# PERFORMANCE OF MECHANICAL WEEDING LEVELS ON YIELD AND VEGETATIVE COMPONENT OF RICE UNDER THE SYSTEM OF RICE INTENSIFICATION (SRI) AT TANJUNG KARANG IRRIGATION SCHEME, MALAYSIA

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## ABSTRACT

*Among the practices of System of Rice intensification is the intensive mechanical weeding need at 10 to 12 days intervals up to 40 days after transplanting (DAT) or canopy closure. This practice aerates the soil, adds biomass and increase yield. This study was carried out to evaluate the effect of levels of mechanical weeding using four different locally fabricated rotary weeders on the yield and vegetative components of rice under the System of Rice Intensification at Tanjung Karang Irrigation Scheme of Malaysia. Results indicated that mechanical wedding levels had a significant effect on vegetative paddy height at P (0.05) level with 60.05 cm as the highest average vegetative height obtained at three levels of rotavation (mechanical weeding) using treatment D. The analysis of variance of the yield from the treatments indicates a significant difference in yield with increase in the levels of mechanical weeding with 13.1 tons/Ha being the highest obtained from treatment D (three levels of rotavation) at 30DAT. The lack of machine ground clearance hindered weeding up to canopy closure or 40 DAT.*

**Keywords:** Mechanical Rotavation, Weeding levels, Rice, Yield, System of Rice Intensification (SRI)

## INTRODUCTION

Rice (*Oriza sativa L.)* is a popular food crop that feeds more than 60% of the world's population. In Asia more than 80% of the people live on rice and their primary food security is entirely dependent on the volume of rice produced in this part of the world (Kabir, 2006). As the world population especially in rice growing areas is expanding, increased yield is vital. According to (Khush, 2005) over 40% more rice production will be required by 2030 to satisfy growing demand with no increase in cropping areas. Malaysia's land area for rice remained fairly constant at no more than 0.7 million hectares since 1980's. Though land area remained constant, Malaysia's rice productivity increases every year from 2.1 tons/ha in 1961 to 3.6 ton/ha in 2008 (Christopher 2010). Australia is the world's most efficient producer of rice, producing an average of 8.7 tonnes of rice per hectare per year from 2000-08, followed by Japan (6.4 tons/ha) and China (6.3 tons/ha). Considering that Malaysia is currently only 72% self-sufficient in rice, and targeting to be self-sufficient by 2015 a most efficient production system has to be in place. With operational land holding size barely constant or shrinking through degrading land and water resources due to population pressure, the System of Rice Intensification (SRI) may be an appropriate practice to produce more rice in the country. SRI is a new and promising resource-saving method of growing rice under irrigated



