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Work Performance, Crop Yield and Economics of Transplanting Against Broadcasting Method in Wet Rice Planting in Malaysia

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ABSTRACT

A comparative study in rice planting between transplanting method using a 4WD 6 rows Ride-on KUBOTA NSPU68C 12.5W @3600 rpm transplanter and broadcasting method using a knapsack HARRY Mist Duster Power Broadcaster 2.13Kw @ 7500 rpm was conducted in a 9 hectares rice plot at Sungai Burung, Tanjung Karang, Selangor. Rice seedlings were planted using transplanter at a spacing of 20 cm×30 cm with 6 seedlings per hill while rice seeds were broadcasted by the Mist Duster at a seeding rate of 134.45 kg/ha or about 449 seeds/m^2. The broadcaster showed 1.7 times greater mean effective field capacity (1.31 ha/hr and 0.49 ha/hr) and 7.38 times lesser mean fuel consumption (0.79 l/ha and 6.7 l/ha) than the transplanter. However, the fields under transplanting method showed 25.18% greater mean planting density (522 and 417 stems/m^2), 20% greater mean number of panicles (480 and 400 panicles/m^2), 7.3% less mean population of weedy rice (4.89% and 12.16% of weedy rice) than the field under broadcasted method. The mean spikelet filling percentage was found 83.2% for the fields under transplanting method and 77.8% for the fields under broadcasted method. The mean rice yield was 22.41% more with the fields under transplanting method than the broadcasted method (7.09 and 5.8 ton/ha). Transplanted method showed 1.71 times greater mean total economic cost of planting operation (1154.4 RM/ha and 426 RM/ha) but 1.8 times mean greater net income (1554.54 RM/ha and 555.76 RM/ha) than the broadcasted method. Benefit Cost Ratio of transplanted and broadcasted method was found to be 1.232 and 1.108.

KEYWORDS

Rice Cultivation, Transplanting, Broadcasting, Field Machinery performance, Crop Performance

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Rice is one of the most important crop and staple food for millions of people where the crop is grown in more than 110 countries in the world with a total production of 527 million tons of which 78% is contributed by major rice growing countries of Asia (Murumkar et al., 2015 and Goel, Behera and Swain, 2008). Rice planting currently is done in two main methods; direct seeding or transplanting method. Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting rice seedlings from the nursery as in transplanting. There are three principal methods of direct seeding; dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils) and water seeding (seeds sown into standing water). Comparative study is conducted here to compare between mechanical transplanting and direct seeding. The growing of rice in Malaysia is done in two seasons in a year and it is the main economic activity of the rural community (Toriman et al., 2013).

Many comparative studies have been conducted between transplanting and direct seeding such as IK Garg, VK Sharma et al., 2008 reported that higher and more stable yield was obtained from transplanted rice than direct seeded rice; they showed that, transplanted rice yielded 10 to 20 % higher than broadcast rice. Goel et al., 2008 explained that, transplanting has some added advantages when it compared to direct seeding such as facilitates the control of weeds effectively, better water for plant, uniform ripening and less lodging.

Huang et al. (2011) reported that direct seeding produced more panicles per m^2 but less spikelet per panicle than transplanting. The differences in the number of spikelet per m^2, spikelet filling percentage and grain weight between direct seeding and transplanting were not significant and the number of panicles per m^2 in direct seeding were larger than transplanting. Birhane (2013) showed for three different varieties of rice, grain yield increased by 19.5%, 40.36% and 42.81% by transplanting seedlings when compared with direct sowing. Maintaining optimum plant population in transplanting enhanced paddy yields (Hussain et al., 2013). Bhowmik et al. (2012) claimed that the numbers of filled grains/panicle, spikelet/panicle and grain yield were significantly affected by plant spacing. The number and weight of filling grains per panicle and number of primary branches per panicle was the most component characters that contribute for high yield production (Afza et al., 2017). Hauhan and Johnson (2010) reported that rice sown in 30-cm rows produced 40.91% seeds/plant greater than 20 cm spacing rows. Wang et al. (2014) mentioned that with increases in seeding spacing from 25 cm X 15 cm to 25cm X 23cm, the panicles per hill were increased by 34.2% and 50.0% in two different fertility soils. Many researchers found that the maximum grain yield was produced at the widest spacing of 25 cm X 20 cm which was the consequence of highest bearing tillers/hill, total spikelet/panicle, grains/panicle and grain yield (Hasanuzzaman et al., 2009; Amin et al, 2004; and Baloch, et al., 2002). Mechanical transplanting requires a special type of seedlings raised on mat type nursery, while direct seeding avoids nursery raising, seedling uprooting, and transplanting, and thus reduces the costs (Murumkar et al. 2014). The wide spacing in transplanting method produced better plant stand, gave more panicle density and higher grain yield, the plants have more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process.

