TABLE OF CONTENT

TABLE OF CONTENT IV

LIST OF TABLES XI

LIST OF FIGURES XIII

LIST OF PLATES XVII

Acknowledgements XVIII

Abstract XIX

Chapter 1

General Introduction 1

1.1 Introduction 1

1.2 Objectives 3

1.2.1 Overall objective 3

1.2.2 Specific objectives 3

Chapter 2

Literature Review 4

2.1 Botany of the plant 4

2.2 Plant Classification 5

2.2.1. Scientific Classification of *Vetiveria zizanioides* (L.) 5

2.2.2. Different botanical names used for *Vetiveria zizanioides* (L.) 5

2.2.3. Synonyms used for *Vetiveria zizanioides* (L.) 6

2.3 Distribution of the plant 6

2.4 Climatic and soil requirements for the plant 7

2.4.1 Elevation 7

2.4.2 Temperature 7

2.4.3. Rainfall 7

2.4.4 Soil 7

2.4.4.1 Soil types 7

2.4.4.2 Soil pH 8

2.4.4.3 Soil nutrients 8

2.5 Uses of Vetiver plant 8

2.5.1 Medicinal uses of Vetiver plant 9

2.5.2 Other uses of Vetiver plant 10

2.6 Ethno-pharmacology and pharmacological characteristics of *Vetiveria zizanioides* 11

2.6.1. Antibiotic actions 11

2.6.2. Antimalarial action 11

2.6.3. Control of diabetes 11

2.6.4. Lotion 11

2.6.5. Side effects 12

2.6.6. Shelf life of processed roots 12

2.6.7. Precaution and contra-indications 12

2.7 Agronomic practices of Vetiver 12

2.7.1 Propagation 13

2.7.2 Nursery management practices 13

2.7.3. Planting technique of Vetiver 14

2.7.3.1. Preparing the soil for planting 14

2.7.3.2. Planting time 14

2.7.3.3. Planting density 15

2.7.3.4. Planting 15

2.7.4. Manuring and fertilization 15

2.7.5. Weed control 16

2.7.6. Irrigation 17

2.7.7. Earthing up 17

2.7.8. Pest and diseases 17

2.7.9. Inter cropping 18

2.7.10 Harvesting 18

2.7.11 Washing / Cleaning 19

2.7.12 Drying 19

2.8 Root yields 19

2.9 Storage of roots 20

2.10 Vetiver oil 20

2.10.1. Oil extraction techniques for Vetiver 20

2.10.1.1. Trituration of the roots 20

2.10.1.2 Distillation of the oil 21

2.10.1.3 Decantation and dehydration 22

2.10.1.4 Testing 22

2.10.2 Yield and quality of the oil 22

2.10.3 Storage of Vetiver oil 22

2.10.4. Characteristics of Vetiver oil 23

2.10.4.1. Physical characteristics of Vetiver oil 23

2.10.4.2. Chemical characteristics of oil 24

2.10.5 Demand and supply of Vetiver oil 26

2.11 Commercial cultivation of Vetiver 26

Chapter 3

Materials and Methods 28

3.1 Experimental sites and description of the sites 28

3.1.1 Climatic data and soil conditions of the experimental site 28

3.2 Nursery management practices for planting material production 30

3.3 Selection of the most promising potting mixture for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 31

3.3.1 Determination of the total oil content 32

3.3.2 Determination of the oil quality 33

3.4 Selection of the most promising compost mixture for better growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 34

3.5 Selection of the most suitable pot height and harvesting stage for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 36

3.5.1 Determination of root fiber content of Vetiver 36

3.6 Selection of the most promising fertilizer mixture and irrigation frequency for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 37

3.7 Selection of the most suitable planting method for optimum growth and yield of Vetiver (*Vetiveria zizanioides*) 40

3.8 Selection of the most promising plant spacing for optimum growth and yield of Vetiver (*Vetiveria zizanioides*) 41

3.9 Selection of the most promising organic and inorganic fertilizer mixture for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 43

Chapter 4

Results and Discussion 45

4.1 Selection of the best potting mixture for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 45

4.1.1 Effect of different potting mixtures on biomass production of Vetiver 45

4.1.2 Effect of different potting mixtures on oil content and oil quality of Vetiver ... 50

4.2 Selection of the best compost mixture for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 54

4.2.1 Background 54

4.2.2 Effect of different compost mixtures on biomass production of Vetiver 54

4.2.3 Effect of different compost mixtures on oil content and oil quality of Vetiver . 57

4.3 Selection of the most suitable pot height and harvesting stage for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 63