ISSN: 2223-9944, e ISSN: 2223-9553

or rain-fed conditions, with an impressive yield at an average of 7 tons/ha ( SRI Issue, 2006). The system of rice intensification (SRI) was developed in Madagascar in 1993 by Father Henri de Laulaníe, a French Jesuit priest, and is based on the application of the following six practices so as to achieve the best results: 1. Transplant young seedling, 8- to 12-day-old; 2. transplanting single seedlings per hill quickly with minimal root disturbance; 3. Row and intra-row spacing from 20 cm × 20 cm up to 50 cm × 50 cm; 4. An alternate wet and dry soil moisture regime (No permanent flooding) to maintain aerobic soil conditions; 5. Use of organic, rather than mineral, fertilizers; 6. Frequent/intensive mechanical weeding, at 10-12 days interval up to 40 days during early crop development stages so as to control weeds and aerate the soil (Stoop, 2011; Stoop et al, 2002). SRI (Issue, 2006) reported that despite several constraints, yields for the variety Beranang were highly encouraging giving about 7 and 5 tons per ha for MR219 and UKR2, repectively. The MR219 variety developed by Malaysian Agricultural Research and Development Institute (MARDI), a common variety to farmers in Tanjung Karang records yield of up to 13 tonnes per hectare (Melati Mohd Ariff 2012). The success story of SRI prompted research interest to make comparative studies with other known cultural practices in rice cultivation. Thakur et al (2010) compared the performance of SRI and Recommended Management practice (RMP), and reported that both sets of practices gave their highest grain yield with the spacing of 20 cm x 20 cm; however, SRI yielded 40 % more than the RMP. Regardless of the cultivation practices adopted by farmers, weed control accounts for a substantial cost in agricultural production, and an important constraint to increasing yields wherever rice is grown. Alizadeh (2011) and (Olaoye & Adekanye 2013) reported that weeding is one of the critical stages in rice cultivation and affects yield and quality of rice. According to (Van der Weide et al 2008) weed control within crop rows is one of the main problems in organic farming. Scientist and researchers have come up with a great amount of useful scientific information and technologies on weed control. There is an increasing interest in the use of mechanical inter-row weeders because of concern over environmental degradation and a growing demand for organically produced food. The impressive average yields of above 7 tons /ha under SRI and its organic nature, the high labour demand especially its intensive mechanical weeding requirement has both stimulated the interest and concern of farmers. Farmers in Tanjung Karang rice irrigation scheme of Malaysia adopting SRI faced by its challenges developed locally fabricated rotavators of different configurations and capacities. This research work was conducted to evaluate the effect of intensive mechanical weeding on the yield and vegetative components of rice under the SRI at Tanjung Karang Irrigation Scheme of Malaysia.

## MATERIALS AND METHODS

### Study Area

The experimental study plot (figure 1.) was located at Sungai Burong, Tanjung Karang, Malaysia. The study area was a flat plain with a mean annual rainfall of about 1600 mm and a standard deviation of 75 mm. Climate is semi and subtropical continental with mean monthly temperature of 28$^{o}$ C. The soil type in the study area is predominantly silty clay, belonging to the Selangor soil series (Vertic to Typic Dystropept) with mechanical analysis of 1.1% sand (2000-50 μm), 45.4% silt (2-50 μm), and 53.5% clay (< 2μm) (Abubakar et al., 2010) and (Bockari-Gevao et al., 2004).

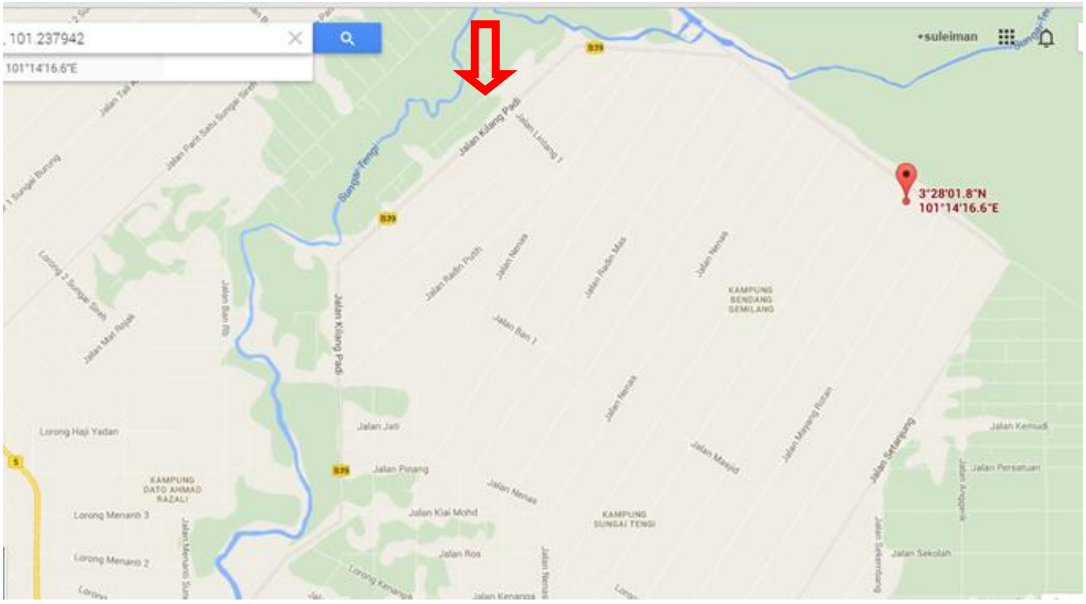


Figure 1. Map of Tanjung Karang Rice Irrigation Scheme with Location of plot shown in red balloon red