For the operation of paddy transplanter, the soil flow caused by sinkage is the most critical factor affecting the performance of transplanter (Garg et al., 2000). Murumkar et al. (2014) reported that the field capacity, field efficiency and fuel consumption of the four-row self-propelled paddy transplanter were 0.1 ha/h, 65% and 10 l/ha, respectively.

MATERIALS AND METHODS

The study was conducted in Sungai Burung (3º29´47´´N, 101º09´56´´E), Tanjung Karang, Selangor Malaysia, from June to November 2017. The soil of the field was clay loam in texture with average pH of 5.20. The data collected were from 15 farms where 7 farms under transplanted method and 8 farms under broadcasted method with a total net area of 13.791 ha and farms having area size ranging from 0.524 to 1.190 ha and an average size of 0.919 ha. The mean daily temperature recorded in the area was 27.56^{o}C, mean relative humidity of 85.6% and mean solar radiation of 254.70 W/m^2. The comparison between transplanted method and broadcasted method in this study was made based on field performances of transplanter and broadcaster, time analysis, yield and yield components cost of production, net economic benefits and benefit cost ratios.

Field Performances

The farms were planted with MR220-CL2 variety of rice. For the transplanting method, the seedlings were raised in nursery beds, and 20-day-old seedlings were transplanted using a 4WD 6 rows Ride-on KUBOTA NSPU68C 12.5W @3600 rpm transplanter at a spacing of 20 cm×30 cm with 6 seedlings per hill on 2nd and 4th August. For the broadcasting method, the seeds were soaked for 36 hours and then allowed to dry for 8 hours so that it is easily blasted and after that the pre-germinated seeds were broadcasted by the knapsack HARRY Mist Duster Power Broadcaster 2.13Kw @ 7500 rpm at a seeding rate of 134.45 kg/ha or about 449 seeds/m^2 from 10th to 17th August. All transplanting and broadcasting was performed on a puddled soil (Figure 1).

Table 1 presents the specification of the rice transplanter and broadcaster. The field performance of the KUBOTA rice transplanter in comparison with the knapsack HARRY Mist Duster Power Broadcaster while the speed of operation, theoretical field capacity, actual field capacity, field efficiency, labor hour and fuel consumption were computed.

Table 1: Specifications of rice transplanter and mist duster broadcaster

Specification	Transplanter	Broadcaster
Name	KUBOTA Rice transplanter	HARRY Mist Duster
Model	NSPU68C	3WF28
Max power	12.5 kW	2.13 KW
Rated speed	3600 rpm	7500 rpm
Weight	590 (kg)	12.5 (kg)
Drive type	4WD	Portable
Fuel type	Gasoline	Gasoline
Fuel tank capacity	17 l	1.8 l
Tray capacity /Material Tank	12 Mat	28 l
Planting rows/Outlet distance	6 Row	12 m
Worker	2 Person	1 Person

(a) Transplanting *(b) Broadcasting*

Figure 1: Farmer workers performing paddy planting operation in one of the study farms

Yield and Yield Component

At maturity, 2 m^2 area from each lot was harvested manually by randomly placed 8 pieces of square frames with 0.25m^2 into the standing plants. Yield component such as number of panicles/m^2, number of spikelets/panicles, number of spikelets/m^2, spikelet filling percentage and number of stems were calculated from the cut plants. In order to count spikelets/panicles in each 0.25m^2 frame 10 panicles were randomly selected from the samples and hand threshed first and later the filled spikelets were separated from unfilled spikelets. Paddy yield was harvested using combine harvester and expressed in terms of ton/ha and these harvested paddies was then expressed in terms of RM/ha.

