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The Impact of Land Preparation Operations on the Land Leveling Index Status in a Rice Field

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ABSTRACT

Land preparation is essential in rice cultivation. Levelling is one activity of land preparation that is done to achieve good crop establishment and high-yield production. There are several methods for achieving this. Implementing the major levelling method or the cut and fill method produces the best land levelling results, especially during the dry season. However, during the wet season, this method cannot be implemented to level the land as the amount of water in the soil would make it impossible to do any cut and fill operation. As a result, this study was carried out to evaluate the outcome of various methods of land levelling. Land levelling work was done using a power tiller, box leveler, and power harrow implements. Meanwhile, a Global Navigation Satellite System (GNSS) with the support of a Real Time Kinematic (RTK) system was used to map the levelness of the land. Land levelness mapping data was taken after each land preparation activity was done. Following that, the mapping data was processed to determine the levelling index for each activity. A high value of the levelling index indicated a more perfect levelling quality of the land. A total of two study plots at MARDI Parit Station, Perak, were used for this study, with each plot having an area of 0.5 hectares. The results showed that the average levelling index for the power tiller, box leveler, and power harrow was 60.0%, 76.8%, and 85.9%, respectively. The use of a box leveler resulted in the greatest increase in the levelling index, with a difference of 24.2% compared to an increase of 11.9% with a power harrow. In conclusion, some land preparation activities can improve land levelness quality even during the wet season. Furthermore, during the wet season, the use of a box leveler can be recommended during land preparation work to replace major levelling work that cannot be performed to improve the quality of the land's levelness.

Keywords: Land preparation, Land levelling, Global navigation satellite system, Levelling index.

1. INTRODUCTION

Rice has the third largest growing area in Malaysia after palm oil and rubber, with 644 thousand hectares and a total production of 3.64 million metric tons in 2020 [1]. While Malaysia's rice self-sufficiency level (SSL) is currently between 65% and 75% [2], the remaining amount is imported to meet the needs of the country's 33.2 million population [3]. The Malaysian government aims for greater average production of roughly eight tons per hectare and practices cultivation of rice

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twice a year to ensure the security of the country's food supply and enhance farmer income. However, during the main season of rice cultivation, land preparation and planting operations are carried out in wet conditions, whilst harvesting is carried out in dry conditions, as contrasted with off-season cultivation.

Furthermore, various elements such as soil levelness, seed selection, irrigation system, and fertilization methods must be considered in order to ensure conditions ideal for the production of high yields. Perfect soil preparation operations can result in a high level of soil uniformity, which increases the ability to use water, the growth of rice plants, the usage of input materials and machinery, and the output of rice production [4]. Uneven rice fields induce non-uniform germination of rice plants, such as low and deep waterlogged areas will reduce the population of rice plants [5]. Non-uniform water depth levels will also impact rice production [6].

Land preparation works in rice fields can begin immediately following harvest or hay collecting season. This action is critical for repairing damage to the evenness of the land surface caused by large machinery weighing more than five tons, such as a combine harvester, during harvesting [7]. Land preparation is typically separated into many stages that are dependent on a variety of factors. When the rice fields are dry, it is the perfect time to do land preparation work. However, farmers must perform at least one rotor tillering and one levelling work before planting during wet conditions. Land preparation will use rotary tiller equipment to cut, crush and improve soil structure. Additionally, a box leveler can be used to level the soil in wet rice fields. This tool is used to move soil from higher areas to lower levels. Meanwhile, the power harrow implements work to plough and level the soil simultaneously.

Traditional methods rely on the naked sight to assess the quality of the land preparation and levelling work. This method is inaccurate and misrepresents the actual evenness of land levelling. As a result, the levelling index is the most precise tool for determining the quality of land level. The ideal prerequisite for water management and paddy planting is the evenness of rice field land with zero gradients. The optimal conditions for good water management are a levelling index of 5 cm (LI_5) above 85% and a difference between the highest and lowest levels of less than 20 cm [8]. This levelling index is defined as the average numerical variation in centimeters between the proposed levels and the existing average field level before or after the levelling work is completed [9].