Source: Google map 3°28'01.8"N 101°14'16.6"E

**Experimental Layout**

The experimental plots of 6.85 m x 28.14 m were set up in a split plot design with five main plots, four sub plots treatment factors and four replications. The main plot treatments are: A: Three-row low clearance rotavator, B: one-row rotavator, C: Four-row low clearance rotavator, D: Five-row rotavator and E: No weeding (control). The sub plot factors are four (4) levels of weeding rotovtion at 10, 20, 30 and 40 days after transplanting (DAT). MR219 rice variety commonly cultivated by farmers in the study area was prepared in an un-flooded nursery as required by SRI practices on the 3rd of January, 2014 and transplanted manually at 25 cm x 25 cm row and intra-row spacing on the well leveled/puddled experimental plots on the 13th January, 2014. Harvesting of the experimental plots was done on the 30$^{th}$ April, 2014 using Iseki 695 Combine shown in figure 2.0. Yield data was recorded accordingly and analysed as per procedure of analysis of variance and significance tested using Minitab 16 statistical software package. The specifications of the mechanical rotavators are show in Table 1.

**Table 1. Specification of Rotavators and their weeding limits**

| | ROTAVATORS | | | |
|---|---|---|---|---|
| Particulars | A | B | C | D |
| Power (Hp) | 2.0 | 1.2 | 2.5 | 8.0 |
| Power source | Mitsubishi TB 50 | Sthil KM85R | Kawamoto | G430Yanmar HSK4 |
| No. of rows | 3 | 1 | 4 | 5 |
| Working width (cm) | 80 | 23 | 140 | 160 |
| Limit of Wedding Level | 20 DAT | 20 DAT | 20 DAT | 30 DAT |

**Organic Manure Application**

The experimental plots were uniformly treated with liquid organic Fertilizers at the rate of two (2) liters/ha in the order below:

1. 2 liters for 1 hectare land, sprayed on 15 DAT paddy,
2. 2 liters for 1 hectare sprayed on 25 DAT paddy,
3. 2 liters for 1 hectare sprayed on 42 DAT paddy to stop further growth of tillers, thus promoting flowering of paddy.

**Machine Harvesting**

Machine harvesting of the experimental plots was done using ISEKI 695 combine harvester (figure 2.) on 30th April, 2014. Two passes of the combine was on each experimental plot and the area in hectare was calculated as described by Lauer (2002)**.** The yield from the combine was emptied into a jute bag and weighed on IBM Flat stainless plate weighing balance of 150 kg capacity. The yield sample per plot was converted to tons equivalent to obtain the yield in tons/ha. Moisture content of rice at harvest was obtained directly using Mini GAC2100b (figure 3.). The Mini GAC, measures moisture content very accurately, based on the standards of DICKEY-john's GAC2100b, the U.S. federal standard for grain trading. The instrument measures grain moisture between 5% and 45%, and grain temperature ranging from 32 to 122° F automatically, without any further preparation of the grain sample.


Figure 2. Iseki 695 Combine harvesting the experimental plot

Figure 3. Mini GAC2100b measures moisture

**Manual Harvesting of the Experimental Plot**

Ten samples from five hills on each plot were randomly selected and the number of spikes, grains in each spike, filled seeds and sterile seeds for each treatment were obtained manually. The number of spike on each tiller was counted and grains striped manually (figure 4.) and weighed (figure 5.). Yield per hectare was estimated based on the average weight of grain per



ISSN: 2223-9944, e ISSN: 2223-9553
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tiller by the average tiller per plot in tons/Ha. The resulting yield was compared with machine yield were paired statistically.