Economic cost

For the comparison of cost elements relating to seed/seedling cost, fuel cost, machinery cost and labor cost between farms under transplanting and broadcasting methods, all involved costs were expressed in

terms of RM/ha. The prices of harvested paddy refer to the current market price of harvested paddy per unit area.
The total production cost of rice transplanting method and broadcasting method was computed based on all involved operation costs (i.e. tillage, planting, fertilizer, chemicals, harvesting and slashing), transport cost and land rent cost. There were others costs such as cost for maintaining workers' path in the field, cost for cutting weedy rice and cost for replanting missing hills that were also included in the total production cost. The data was analyzed using excel spread sheet.

Gross income (RM/ha) was computed by multiplying mean yield (ton/ha) with its price (RM/ton) while net income (RM/ha) or the money available to the farmer after meeting all the crop production expenses was calculated by deducted total cost of production (RM/ha) from the gross income (RM/ha).

RESULTS AND DISCUSSIONS

Grain Yield and Yield Components

Table 2 and Figure 2 show that transplanting has 25.18% greater mean planting density (522 versus 417 stems/m^2), 20% greater mean number of panicles (480 versus 400 panicles/m^2), 41.4% greater mean number of spikelets/panicle (198 versus140 spikelets/panicle), 69.6% greater mean number of spikelets (95 versus 56 spikelets/ m^2), 23.5% greater mean number of grain weight/panicle (4.1 versus 3.4 g/panicle), 7.3% less mean population of weedy rice (4.89% versus 12.16%) than the field under broadcasted method. The mean spikelet filling percentage was found 83.2% for the fields under transplanted method and 77.79% for the fields under broadcasted method. The mean rice yield was 22.41% more with transplanting than broadcasting (7.1 versus 5.8 ton/ha). Similar results were also reported by Goel et al. (2008) where transplanted rice yielded 10 to 20 % higher than broadcasted rice.

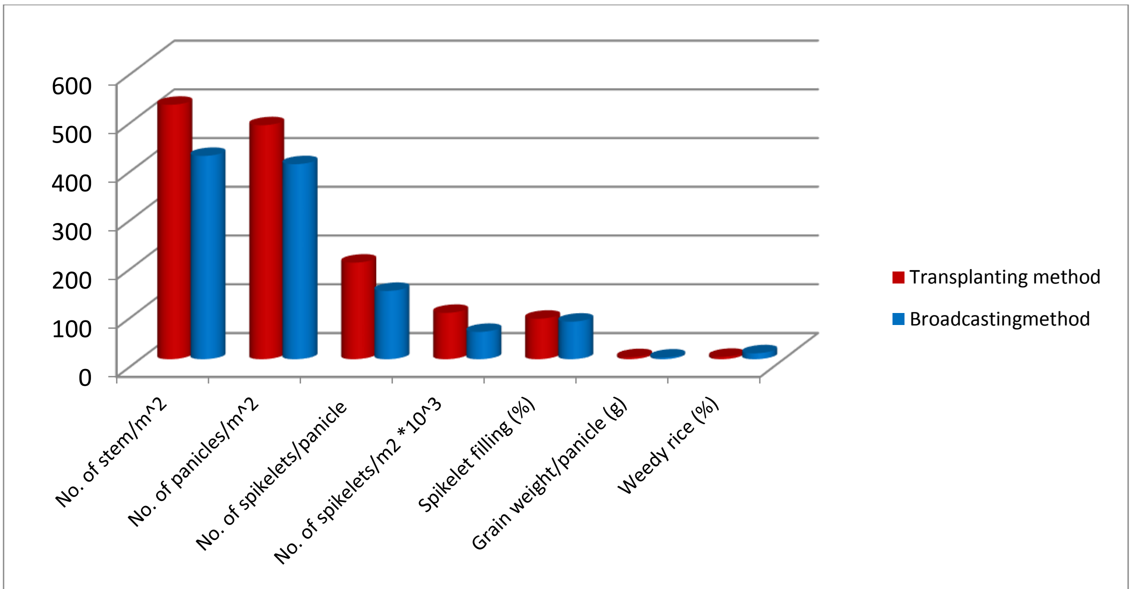

Figure 2: Yield components of rice grown under transplanting and broadcasting method.