There are numerous support systems that can be utilized as guides to determine the evenness of the land, such as laser systems and the Global Navigation Satellite System (GNSS). Both of these methods can acquire data about the land's levelling status with an accuracy of up to 2 cm [10]. Laser technology, on the other hand, requires manual data collection. The 10 m × 10 m grid approach is commonly used to manually plot the levelness map. In comparison to the usage of GNSS systems, which can collect data and generate levelness maps that are automatically applied. This has benefits and saves time.

The goal of this research is to evaluate the state of the land level at each step of land preparation activities. There are three tiers of land preparation operations that require three different types of tools: the rotary tiller, the box leveler, and the power harrow. Moreover, the GNSS system is utilized to collect data on the status of land level at each stage of land preparation.

2. MATERIAL AND METHODS

This research was carried out at the MARDI Parit Station in Perak, which covers 63 hectares. This study employed two specific plots from this station, namely plots C3 and C4. These two plots are 82 m long and 61 m wide, with a total area of 0.5 hectares. This research was carried out during land preparation work for the main season 2022/2023, which began in August 2022.

In this study, three types of land preparation equipment were used: a rotary tiller, a box leveler, and a power harrow. In general, all these pieces of equipment require the use of a primary mover, such as a tractor, to operate. As indicated in Figure 1(a), the rotary tiller utilized is a heavy-duty type with a width of 250 cm. To cut and crush the soil, this rotary tiller has an L-shaped blade that is larger and more powerful [11]. As a result, this implement is best suited for usage during the first stage of soil preparation in rice fields. Also, when the cover plate at the back is closed, it drags and levels the ploughed soil.

A box leveler is an instrument used to draw and level the soil in wet rice fields, as shown in Figure 1(b). This tool is 414 cm wide and is intended for use after the first plough with stagnant water in the rice field at a depth of 5 - 10 cm. Moreover, the power harrow implements illustrated in Figure 1(c) is utilized in the final stage of land preparation, which is known as smoothing. This implement works almost the same as a power tiller to till the soil with a wider size of 468 cm. However, because it has more and closer blades than a rotary tiller, this implement uses a C-shaped blade and can generate smaller soil particles. This is due to the fact that this implement utilizes roughly 19-29% less energy than the L-shaped blade [12].

(a)

(b)

(c)

Figure 1: (a) Power tillers implemented with the tractor, (b) Box leveler implemented with tractor, (c) Power harrow implement attached with GNSS sensor system with the quad-track tractor.

The Global Navigation Satellite System (GNSS) assisted by the Real Time Kinematic (RTK) system, was used in this study to collect ground elevation data. This system had a vertical precision of 20 mm and a horizontal accuracy of 10 mm. This system is separated into two components: dynamic components mounted on the tractor, such as the processing module in the driver's cockpit, the radio RTK antenna on the tractor's roof and the GPS antenna on the auto leveler implement, as shown in Figure 2(a). The second component is a static component or base station where the GPS and RTK radio are located, as shown in Figure 2(b).

(a) (b)

Figure 2: (a) Auto levelers attach with GNSS system, (b) RTK base station.

The survey activity of collecting land elevation data was performed after each land preparation task, such as the first plough with a power tiller and land levelling with a box leveler. However, during the final tilling smoothing activity with a power harrow, the land elevation survey work was done concurrently while the work was being done. This is because the GPS antenna is linked directly to the levelling board, as shown in Figure 1(c), and data is collected every 5 m.

3. RESULTS AND DISCUSSION

The collected land elevation survey data was analyzed and classified into three categories: high, low, and even. Elevation measurements within 2.5 cm of the overall average were assigned to the even group. Land elevation data that differs more than 2.5 cm from the average was classified as high, whereas elevation data that differs less than 2.5 cm from the average was classified as low. Figure 3 depicts the outcomes of the soil mapping software module after the data has been processed. Gray represents even land areas, black represents low land regions, and white represents high land areas.

