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HARVEST AGE AND PLANTING DENSITY EFFECTS ON YIELD AND QUALITY OF TWO KENAF (HIBISCUS CANNABINUS l.) VARIETIES FOR FIBRE AND ANIMAL FEED

MASNIRA BINTI MOHAMMAD YUSOFF

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By

MASNIRA BINTI MOHAMMAD YUSOFF

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

April 2015

Specially dedicated to my husband, family and friends for their continued support and everlasting love

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Science

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Chairman: **Associate Prof. Mohd Ridzwan bin Abd Halim, PhD**
Faculty: **Agriculture**

Kenaf (*Hibiscus cannabinus* L.*)* has been identified as a viable alternative crop to replace tobacco in Malaysian agriculture in the 21st century. Kenaf can be utilized for multiple purposes, whether for industrial applications or for livestock feed. Much information on components of yield such as plant height and density, stalk and leaf yield and total biomass have been obtained for the variety V 36. However, information on the new variety, MHC 123 is lacking, especially the understanding on how the yield components are affected by plant density and age. As plant density usually has an interaction with variety and harvest age the study looked at these factors in factorial combinations. From this information the optimum age and planting density for production of feed and fibre can be determined. The study was comprised of two experiments, one looking at harvest age and the other one on planting density effect.

The first experiment had four harvest age treatments (8, 12, 16 and 20 weeks after planting) and two varieties (MHC 123 and V 36) as the treatments. The results indicated that the most suitable harvesting age for forage for kenaf variety V 36 was at 8 weeks after planting (WAP) while for MHC 123 it was at 12 WAP. This is based on the low decline in crude protein content from 8 to 12 WAP in MHC 123 (18.9 to 17. 2 %) compared to the rapid decline for V 36 (21.7 to 11.3 %). In addition, acid detergent fibre content in MHC 123 increased slowly (31.7 to 36.9 %) but in V 36 it increased drastically (39.5 to 55.6 %) from 8 to 12 WAP. Dry matter yield also was higher at 12 WAP (11.2 t ha^{-1}) compared with 8 WAP (8.5 t ha^{-1}) for MHC 123.

The harvesting age for fibre was based on biomass yield and fibre quality (tensile strength, water absorption, bast and core yield). The suitable harvesting age for MHC 123 and V 36 were at same age, 16 WAP. However, MHC 123 had greater biomass yield with 11.7 t ha^{-1} compared to V 36 which was 8.7 t ha^{-1}. The tensile strength of the fibre from MHC 123 (101.7 MPa) was higher than that of V 36 (59.8 MPa). Fibre from MHC 123 absorbed less water (116%) compared to V 36 (124.3%). The bast yield was also higher in MHC 123 (3.4 t ha^{-1}) compared to V 36 (3.3 t ha^{-1}).

In the second experiment, there were 3 treatment combinations: planting density, harvest age and variety in split-split plot design with 4 replications. Harvest age was set as the main plot, planting density as a sub plot and variety as a sub-sub plot. The suitable plant density for MHC 123 and V 36 for forage was at 666,700 plants ha^{-1}. This was based on MHC 123 and V 36 having higher CP content and lower ADF content at planting density of 666,700 plants ha^{-1}.

Planting density of 444,400 plants ha^{-1} was the best for fibre production for MHC 123 and V 36. This was based from the finding that MHC 123 and V 36 were higher in dry matter yield, bast yield, core yield at density of 444,400 plants ha^{-1}. The dry matter yield was significantly ($p<0.05$) higher at the lowest density, 444,400 plants ha^{-1} with 12.7 t ha^{-1}, followed by decreasing dry matter yield of 11.5, 11.2 and 10.3 t ha^{-1} for plant density at 500,000, 571,500, and 666 700 plants ha^{-1} respectively. MHC 123 has a potential to replace V 36. The superiority of MHC 123 over V 36 includes the higher leaf yield, stem yield, number of leaf plot^{-1}, leaf to stem ratio, leaf area index (LAI), number of day to flowering and bast yield. The result of this study indicated that optimum harvest age and planting density vary with the variety of kenaf.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN KEPADATAN TANAMAN DAN UMUR PENUAIAN TERHADAP HASIL DAN KUALITI DUA VARIETI KENAF (H*ibiscus cannabinus* L.) UNTUK PENGELUARAN SERAT DAN MAKANAN TERNAKAN

Oleh

MASNIRA MOHAMMAD YUSOFF

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Pengerusi: **Profesor Madya. Mohd Ridzwan bin Abd Halim, PhD**
Fakulti: **Pertanian**