Figure 4. Evaluation of grain quality/spike

Figure5. Weighing of filled and sterile grains

## Yield Adjustment

The moisture content of the rice grain at harvest was adjusted to recommended storage moisture content of 14% wet basis (Sidik, 2012) and ( Zheng et at 2011). The moisture content adjustment was achieved using equation (1.0) (Kenneth, 1995).

$$Adj.wt. = \frac{100 - Adj.\ Mc(\%)}{100 - Act.Mc(\%)} X\ Measured\ Wt. \qquad (1.0)$$

Where: $Adj.wt.$ = Adjusted weight (ton)

$Adj.\ Mc$ = Adjusted moisture content (%)

$Act.Mc$ = Actual moisture content at harvest (%)

$Measured\ Wt$ = Measured weight at harvest (ton)

## RESULTS AND DISCUSSION

### Mechanical Weeding Levels and Vegetative Traits

The vegetative properties of rice at each level of weeding was recorded, the analysis of variance for the effects of treatments on vegetative height are presented in Table 2. The analysis indicates that there is significant difference ($P \leq 0.05$) in paddy height at 30 DAT



ISSN: 2223-9944, e ISSN: 2223-9553 www.journals.savap.org.pk

due to the treatment effect. This result is similar to that reported by (Cherati et al 2012). They evaluated and compared engine powered and without engine powered weeders, and reported significant difference in paddy height at 30DAT. The mean comparison Table 3 indicates that the control plot E, had the least vegetative paddy height, this may be attributed to paddy competition with weeds for available nutrients and also lack of soil aeration due to absence of weeding on the plot. The highest vegetative height was on plot treatment D, which had three levels of weeding. The gains in vegetative height in treatment D may be due to the increase in weeding level, biomass and high aeration of the root zone. The means for treatments C & A had no difference with means treatment B which had the least vegetative height among the treatment plots. Perhaps this may be due to the high crop damage induced by the single row machine on the vegetative component of rice. Figure 6 shows the normal plot of residual errors for vegetative paddy heights at 30 DAT.

**Table 2. ANOVA: Vegetative height (cm) at 30 DAT versus Treatments**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Treatments | 4 | 371.00 | 92.75 | 45.24 | 0.000 |
| Error | 15 | 30.75 | 2.05 | | |
| Total | 19 | 401.75 | | | |
| | S = 1.432 | R-sq = 92.35% | R-sq (adj) = 90.30% | | |

**Table 3. Mean comparison of Vegetative height Using Tukey Method**

| Treatments | N | Mean | Grouping |
|---|---|---|---|
| D | 4 | 60.500 | a |
| C | 4 | 58.500 | ab |
| A | 4 | 58.500 | ab |
| B | 4 | 55.00 | b |
| E | 4 | 48.250 | c |

*Means that do not share a letter are significantly different.