Figure 3(a) shows the land levelness map for plot C3 after the rotary plough with the largest percentage of low land area, 27.4%, and the lowest percentage of high area, 9.2%, as indicated in Figure 3(c). After two land preparation processes with a box leveler and a power harrow, the low area of plot C3 dropped by 48.5%, while the even area rose by 51.2%. Figure 3(f) shows the levelness map for plot C4 after two land preparation processes, with a 26.8% increase in an even area and a 53.5% decrease in a low area. Low spots are given more attention than high areas in rice field levelling because they will develop spotted floods, which reduces the probability of seed germination in afflicted areas [13]. Significant changes in the placement of high and low areas are observed after the levelling process using the box leveler is completed, as shown in Figures 3(b) and 3(e).

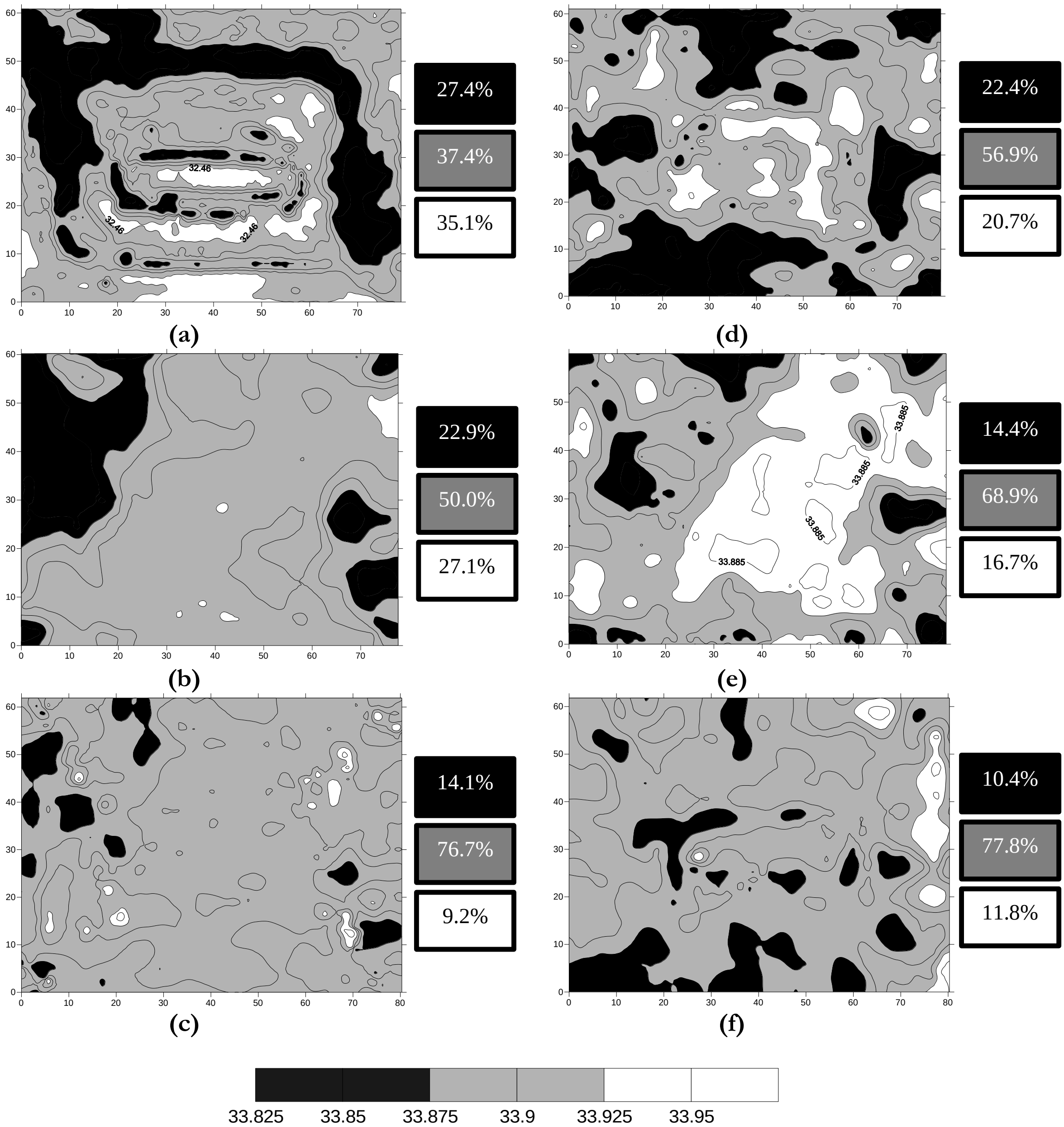

Figure 3: Land levelness map and percentage area of low, high and even region. (a) Plot C3 power tiller (C3-PT), (b) Plot C3 box leveler (C3-BL), (c) Plot C3 power harrow (C3-PH), (d) Plot C4 power tiller (C4-PT), (e) Plot C4 box leveler (C4-BL), (f) Plot C4 power harrow (C4-PH)

Figure 4 depicts the levelling index and elevation difference between the highest and lowest points for plots C3 and C4 at each stage of land preparation. In this study, the levelling index 2.5 cm ($LI_{2.5}$) is utilized to