Kenaf (*Hibiscus cannabinus* L.) daripada family Malvacea, telah dikenalpasti sebagai tanaman alternatif menggantikan tembakau untuk pertanian Malaysia pada abad ke-21. Kenaf boleh digunakan untuk pelbagai kegunaan sama ada untuk kegunaan perindustrian atau makanan ternakan. Kebanyakan maklumat berkenaan komponen hasil seperti ketinggian pokok dan kepadatan, hasil batang dan daun dan jumlah hasil biomass yang diperolehi adalah berdasarkan V 36. Walaubagaimanapun, maklumat tentang varieti baru, MHC 123 masih lagi kurang, terutamanya mengenai bagaimana komponen hasil dipengaruhi oleh kepadatan dan umur pokok. Kepadatan tanaman kebiasaanya mempunyai perkaitan dengan varieti dan umur tuaian, kajian ini dijalankan dengan faktor tersebut dengan kombinasi factorial. Melalui maklumat ini, umur optimum dan kepadatan tanaman optimum untuk pengeluaran makanan ternakan dan serat boleh ditentukan. Kajian melibatkan dua eksperimen, pertama mengenai umur penuaian dan satu lagi kesan kepadatan tanaman.

Eksperimen 1 melibatkan empat rawatan umur penuaian (8, 12, 16 dan 20 minggu selepas tanam) dan 2 varieti (MHC 123 dan V 36). Keputusan menunjukkan umur penuaian yang paling sesuai untuk makanan ternakan untuk kenaf varieti V 36 adalah pada 8 minggu selepas tanam (MST) manakala untuk MHC 123 adalah pada 12 MST. Ini adalah berdasarkan kepada penurunan yang perlahan kandungan protein kasar daripada 8 kepada 12 MST dalam MHC 123 (18.9 kepada 17. 2%) berbanding penurunan mendadak dalam V 36 (21.7 kepada 11.3%). Tambahan pula, kandungan serat detergen acid (ADF) di dalam MHC 123 meningkat dengan perlahan (31.7 kepada 36.9%) tetapi di dalam V 36 ia meningkat secara drastik (39.5 kepada 55.6%) daripada 8 kepada 12 MST. Hasil berat kering juga lebih tinggi pada 12 MST (11.2 t ha^{-1}) berbanding pada 8 MST (8.5 t ha^{-1}) untuk MHC123.

Umur penuaian untuk serat adalah berdasarkan hasil biomassa dan kualiti serat (kekuatan tegangan, serapan air, hasil serat luar dan dalam). Umur penuaian yang sesuai untuk MHC 123 dan V 36 adalah pada umur yang sama, 16 MST.

Walaubagaimanapun, MHC 123 mempunyai hasil biomassa yang lebih tinggi iaitu 11.7 tha^{-1} berbanding V 36 dengan 8.7 t ha^{-1}. Kekuatan tegangan serat MHC 123 (101 Mpa) adalah lebih tinggi daripada V 36 (59.8 MPa). Serat daripada MHC 123 menyerap air lebih rendah (116%) berbanding dengan V 36 (124.3%). Hasil serat luar MHC 123 (3.4 tha^{-1}) juga lebih tinggi berbanding V 36 (3.3t ha^{-1}).

Dalam eksperimen kedua, terdapat 3 kombinasi rawatan: kepadatan tanaman, umur penuaian dan varieti dalam susunan plot belah belahan dengan 4 replikasi. Umur penuaian disusun sebagai plot utama, kepadatan tanaman sebagai sub plot dan varieti sebagai sub-sub plot. Kepadatan tanaman yang sesuai untuk MHC 123 dan V 36 bagi makanan ternakan adalah pada 666,700 pokok sehektar. Ini adalah berdasarkan MHC 123 mempunyai kandungan protein kasar dan kandungan ADF yang rendah di kepadatan tanaman 666,700 pokok sehektar.

Kepadatan tanaman 444,400 pokok sehektar adalah kepadatan terbaik untuk pengeluaran serat untuk MHC 123 dan V 36. Ini adalah berdasarkan hasil kajian MHC 123 dan V 36 mempunyai hasil berat kering, hasil serat luar dan hasil serat dalam yang tinggi di kepadatan 444,400 pokok sehektar. Hasil berat kering secara signifikannya lebih tinggi ($p<0.05$) pada kepadatan yang rendah, 444,400 pokok sehektar dengan 12.7 tan sehektar diikuti dengan penurunan hasil berat kering kepada 11.5, 11.2 dan 10.3 tan sehektar masing-masing untuk 500,000, 571,500 dan 666 700 pokok sehektar. MHC 123 mempunyai potensi untuk menggantikan V 36. Kelebihan MHC 123 berbanding V36 meliputi hasil daun, hasil batang, bilangan daun per plot, nisbah daun dan batang, indek keluasan daun (LAI), bilangan hari berbunga dan hasil serat luar yang lebih tinggi. Keputusan kajian menunjukkan umur tuaian dan kepadatan tanaman yang optimum berbeza untuk setiap varieti kenaf.