Figure 3 indicates that the 22.41% increase in yield of the fields under transplanted method than the fields under broadcasted method may be due to the planting of 20 days-old seedlings as compared to the sowing of 44 hours-old germinated seeds which increased the ability of the planted plant to overcome the field conditions such as the wind, sunlight, rainfall, pets and diseases risks. This in returns, enhanced for greater number of panicles/m^2 and number of spikelets/panicle and the yield. Also, uniform space between rows and between plants in fields under transplanted field lead to increase weeding control and made the application of fertilizer and chemicals to be more effective (Goel et al., 2008) (Figure 4).

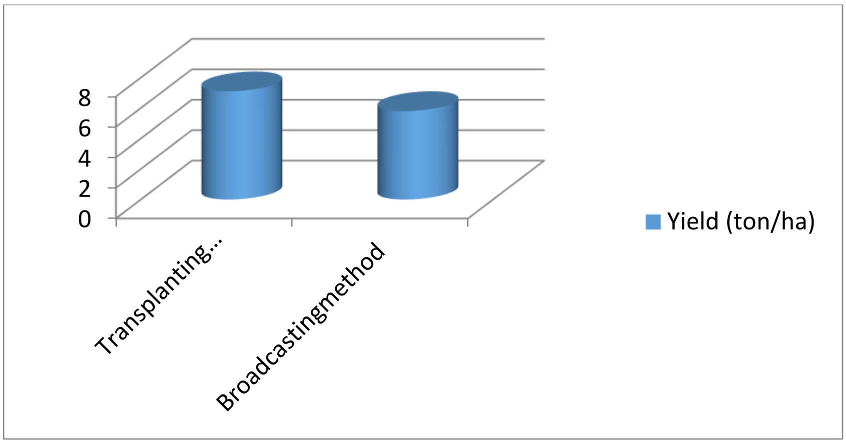

Figure 3: Comparison of grain yield of rice grown under transplanted and broadcasted method

Table 2: Grain yield and yield components of rice grown under transplanted and broadcasted method

Yield Components	Transplanting	Broadcasting
No. of stem/ m^2	522±57	417±152
No. of panicles/m^2	480±27	400±154
No. of spikelet/panicle	198±12	140±20
No. of spikelet/m^2 *10^3	95±9	56±26
Spikelet filling (%)	83.2±6	77.8±4
Grain weight/panicle (g)	4.2±0.33	3.4±0.34
Weedy rice (%)	4.89 ±12.085	12.16±4.264
Yield (ton/ha)	7.1±0.44	5.8±0.71

(a) Transplanting

(b) Broadcasting

Figure 4: Uniform space versus non-uniform space between rows and between plants.

Working Performance of Rice Transplanter and Broadcaster

Table 2 and Figure % present the machinery field performance in planting operation with the rice transplanter and mist duster broadcaster. The broadcaster showed 1.7 times greater mean actual field capacity (1.31 versus 0.49 ha/h), 1.33 times greater mean theoretical field capacity (2.41 versus 1.04 ha/h), 5% greater mean field efficiency (0.54% versus 0.49), 7.38 times lesser mean fuel consumption (0.79 versus 6.7 l/ha), and 1.16 times lesser mean operation speed (2.53 versus 5.46 km/h) than the transplanter.

In terms of labor hours needed to complete the task of planting operation for one hectare the result reveals that the mean total time a labor spent in transplanting was 1.06 times greater than the broadcasted method (3.54 versus 1.72h/ha).

