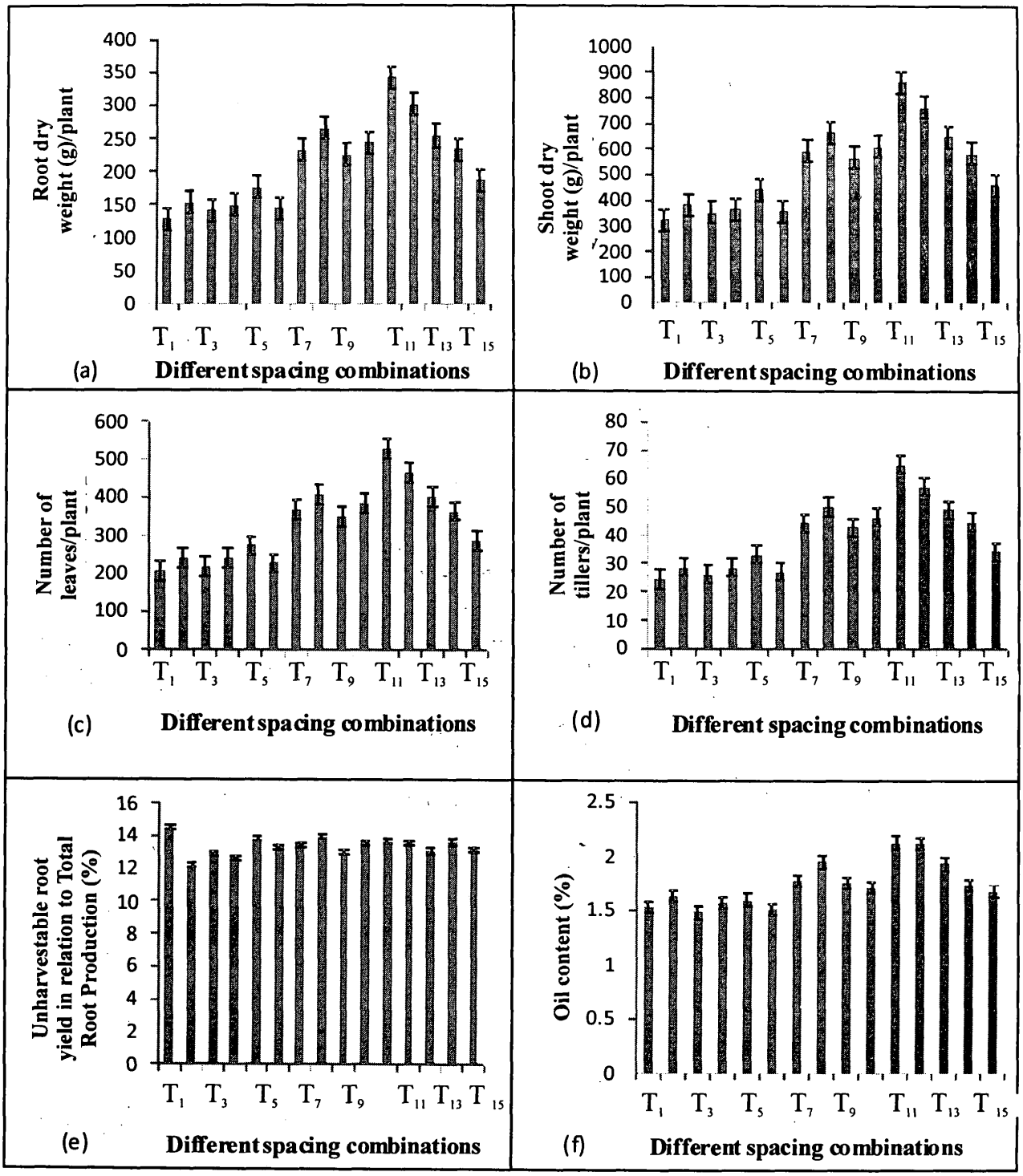

Figure 2: Changes in root dry weight (a), shoot dry weight (b), number of leaves (c), number of tillers (d), un-harvestable root dry weight (e) and oil content (f) of Vetiver with different spacing combinations at 9 months after planting.