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This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Agricultural Science. The members of the Supervisory Committee are as follows:

Mohd. Ridzwan Abd Halim, PhD
Associate Professor
Faculty of Agriculture
University Putra Malaysia
(Chairman)

Mohd Rafii Yusop, PhD
Professor
Faculty of Agriculture
University Putra Malaysia
(Member)

Mohd Jani Saad, MSc
Agrobiodiversity and Enviromental research centre
Malaysian Agricultural Research and Development Institute (MARDI)
(Member)

____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: ________________________________

Name of Chairman of Supervisory Committee: ________________________________

Signature: ________________________________

Name of Member of Supervisory Committee: ________________________________

Signature: ________________________________

Name of Member of Supervisory Committee: ________________________________

Signature: ________________________________

Name of Member of Supervisory Committee: ________________________________

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of variance
As	:	Arsenic
BRIS	:	Beach ridges interspersed with swale
Cd	:	Cadmium
DAP	:	Day after planting
et al	:	and friends
Hg	:	Mercury
LKTN	:	Lembaga Kenaf dan Tembakau Negara
MARDI	:	Malaysian Agricultural Research and Development Institute
MPa	:	Mega Pascal
NIRS	:	Near infrared reflectance spectrophotometer
Pb	:	Lead
RCBD	:	Randomized Complete Block Design
SAS	:	Statistical Analysis Software
St	:	Strontium
WAP	:	Week after planting

CHAPTER 1

INTRODUCTION

1.1 Background

Plant fibre includes natural fibres obtained from stem, leaves, roots, fruits and seeds of plant (Rao and Rao, 2007). Kenaf fibre from the stem is one of the important fibre in the new decade. Kenaf or its scientific name, *Hibiscus cannabinus* is a tropical plant that is grown around the world as a source of animal feed and fibre. Kenaf is a warm season annual fibre crop and is closely related to cotton and jute. Kenaf is cultivated in many countries in the world like Bangladesh, India, Thailand, Australia, Indonesia, Vietnam, Africa, China, Southeast Europe and Malaysia.

Kenaf was introduced in Malaysia in early 2000 (Mat Daham *et al.*, 2006) mainly for use as forage while currently the crop is studied for other purpose such as biocomposite. In Malaysia, kenaf has become an important industrial crop supplying natural fibre source for the manufacture and building material.

1.2 Problem statement

Kenaf has a potential to be commercialized but there are a lot of barrier to achieve it. The limiting factor for commercialization of kenaf in Malaysia is lack of suitable variety to be cultivated under Malaysian condition. So far there was only one variety already introduced by MARDI which is V 36. The existing variety has limitations in yield and newer varieties with higher yield and good quality especially for forage and fibre may boost production. Various varieties of kenaf can be found in several countries like China, India and Bangladesh. They are variable in plant growth rate, photosensitivity to day length, stem and leaf colour, leaf and seed shape and the suitability to the different environment. To produce enough biomass of high quality which can be converted to fibre and animal feed there is need to identify kenaf varieties with potential for high biomass yield and specific quality traits (Agbaje *et al.*, 2008). One of the potential varieties is MHC 123.

MHC 123 exhibits good agronomic characteristics compared to V36. New varieties like MHC 123 have to come with new agronomic practices because different varieties have different life spans. Normally for V36 it takes about 6-8 weeks to harvest for animal feed while for fibre it takes about 4 months. For MHC 123 the time to harvest which gives high dry matter yield with good quality may be different. Other factors such as planting density are also important and a combination of optimal planting density and appropriate harvest time are the key to maximixing kenaf yield and quality. Previous recommendation for cultivation were based solely on using existing farm equipment for kenaf production to minimize start-up cost and the lack of herbicide to control weeds in kenaf planted in narrow row. Practicing various planting densities may be useful in tailoring kenaf fibre production to its desired use. For example, the narrow row spacing in kenaf not only increases the total biomass yield, but also increases the bast fibre percentage of the stalks (Baldwin and Graham, 2006). A better understanding on how the yield component (plant population, plant height, stalk and leaf yield, total biomass) are affected by agronomic practices and other factors needs to be studied especially in Malaysian condition.

The best economically viable management practices for growing kenaf must be developed (Danalatous and Archontoulis, 2010). This is necessary for farmers and industrialist to benefit from the recent innovative use of kenaf as a bio-renewable energy resources.

1.3 Aims and research objectives

The aims of the study were to identify the suitable harvesting age and planting density for new kenaf variety for forage and fibre to fit the high kenaf demand. The specific objectives of the experiments were:

1) To determine the optimum harvesting age for forage and fibre production for MHC 123 and V 36.
2) To determine the suitable planting density of MHC 123 and V 36 for animal feed and fibre production.
3) To compare MHC 123 with V 36 in terms of productivity and quality as animal feed and fibre.

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