



**UNIVERSITI PUTRA MALAYSIA**

**SAYSTEM APPROACH TO EFFICIENT FIELD MACHINERY  
UTILIZATION FOR LOWLAND RICE PRODUCTION**

**SAHR MARVIN BOCKARI-GEVAO.**

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**SYSTEMS APPROACH TO EFFICIENT FIELD MACHINERY  
UTILIZATION FOR LOWLAND RICE PRODUCTION**

**By**

**SAHR MARVIN BOCKARI-GEVAO**

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**Chairman: Professor Wan Ishak Wan Ismail, PhD**

**Faculty: Engineering**

Within the agricultural sector, there are wide variations in the level and pattern of energy use among various crops. To assess this energy demand, quantitative data on operating conditions is required for each unit operation. With the current increase in world population, energy consumption needs effective planning. One way to optimize energy consumption in agriculture is to determine the efficiency of methods and techniques used.

This study was carried out with the ultimate aim of developing a model that could be used for estimating the energy consumption in a lowland rice production system and to predict the potential yield of rice from operational energy inputs and from quality indices of tillage and planting operations. Tillage systems obtained with factorial combinations of tractor forward speeds obtained from four transmission gear selections and three rotary tilling speeds were compared with respect to effective field capacity and energy requirements for implements used in the typical sequence for each system. The effects of the rotary tillage systems on irrigated soil properties in terms of changes in bulk density, cone index, plasticity index, aggregate uniformity coefficient and organic matter content were also investigated. Energy

analysis for the entire production process included the operational energy consumption by field machinery and human labour, and the indirect energy accounted for by fertilizer, pesticides and seeds used. Functional relationships that allow the quantification of the different processes in the developed simulation model were formulated essentially through the use of secondary data and through curves fitting to some real data. Mathematical equations from agricultural machinery management and empirical equations were employed.

Results from the tillage experiment indicate that differences in field capacity, and fuel and total energy requirements for each tillage system can be attributed primarily to many factors such as soil moisture, soil density, rotary tilling speed, and operation speed and depth. Average total energy inputs in the lowland rice production system (excluding irrigation energy) summed up to about 12225.97 MJha<sup>-1</sup>. As main consumers of energy, fertilizer (7721.03 MJha<sup>-1</sup>; 63.2%) and fuel use (2717.82 MJha<sup>-1</sup>; 22.2%) were identified. Human labour, pesticide, seeds and indirect energy for machinery use had marginal importance, contributing only 0.2%, 0.6%, 6.8% and 6.9%, respectively to the total energy consumption. Focusing on the operational energy consumption for the lowland rice production, the main energy use was in field cultivation activities (2310.24 MJ/ha; 64.2%, planting included) and harvesting (1171.44 MJha<sup>-1</sup>; 32.6%), while spreading of fertilizer and pesticide had only little importance within total mechanization. Indirect energy use for mechanization took about 848.95 MJha<sup>-1</sup> or 23.6% from total energy use for mechanization of 3595.87 MJha<sup>-1</sup>. Compared to total energy demand of 12225.97 MJha<sup>-1</sup>, indirect energy use for mechanization was even less important (6.9%). Average grain yield was 6470.8 kg ha<sup>-1</sup>, representing energy output of 108321.75 MJha<sup>-1</sup>, that is, 96095.78 MJ net

energy gain or 8.86 MJ output per MJ input. Energy input per kilogram grain yield was 1.89 MJkg<sup>-1</sup>. The simulation results obtained from the developed computer program regarding direct and indirect operational energy consumption in the lowland rice production were consistent with those obtained from the field study.

The results of the study could serve as a guide to lowland rice farmers in other geographical locations in achieving their production goals. Improvements could be made through the application of the simulation model by figuring out the energy input requirements for all possible combinations of field operations for lowland rice production. It is suggested, as a consequence of this research, that paddy farmers in the Tanjong Karang Rice Irrigation Scheme of Malaysia and other schemes with similar operational conditions adopt the use of Gear 1 High and rotary tilling speed of 175 rpm for tillage operations. The application of this practice should reduce the excessive demand on fossil fuel energy which currently is very expensive and whose continuous availability is unpredictable. This will assist in the on-going campaign to minimize the flux of hard currency out of most developing and transition countries in the form of energy bills. The results and recommendations here are based on the available data on the current practices involved in the lowland rice production system of Malaysia and hence are useful for the current lowland rice crop planning and farm management practices.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENDEKATAN SISTEM KECEKAPAN PENGGUNAAN JENTERA  
LADANG UNTUK PENGELUARAN PADI TANAH RENDAH**

Oleh

**SAHR MARVIN BOCKARI-GEVAO**

**April 2005**

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Di sektor pertanian terdapat pelbagai tahap dan bentuk tenaga yang digunakan oleh berbagai-bagai jenis tanaman. Penilaian permintaan tenaga memerlukan data kuantitatif pada keadaan kendalian yang diperlukan oleh setiap unit operasi. Bagi menampung keperluan yang tinggi, keperluan tenaga haruslah diuruskan dengan betul. Salah satu cara untuk mengoptimumkan keperluan tenaga didalam sektor pertanian ialah menggunakan cara-cara yang berkesan dan teknik yang betul.