measure the quality of land evenness. The power harrow stages have the highest $LI_{2.5}$ for these two plots, with the C3-PH plot recording the highest $LI_{2.5}$ percentage of 94.1%. After three land preparation activities, both plots exhibit an increasing tendency for $LI_{2.5}$ and a decreasing trend for the elevation difference between the highest and lowest points. For power tiller, box leveler, and power harrow, the average $LI_{2.5}$ is 60.0%, 76.8%, and 85.9%, respectively. While a box leveler produces the biggest improvement in the levelling index, with a difference of 24.2%, a power harrow produces an increase of 11.9%.

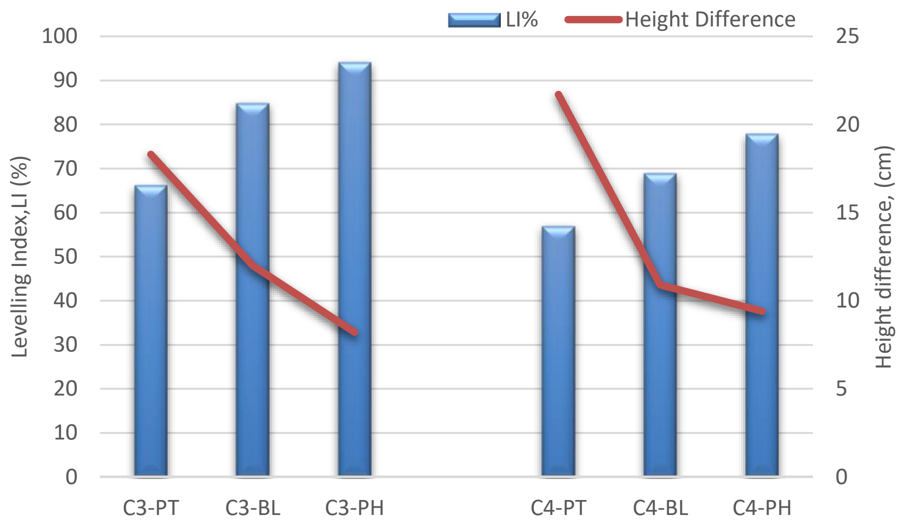

Figure 4: Levelling index and height difference of the highest and lowest points for each experimental plot

4. CONCLUSION

In conclusion, even during the wet season, some field preparation actions might improve land levelness quality. The GNSS approach, in conjunction with an RTK system, can be utilized to identify the evenness of the land and serve as a guide for land levelling work with a box leveler. Furthermore, during the wet season, the use of a box leveler during land preparation work can be recommended to replace major levelling work that is impractical in order to improve the quality of the land's level. According to observations, the evenness of the paddy field can also ensure the growth of rice plants, hence enhancing rice yield.