4.3.1 Effect of different pot heights and harvesting stages on biomass production of Vetiver 63

4.3.2 Effect of different harvesting stages on oil content and oil quality of Vetiver .. 66

4.4 Selection of the most promising fertilizer mixture and irrigation frequency for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 74

4.4.1 Effect of fertilizer mixtures and irrigation frequencies on biomass production of Vetiver 74

4.4.2 Effect of fertilizer mixtures and irrigation frequencies on oil content and oil quality of Vetiver 77

4.5 Selection of the most suitable planting method for optimum growth and yield of Vetiver (*Vetiveria zizanioides*) 82

4.5.1 Effect of different planting methods on biomass production of Vetiver 82

4.5.2 Effect of different planting methods on oil content of Vetiver 86

4.5.3 Observations on roots morphology 87

4.5.4 Income- expenditure analysis 88

4.6 Selection of the most promising plant spacing for optimum growth and yield of Vetiver (*Vetiveria zizanioides*) 91

4.6.1 Effect of different plant spacings on biomass production of Vetiver 91

4.6.2 Effect of different plant spacings on oil content of Vetiver 96

4.7 Selection of the most promising fertilizer mixture for optimum growth, yield and oil quality of Vetiver (*Vetiveria zizanioides*) 98

4.7.1 Effect of different fertilizer mixtures on biomass production of Vetiver 98

4.7.2 Effect of different fertilizer mixtures on oil content and oil quality of Vetiver 101

Chapter 5

Conclusions and Recommendations 107

5.1 Conclusions 107

5.2 Recommendations 108

5.2.1 Cultivation of Vetiver in pots 108

5.2.2 Cultivation of Vetiver in field 108

References 109

LIST OF TABLES

Table	Title	Page

Table 2.1: Main characteristics of the best Vetiver oil 23

Table 3.1: Monthly average Climatic data [Temperature (T), Rainfall (RF), Relative humidity (RH) and Number of rainy days (NRD)] of the experimental site for the study period from January 2007 to May 2010. 29

Table 3.2: Different combinations of organic and inorganic fertilizer 38

Table 3.3: Chemical composition of compost used in the pot experiment 38

Table 3.4: Different mixtures of organic and inorganic fertilizers 44

Table 4.1: Changes in root and shoot dry weight (g)/plant of Vetiver as affected by different potting mixtures at different harvesting stages. 46

Table 4.2: Changes in number of leaves/plant and tillers/plant of Vetiver as affected by different potting mixtures at different harvesting stages. 47

Table 4.3: The changes in oil content (%) and oil quality of Vetiver grown in different potting mixtures 51

Table 4.4: Chemical composition of two compost types used in the experiment 54

Table 4.5: Changes in root dry weight (g/plant), shoot dry weight (g/plant), number of leaves/plant, number of tillers/plant of Vetiver as affected by different pot heights (cm) at different harvesting stages 64

Table 4.6: Changes in root and shoot dry weight (g/plant), number of leaves (plant) and number of tillers (plant) of Vetiver as affected by different percentages of organic and inorganic fertilizers and irrigation frequencies at 9 months after planting. .. 75

Table 4.7: Changes of oil content and different chemical compounds in Vetiver as affected by different ratios of organic and inorganic fertilizers and irrigation frequencies at 9 months after planting 79

Table 4.8: Income-expenditure analysis for Vetiver in different planting methods 89

LIST OF FIGURES

Figure	Title	Page

Figure 2.1: Structural formulae of main active ingredients (α-vetivone, β- vetivone, Iso-valencenol, Khusimol and β- vetivenene) present in Vetiver oil 25

Figure 3.1: Diagrammatic illustration of Vetiver oil quality determination path..... 33

Figure 4.1: Changes in root dry weight (g)/plant of Vetiver with different compost mixtures at 6 and 9 months after planting. 55

Figure 4.2: Changes in shoot dry weight (g)/plant of Vetiver with different compost mixtures at 6 and 9 months after planting 55

Figure 4.3: Changes in number of leaves/plant of Vetiver with different compost mixtures at 6 and 9 months after planting. 56

Figure 4.4: Changes in number of tillers/plant of Vetiver with different compost mixtures at 6 and 9 months after planting. 56