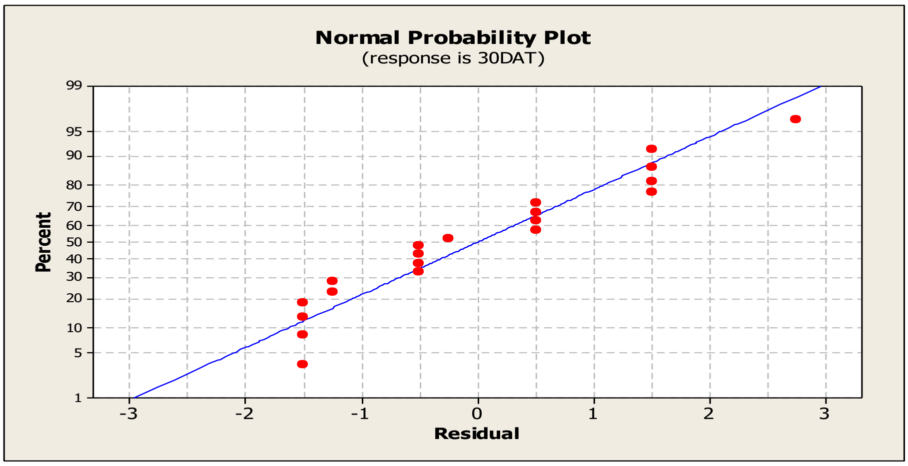


Fig. 6. Normal plots of vegetative height residuals at 30DAT

## Mechanical Weeding Levels and Yield Components of Rice

The yield from the experimental plots were analysed to compare if variation exists between the means of treatment plots. The analysis of variance (Table 4.) suggests that significant differences ($P \leq 0.05$) exist between the yields of treatment plots. Mean comparison of the yield Table 5.Suggest that treatment D, with three levels of weeding up to (30 DAT) and average yield of 13.1tons/ha had the highest yield among the treatments, this result is slightly higher 13.0 tons/ha reported by (Melati Mohd Afrif 2012) . The higher yield may be attributed to the high weeding level up to three times which can resulted in greater aeration of the soil and biomass at the root zones. The normal plotting of residuals is presented in figure 7.

**Table 4. ANOVA: Yield versus Machines (Treatments)**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Machine | 4 | 90.44 | 22.61 | 18.01 | 0.000 |
| Error | 15 | 18.83 | 1.26 | | |
| Total | 19 | 109.27 | | | |
| S = 1.120 | | R-sq = 82.77% | | R-sq (adj) = 78.17% | |

**Table 5. Mean comparison of Yield and Treatments Using Tukey Method**

| Machine | N | Mean | Grouping |
|---|---|---|---|
| D | 4 | 13.085 | a |
| A | 4 | 11.400 | ab |
| B | 4 | 10.258 | b |
| C | 4 | 9.672 | b |
| E | 4 | 6.655 | c |

Means that do not share a letter are significantly different.

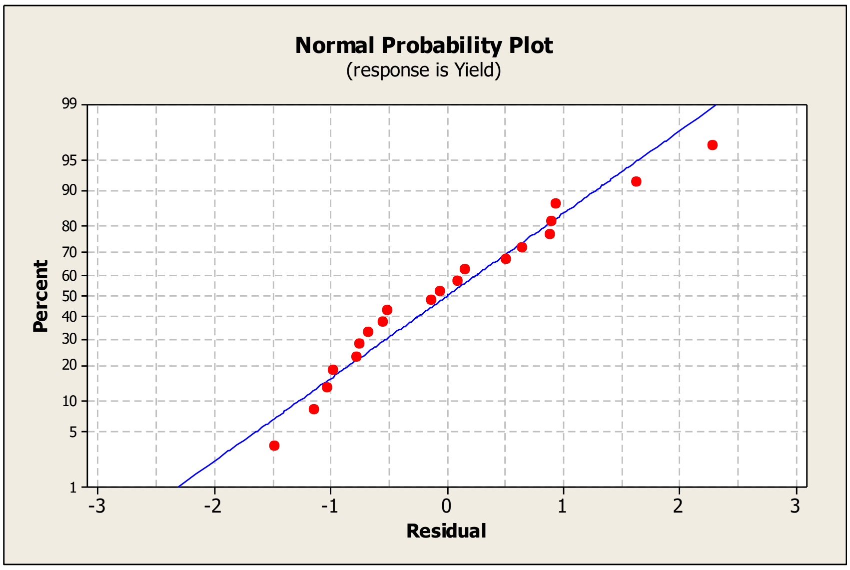


Fig.7. Normal plots of yield residuals

## Effect of Treatments on Filled Grains

The result of analysis of variance (Table 6.) for filled grain per treatment suggests that there was no significant difference in percentage of filled grain per treatment; though mean separation (Tablem7.) indicates that treatment D had higher percentage of filled grain.

