Design and development of integrated transplanter and weeder mechanism for System of Rice Intesification (SRI) cultivation in Malaysia

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LIST OF ABBREVIATIONS

BOM	Bill of Material
CAD	Computer Aided Drawing
CAE	Computer Aided Engineering
FEA	Finite Element Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOS	Factor of Safety
QFD	Quality Function Deployment
RPM	Revolution Per Minute
SRI	System of Rice Intensifications
VOC	Voice of Customer
GVW	Gross vehicle weight
RR	Rolling resistance
CF	Climb force
FA	Accelerate force
TTE	Total tractive effort
GR	Gear ratio

LIST OF SYMBOL

M_A	Moment (N.m)
Σ	Summation
F	Force (N)
τ	Torque
V	Velocity (m.s^{-1})
C_{rr}	Rolling resistance
r	Radius
D	Diameter
G.R	Gear ratio
α	Incline angle
r_w	Radius of wheel
V_{max}	Desired top speed
T_a	Desired acceleration time
t_w	Wheel torque

Reka bentuk dan Pembangunan Bersepadu Mekanisma Menanam dan Menggembur bagi Sistem Tanaman Padi Intensif (SRI) di Malaysia.

ABSTRAK

Sistem tanaman padi secara intensif (SRI) telah dipraktikan di Lembah Organik Lentang, Kampung Lintang semenjak 2010. Penambahan petak sawah sejak beberapa tahun kebelakangan ini telah menyebabkan permintaan untuk mesin dalam membantu petani semakin mendesak. Ini disebabkan kebanyakkan mereka melakukan kerja dengan tangan dan sedikit bantuan melalui alatan tangan untuk menggembur dan menanam padi di samping waktu bekerja dan juga jumlah pekerja yang tinggi. Sebagai contoh, proses menggembur perlu dilakukan 4 kali semusim. Oleh itu, kajian di jalankan untuk membangunkan mesin mekanikal untuk menanam dan menggembur yang boleh di tarik oleh satu casis. Projek ini direkabentuk untuk membolehkannya beroperasi mengikut kaedah SRI di Malaysia. Spefikasi produk diperolehi dari petani tempatan bertempat di Kampung Lentang, Belantek, Kedah. Beberapa konsep dibuat dan hanya terbaik dipilih untuk pembangunan dan kajian lanjut. Casis baru dibina demi menggantikan penggunaan traktor agrikultur. Casis baru ini mampu memuatkan enjin berkapasiti kecil dan satu roda utama. Direka bentuk untuk menarik mekanisma Penggembur dan Penanaman SRI. Penggembur mekanikal SRI mampu menggembur tanah sehingga padi berumur 40 hari selepas tanaman. Kaedah unsur tak terhingga diguna pakai untuk mengenal pasti kegagalan yang mungkin berlaku dalam mereka bentuk dan seterusnya menyelesaikan masalah tersebut di peringkat awal. Besi dipilh sebagai bahan asas dalam pembinaan untuk mengurangkan kos fabrikasi. Besi tahan karat dan aluminum juga selamat digunakan tetapi agak mahal untuk diperolehi. Bagi Penanaman SRI pula, pergerakan mekanikal direka untuk menjatuhkan anak padi jatuh ke atas tanah berserta dengan tanah dari tapak semaian. Kaedah ini dapat mengurangkan risiko anak padi tadi tercedera. Mesin penanaman padi sedia ada tidak mampu melakukan seperti yang diperlukan dalam kaedah SRI. Mesin itu bukan sahaja tidak mampu menanam satu anak padi untuk setiap poin, malah anak padi ditanam dengan mencabut akar dari tapak semaian. Analisis pergerakan yang dialakukan oleh perisian komputer digunakan untuk mekanisma menanam Penanaman SRI. Setiap bahagian yang bergerak juga dianalisa dengan menggunakan kaedah unsur tak terhingga untuk mengenal pasti tekanan maksimum tidak melebihi yang dibenarkan. Dua dari tiga produk yang direka bentuk difabrikasi untuk menghasilkan prototaip iaitu Casis SRI dan juga Penggembur SRI. Kedua-duanya telah diuji di lapangan dengan persekitaran kerja sebenar. Hasil mendapati mesin ini berjaya mengurangkan 67% penggunan pekerja, mengurangkan 42% waktu bekerja dan keseluruhannya menjimatkan 60% kos operasi.