Tujuan kajian ini adalah membangunkan sebuah model supaya dapat digunakan untuk menganggarkan penggunaan tenaga, dan meramalkan pengeluaran padi daripada sumber operasi tenaga dan juga dari kualiti cucuk tanam serta operasi penanaman. Sistem pembajakan yang didapati daripada gabungan kelajuan traktor hasil daripada pemolihan keempat-empat gear penghantaran dan tiga kelajuan penggembur putar dibuat perbandingan terhadap keberkesanan kecekapan ladang dan juga tenaga yang diperlukan bagi peralatan yang digunakan pada setiap yang dikaji. Perubahan pada sistem pembajakan putaran keatas ciri tanah seperti ketumpatan

organik pada tanah yang turut dikaji. Analisis tenaga pada keseluruhan proses pengeluaran merangkumi operasi penggunaan tenaga oleh jentera ladang dan tenaga buruh, dan juga tenaga tidak langsung seperti baja, racun dan biji benih. Perhubungan Fungsi membenarkan pengkuantitatif pelbagai jenis proses dalam pembangunan model simulasi melalui penggunaan data kajian terdahulu dan juga kesesuaian pencucukan lengkung data sebenar. Persamaan matematik daripada pengurusan jentera pertanian dan persamaan empirikal telah digunakan.

Hasil daripada ujikaji penggemburan mendapati perbezaan pada keupayaan ladang dan keperluan bahanapi dan jumlah tenaga bagi setiap sistem adalah dari faktor-faktor utama termasuklah kelembapan tanah, ketumpatan tanah, kelajuanalat pemutar, kelajuan jentera serta kedalaman. Purata keperluan tenaga didalam sistem pengeluaran padi tanah rendah (tidak termasuk tenaga pengairan) jumlahnya ialah  $12225.97 \text{ MJha}^{-1}$ . Sumber penggunaan tenaga utama seperti baja ( $7721.03 \text{ MJha}^{-1}$ ; 63.2%), dan kegunaan bahanapi ( $2717.82 \text{ MJha}^{-1}$ ) telah dikenal pasti. Tenaga buruh, racun serangga, biji benih dan tenaga tidak langsung untuk kegunaan jentera telah menyumbang sebanyak 0.2%, 0.6%, 6.8% dan 6.9% terhadap penggunaan tenaga keseluruhannya. Didalam fokus utama operasi penggunaan tenaga sistem pengeluaran padi tanah rendah, kegunaan utama tenaga ialah pada aktiviti penggemburan tanah ( $2310.12 \text{ MJha}^{-1}$ ; 64.2% termasuk penanaman) dan penuaian ( $1171.44 \text{ MJha}^{-1}$ ; 32.6%), sementara penyemburan baja dan racun serangga tidak memberi keutamaan dalam penjenteraan. Kegunaan tenaga tidak langsung untuk penjenteraan ialah  $848.95 \text{ MJha}^{-1}$  iaitu hanya 23.6% daripada jumlah tenaga yang digunakan pada penjenteraan ( $3595.87 \text{ MJha}^{-1}$ ), Berbanding dengan jumlah tenaga yang digunakan sebanyak  $12225.97 \text{ MJha}^{-1}$ , kegunaan tenaga tidak langsung pada

penjenteraan adalah jauh lebih rendah iaitu 6.9%. Purata hasil padi ialah 6470.8 kg $\text{ha}^{-1}$ , mewakili keluaran tenaga sebanyak 108321.75 MJ $\text{ha}^{-1}$ , dimana, 96095.78 MJ ialah kelebihan tenaga bersih atau 8.86 MJ keluaran setiap MJ kegunaan tenaga. Keperluan tenaga setiap kilogram hasil bijiran ialah 1.89 MJ $\text{kg}^{-1}$ . Keputusan simulasi dari program komputer yang dihasilkan tentang operasi penggunaan tenaga secara langsung dan tidak langsung di dalam pengeluaran padi tanah rendah adalah konsisten dengan hasil kajian di ladang atau sawah padi.

Keputusan yang diperolehi dari kajian ini boleh dijadikan panduan kepada semua pengusaha penanam padi tanah rendah dalam mencapai matlamat yang dikehendaki. Peningkatan pengeluaran hasil padi boleh dicapai melalui model simulasi dengan mengetahui keperluan tenaga bagi setiap pergabungan operasi ladang. Hasil daripada penyelidikan ini adalah dicadangkan, petani Skim Pengairan Padi di Tanjong Karang, Malaysia dan juga skim-skim lain untuk menggunakan kaedah operasi gear 1 tinggi dan kelajuan putaran gembur pada 175psm untuk operasi penggemburan tanah. Penggunaan kaedah ini mengurangkan penggantungan terhadap permintaan tenaga bahanapi. Buat masa ini kos bahanapi adalah tinggi dan bekalan tidak menentu. Ini akan membantu kempen kebangsaan dalam mengurangkan pengaliran wang keluar negara terutama dari segi bil tenaga. Keputusan dan cadangan ini adalah berdasarkan kepada data sediaada pada situasi dan amalan semasa yang melibatkan sistem pengeluaran padi tanah rendah di Malaysia dan dengan itu ia berguna untuk pelan pengusahaan penanaman padi dan pengurusan ladang sistematik.



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