**Table 6. ANOVA: Av. Wt of grain/tiller (g) versus Treatments**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Treatments | 4 | 0.9888 | 0.2472 | 2.59 | 0.079 |
| Error | 15 | 1.4319 | 0.0955 | | |
| Total | 19 | 2.4207 | | | |



ISSN: 2223-9944, e ISSN: 2223-9553
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| S = 0.3090 | R-sq = 40.85% | R-sq (adj) = 25.07% |
|---|---|---|

**Table 7. Grouping Information Using Tukey Method**

| Treatments | N | Mean | Grouping |
|---|---|---|---|
| D | 4 | 4.4750 | A |
| C | 4 | 4.1325 | AB |
| B | 4 | 4.1325 | AB |
| A | 4 | 4.1150 | AB |
| E | 4 | 3.7750 | B |

Means that do not share a letter are significantly different.

## Machine and Manual Harvesting Comparison

Table 8 shows the analysis of variance for paired sample t-test of machine and manual harvesting. The result suggests that there exist a significant difference between the mean yields of machine and manual harvesting at ($P \leq 0.05$). The result therefore depicts higher losses in machine harvest compared to manual harvest. A graphical representation of the yield from the two harvesting methods is presented in Figure 8.

**Table 8. Two-Sample T-Test and CI: Yields (Machine & Manual) Harvest**

| Methods | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Machine | 20 | 10.16 | 2.41 | 0.54 |
| Manual | 20 | 12.91 | 3.80 | 0.85 |

Difference = mu (Machine) – mu (Manual)
Estimate for difference: -2.75
95% CI for difference: (-4.79, -0.71)
T-test of difference = 0 (vs no =): T-Value = - 2.73 **P-Value = 0.010** DF = 38
Both used Pooled StDev = 3.1

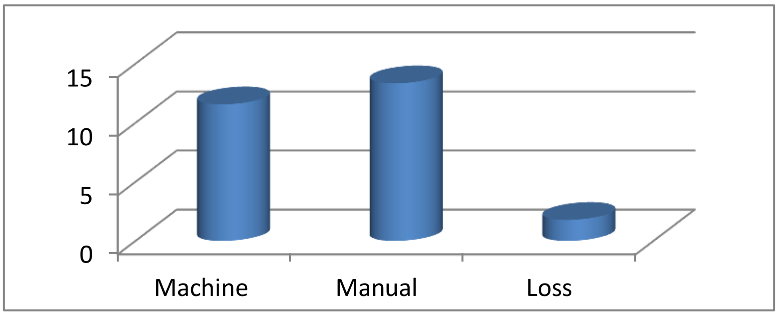


**Fig. 8. Graphical representation of Machine and Manual Harvesting Methods**

## CONCLUSION

In this study we evaluated and compared the effect of levels of mechanical weeding in paddy field under the system of rice intensification at Tajung Karang Scheme, Malaysia. The results suggest a significant increase in yield of paddy with increase in mechanical weeding levels. An average yield of 13.1 tons/ha was recorded with three levels of mechanical weeding. The effect of mechanical weeding levels on the vegetative treats of paddy also indicated significant difference in paddy vegetative height, with the highest vegetative height of 60.05 cm obtained at 30 DAT and three levels of mechanical weeding. Due to lack of ground clearance of the evaluated mechanical weeding machines, the authors hereby recommend that further evaluation of weeding level on yield and vegetative components of paddy at 40 DAT or until canopy closure be carried out using a higher ground clearance mechanical weeder.

## ACKNOWLEDGEMENT

The authors hereby thank the Research University Grant Scheme, for providing the funding of this study. We also thank field assistance rendered by Mr. Salehuddin H. Y for providing the needed support during this study.