Design and Development of Integrated Transplanter and Weeder Mechanism for System of Rice Intensifications (SRI) Cultivation in Malaysia

ABSTRACT

System of rice intensifications (SRI) was practiced by community in Lembah Organik Lentang, Kampung Lentang since 2010. Throughout the years, the paddy plots began to grow in number. Since most of the SRI practices needed to be done manually especially planting the seedlings and using conventional tools to kill weeds and loaming the soil, the demand of machinery was inevitable. This is due to time consumed and numbers of manpower needed to carry out the task. For example, weeding process need to be done 4 times for one season. A new chassis that is able to support mechanical weeder and transplanter for SRI was developed. This project was designed to support SRI practices among Malaysian farmers. Product design specifications were gained from rice farmers situated at Kampung Lentang, Belantek, Kedah. Several concepts were generated and the best was choosen for further development and analysis. New chasiss was developed to replace the current agriculture tractor. The chassis was fit with small petrol engine and one main wheel. It was designed to pull SRI weeder and transplanter mechanism. The weeder mechanism was designed to loam three rows at once and able to be use for weeding process up to 40 days of age. Finite element analysis software was used to identify potential failures and subsequent rectification of the problem at the design stage. Some calculation was done to determine force and torque that may act on design. Steel was chosen as material to reduce fabrication cost. Stainless steel and aluminum were also initially considered as suitable material for the design but was not chosen due to the cost is high. For the rice transplanter, the transplanting mechanism uses linkage to drop rice seedlings on top of the soil. This fits the SRI practices for transplanting the young seedling. It is not just able to plant one seedling at one location but also plant the seedlings without removing it from nursery soil, thus, eliminate possibilities to injure the seedlings. Motion analysis was done to analyze the linkage movement. Finite element analysis also was done to determine maximum stress for each linkage part. Two of the designed products were built into prototype which are SRI Chassis and SRI Weeder and tested in actual working environment at paddy field. The field trial shows SRI Weeder was able to reduce manpower by 67%, working time by 42% and save 60% of overall operating cost.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Rice cultivation has long history with humankind. Rice is the staple food for more than half of the population of the world and plays a crucial role in food security of many countries including Malaysia. As time goes by, the rice cultivation becomes more systematic and the yield per hectare is improving from time to time. The most recent rice cultivation system is System of Rice Intensification (SRI) methodology that was synthesized in the early 1980s by Fr. Henri de Laulanié who came to Madagascar from France in 1961. The experiments and observations over the period revealed that there was significant reduction in the investments on external inputs. The productivity is usually more than the conventional rice cultivation (Uphoff & Norman, 1999). Higher grain yield compared to traditional irrigated transplanted rice can reach up to 7 to 20 percent and it can be as high as 65 percent in certain place (R. Mahender & et. al, n. d).

In 2008, SRI was first introduced in Malaysia by setting up a research group on SRI paddy. Various studies and research activity on SRI was done and trials were conducted on a wider scale. SRI began to appear in various states of Malaysia especially areas in Selangor, Kedah and Kelantan. Koperasi Agro Belantik Sik Berhad has been leading restoration an abandoned paddy field since 2010. The 32 acre land is situated at Kampung Lentang, Sik, Kedah. The chairman of the project is Captain (R)

Zakaria Kamantasha was the primary contact person whom was met and contacted frequently in assisting this research.

In general, SRI farmers are required to transplant each rice seedlings with specified distance. The transplanting technique is also different than conventional practice which obliged farmers to plant it by hand. The water level was controlled to a minimum which encourage growth of weed between crops. As a consequence, weeding process is required. Thus, the objective of this research is to design and develop machine or devices that will support SRI practices among farmers.

1.2 Problem Statement

Based on observations made in SRI Lovely paddy field at Kampung Lentang, Belantek the farmers who practiced the System of Rice Intensification method encountered some difficulties in transplanting and weeding process. Current transplanter machine is not suitable to transplant young seedling age below 14 days. Most of the transplanter machine is designed for seedling of age between 14 days to 20 days. SRI method needs to transfer seedlings sometime as young as 8 days of age. The most difficult task that the current products fail to deliver is to transplant one seedling at each point. Fig. 1.1 shows the example of conventional transplanter machine. This particular machine needs operator to control the machine while walking.

Figure 1.1: Kubota Model NSP-PW (www.kubota.co.in, n.d)

Fig. 1.2 shows a problem that occurred when using current transplanter machine. More than one seedling are planted with conventional transplanter machine with depth of between 2 cm and 3 cm. Farmers at Kampung Lentang manually transplant the rice seedling as shown in Fig. 1.3. These techniques required them to bend repetitively which can cause fatigue. Another problem with the current technique is the transplanting process. When a seedling is transferred from nursery soil into paddy field, the young root will experience something called transplanting shock whereby the young root will be injured and need time to recover thus causing a delay in producing more tillers. Extended days for the young seedling at the nursery soil also may cause the delay of tiller emergence (E. Pasuquin, T. Lafarge & B. Tubana, 2007). The time required for the crops to recover and reinstate with the new environment is considered as waste.

Figure 1.2: Transplanting process using conventional transplanter machine.

Figure 1.3: Farmers planting young seedlings manually.

Fig. 1.4 shows the marking process for seedlings transplanting. They then transplant the seedling at the intersection line manually as shown in Fig. 1.5 and only single seedling is planted for each point as shown in Fig. 1.6.

Figure 1.4: Conventional line marking tool.

Figure 1.5: Farmer manually transplant the seedling at the intersection line.

Figure 1.6: Single seedling manually planted at each point (SRI method).