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REFERENCES

[1] DOA, Statistik Tanaman (Sub-Sektor Tanaman Makanan) Department of Agriculture Malaysia, (2022).

[2] Farah Hanim, A.R., Norhaslinda, Z.A., & Nurul Nazihah, H. Analyzing the Impact of Price Subsidy on Rice Self-Sufficiency Level in Malaysia: A Preliminary Finding, in Proc. 13th IMT-GT International Conf. on Mathematics, Statistics, and their Applications, Kedah, (2017) pp. 801-806.

[3] DOSM, Perangkaan Demografi Malaysia, Suku Tahun Pertama 2023 Department of Statistic Malaysia, (2023).

[4] Kanannavar P.S., Balakrishnan P., Chilur R.S., Ravindra Y., Kumar M. And Basavaraj. Temporal Variability of Levelling Indices as Influenced by Different Land Levelling

Methods. International Journal of Agriculture Sciences, vol 8, issue 31 (2016) pp.1655-1656.
[5] Nawale S. A., Kadu V. M., Rane S. V., Lende A. B. and Gharte L. V., Evaluation of Tractor Mounted Laser Guided Land Laveler. International Journal of Agriculture, Environment & Biotechnology. Vol 1, issue 3 (2008) pp.154-157.
[6] Prakash, M., Sunilkumar, B., Sathiya Narayanan, G., Gokulakrishnan, J., & Anandan, R.. Seed germination and seedling growth of rice varieties as affected by flooding stress. Indian Journal of Agricultural Research, vol 50, issue 3 (2016) pp.268–272. https ://doi.org/10.18805 /ijare .v50i3 .10748.
[7] Ahmad, M., Khadzir, M., Omar, M. Performance of a Triangular Rubber Tracked Tractor in Paddy Fields. Advances in Agricultural and Food Research Journal, vol 1, issue 2 (2020) pp.1–7.
[8] Ayob A.H., Abu Hasan D., Mohamad Fakhrul Z. O., Precision Farming – Variable seeding rates for mechanized direct seeded rice, in Proc. of a National Conference of Agricultural and Food Mechanization, Malacca (2009)
[9] Agarwal, M. C., & Goel, A. C.. Effect of field levelling quality on irrigation efficiency and crop yield. Agricultural Water Management, vol 4, issue 4 (1981) pp. 457–464.
[10] Abu Bakar, B., Ahmad, M.T., Ghazali, M.S.S. Abd Rani, M. N. F., Mhd Bookeri, M. A. Abdul Rahman, M. S. Abdullah, M. Z. K. Ismail, R. Leveling-index based variable rate seeding technique for paddy. Precision Agric, vol 21, (2020) pp. 729–736.
[11] Mesfin Tafesse, Sakda Intaravichai, Banyat Saitthiti and Thanya Kiatiwat. Regression Modeling of Fuel Cosumption Optimization of Rotary Blades of Power Tiller Under Sandy Clay Loam Condition. Kasetsart Journal - Natural Science, vol 41, (2007) pp. 586 – 600
[12] Md. A. Matin, Md. I. Hossain, Mahesh K. Gathala, Jagadish Timsina, Timothy J. Krupnik. Optimal design and setting of rotary strip-tiller blades to intensify dry season cropping in Asian wet clay soil conditions, Soil and Tillage Research, vol 207, (2021).
[13] Shiratsuchi, H., Morita, S., & Takanashi, J.. Differences in the rate of seedling emergence among rice cultivars under low soil-moisture conditions. Plant Production Science, vol 4, issue 2 (2001) pp. 94–102.