Figure 4.5: Changes in oil content (%) of Vetiver with different compost mixtures at 9 months after planting. 58

Figure 4.6: Changes in β-Vetivenene (%) of Vetiver with different compost mixtures at 9 months of planting..... 59

Figure 4.7: Changes in Khusimol (%) of Vetiver with different compost mixtures at 9 months of planting..... 59

Figure 4.8: Changes in Isovaloncenol (%) of Vetiver with different compost mixtures at 9 months of planting. 60

Figure 4.9: Changes in α-Vetivone (%) of Vetiver with different compost mixtures at 9 months of planting. 60

Figure 4.10: Changes in β-Vetivone (%) of Vetiver with different compost mixtures at 9 months of planting. 61

Figure 4.11: Changes in oil content (%) of Vetiver as affected by different harvesting intervals. 66

Figure 4.12: Changes in Khusimol content (%) of Vetiver with different harvesting intervals. 67

Figure 4.13: Changes in β - Vetivenene content (%) of Vetiver with different harvesting intervals. 68

Figure 4.14: Changes in β - Vetivone content (%) of Vetiver with different harvesting intervals 68

Figure 4.15: Changes in α - Vetivone content (%) of Vetiver with different harvesting intervals. 69

Figure 4.16: Changes in Iso-valencinol content (%) of Vetiver with different harvesting intervals 70

Figure 4.17: Changes in root fiber content (%) of Vetiver as affected by different harvesting intervals 70

Figure 4.18: Impact of different planting methods on root dry weight of Vetiver at 6 and 9 months after planting. 82

Figure 4.19: Impact of different planting methods on shoot dry weight of Vetiver at 6 and 9 months after planting. 83

Figure 4.20: Impact of different planting methods on number of leaves of Vetiver at 6 and 9 months after planting. 83

Figure 4.21: Impact of different planting methods on number of tillers of Vetiver at 6 and 9 months after planting. 84

Figure 4.22: Impact of different planting methods on non-harvestable root dry weight of Vetiver at 6 and 9 months after planting. 85

Figure 4.23: Impact of different planting methods on oil content (%) of Vetiver at 6 and 9 months after planting 86

Figure 4.24: Changes in root dry weight (g) of Vetiver at different spacings at 9 months after planting. 91

Figure 4.25: Changes in shoot dry weight (g) of Vetiver at different spacings at 9 months after planting. 92

Figure 4.26: Changes in number of leaves of Vetiver at different spacings at 9 months after planting. 92

Figure 4.27: Changes in number of tillers of Vetiver at different spacings at 9 months after planting. 93

Figure 4.28: Changes in non-harvestable root dry weight (g) of Vetiver at different spacings at 9 months of planting. 94

Figure 4.29: Changes in oil content (%) of Vetiver at different spacings at 9 months of planting. 97

Figure 4.30: Changes in root dry weight (g) of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 98

Figure 4.31: Changes in shoot dry weight (g) of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 99

Figure 4.32: Changes in number of leaves of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 99

Figure 4.33: Changes in number of tillers of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 100

Figure 4.34: Changes in oil content (%) of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 102

Figure 4.35: Changes in β – Vetivenene content (%) of Vetiver with different rates of organic and inorganic fertilizers at 9 months after planting. 102

Figure 4.36: Changes in β – Vetivone content (%) of Vetiver with different levels of organic and inorganic fertilizers at 9 months after planting. 103

Figure 4.37: Changes in Khusimol content (%) of Vetiver with different levels of organic and inorganic fertilizers at 9 months after planting..... 104

Figure 4.38: Changes in α - Vetivone content (%) of Vetiver with different levels of organic and inorganic fertilizers at 9 months after planting. 104

Figure 4.39: Changes in Iso- valencinol content (%) of Vetiver with different levels of organic and inorganic fertilizers at 9 months after planting. 105

LIST OF PLATES

Plate **Title** **Page**

Plate 3.1: Soxhlet apparatus for extraction of Vetiver root oil in the laboratory 32

Plate 4.1: Vetiver roots and rootlets grown in the top soil: sand (1:2) (a) top soil: sand: coir dust (1:2:2) (b) potting mixtures 50

Plate 4.2: Vetiver roots forming a mat at the bottom of the pot 65

Plate 4.3: Root system of Vetiver grown in ridges and furrows (a), raised beds (b) and planting pits (c) 87