**REFERENCES**


[1]. Abubakar, Mohammed Shu'aibu, Ahmad, Desa, Othman, Jamarei, & Sulaiman, Shamsudin. (2010). Mechanical properties of paddy soil in relation to high clearance vehicle mobility. *Australian Journal of Basic and Applied Sciences*, 4(5), 906-913.

[2]. Alizadeh, Mohammad Reza. (2011). Field performance evaluation of mechanical weeders in the paddy fields. *Sci. Res. And Essay, 6*(25), 427-434.

[3]. Bockari-Givao, S.M., Wan Ishak, W.I, Azmi, Y and Chan C.W (2004). Effect of Rotary Tillage on Soil Physical Properties and Energy Consumption in a Malaysian Paddy field. *Malaysian Journal of Soil Science.*

[4]. Cherati. F.E, Naij.T, Amraei.A and Hosseinpor (2012). The Evaluation and the Comparison of the effect of without Engine Power and Power Mechanical Systems on Rice Weed. *World Academy of Science, Engineering and Technology*. 63: 776-781.

[5]. Christopher T.B.S (2010) Will Malaysia achieve 100% self-sufficiency in rice by 2015? Available: www.christopherteh.com. Accessed: 12/09/2014.

[6]. Kabir .H (2006) Adaptation and adoption of the System of Rice Intensification in Myanmar using the Farmer Field Schedule (FFS) Approach. Available: http://www.ciifad.cornell. Edu/thesis/kabirthesis.pdf.

[7]. Kenneth J.Hellenvang (1995) *Agricultural Extension (905) Revised.* North Dakota State University, Fargo. P 1-8

[9]. Khush, G. S (2005) What will it take to feed 5.0 billion rice consumers in 2030. *Plant Mol. Bio*. 59: 1-6

[10]. Kwanchai A. Gomez, Arturo A. Gomez (1984) Statistical Procedures for Agricultural Research. A Wiley-Inter science. Publication. John Wiley. new York.

[12]. Lauer. J (2002) Method of calculating corn yield. *Field Crops*. University of Wisconsin. 28.47-33

[13]. Melati Mohd Ariff (2012). *Hybrid Rice An Effort To Reduce Imports.* Malaysian Agricultural Research and Development Institute (MARDI).

[14]. Olaoye, J. O., & Adekanye, T. A. Development and Evaluation of a rotary power weeder. In *Tillage for agricultural productivity and environmental sustainability-conference, held in Ilorin, Nigeria* (pp. 129-141).

[15]. Sidik, M. (2012). The Quality Changes of Rice Stored Under Vacuum Conditions. *Jurnal Teknologi Pertanian*, *1*(3).

[16]. System of Rice Intensification (SRI Ed.). (2006). *Weed, A reference compendium*. . Hyderabad, India: Watershade Support Services and Activity Network.

[17]. Stoop, W.A. (2011). The scientific case for the System of Rice Intensification and its relevance for sustainable crop intensification. *International Journal of Sustainable Agriculture*.

[18]. Stoop, Willem A, Uphoff, Norman, & Kassam, Amir. (2002). A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems, 71*(3), 249-274.

[19]. Thakur, AK, Rath, S, Roychowdhury, S, & Uphoff, N. (2010). Comparative performance of rice with system of rice intensification (SRI) and conventional

management using different plant spacings. *Journal of Agronomy and Crop Science, 196*(2), 146-159.

[20]. Van der Weide, RY, Bleeker, PO, Achten, VTJM, Lotz, LAP, Fogelberg, F, & Melander, Bo. (2008). Innovation in mechanical weed control in crop rows. *Weed Research, 48*(3), 215-224.

[21]. Zheng, X. Z., Liu, C. H., Chen, Z. Y., Ding, N. Y., & Jin, C. J. (2011). Effect of drying conditions on the texture and taste characteristics of rough rice. *Drying Technology*, *29*(2011), 1297-1305