Table 3: Comparison of field performances between rice transplanter and mist duster broadcaster

Performance	Transplanter	Broadcaster
Operation Speed (km/h)	5.46±0.35	2.53±0.28
Theoretical field Capacity (ha/h)	1.04±0.17	2.41±0.25
Actual Field Capacity (ha/h)	0.49±0.04	1.31±0.13
Field efficiency %	49.0 ±0.07	54.3 ±0.02
Labor hour (h/ha)	3.54±0.96	1.72±0.24
Fuel Consumption (l)	6.71±0.45	0.79±0.04

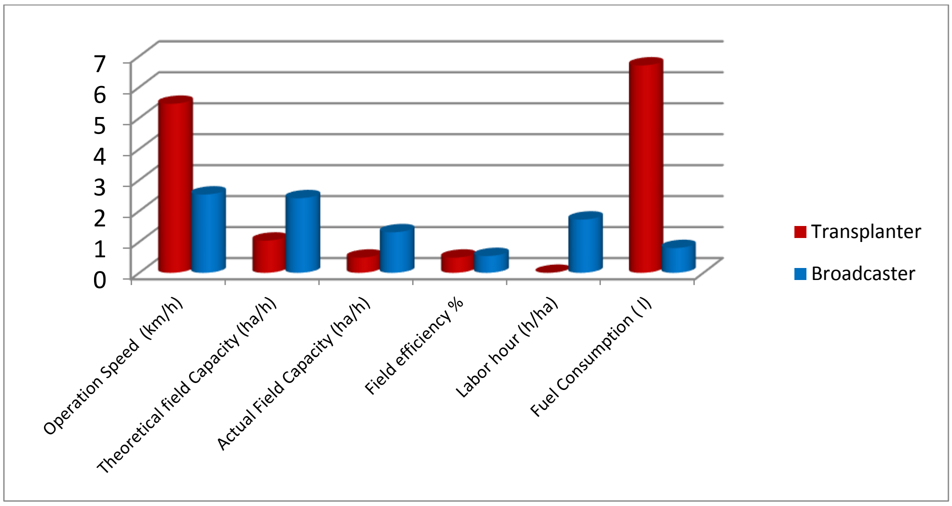

Figure 5: Field performance comparison between rice transplanter and mist duster broadcaster

Field Time Distribution in Performing Planting Operation

Table 4 and figure 6 show that transplanting had 1.67 times greater mean total time of planting operation (2.08 versus 0.78 h/ha) than the farms under broadcasted method. 54.3% (0.423h/ha) of the time was spent in the actual broadcasting activity while 45.7% of the total planting operation time was expended by workers in distributing seed bags (20 kg each) in the field (8 bags/farm), loading /refilling of germinated seeds in broadcaster, and walking in the field. The number of workers was between 2 to 3 persons in performing the planting operation with power broadcaster machines and 1 to 2 persons with transplanter. 43.1% (0.316 h/ha) of the total time was spent in the loading/refilling broadcaster seed tank. Unlike the broadcaster, rice transplanter consumed 26.8% (0.56 h/ha) of the total field time stuck in the mud that lead to the decrease its field capacity which it was the biggest problem facing the performance of the transplanter machines in study area, sometimes the driver spent long time to release the rice transplanter from the mud (0.425 h/ha-0.816 h/ha) this time depend on the condition of the farms, some farmer did not drainage the water from the farms efficiently.

Table 4: Time distribution comparison in planting operation between rice transplanter and broadcaster

Mean time	Transplanted method	Broadcasted method
Effective Time (h/ha)	1.003±0.136	0.423±0.041
Loading Time (h/ha)	0.276±0.097	0.316±0.349
Turning and reverse (h/ha)	0.181±0.068	-----
Stuck/walk in field (h/ha)	0.560±0.092	0.013±0.003
Others (h/ha)	0.060±0.047	0.014±0.000
Total operation time (h/ha)	2.080±0.162	0.780±0.070

Note" Others" means operator time and maintenance time

48.6% of the total time was spent in the actual transplanting activity (1.001 h/ha). The time spent in the loading and feeding the transplanter with mat seedling was 13.2% (0.276) of the total operation time which it 14.5% less than the time consumed of using broadcaster to perform same task (0.316 h/ha), that because the transplanter need 2 worker to performing planting operation one of them as a driver the other one for loading and feeding of the machine, that means the feeding was done without stopping the operation unlike the broadcaster the worker took long time to load and refill the seed tank (43.1% from total time). When the transplanter was operated by one labor the time consumed in loading and feeding the machine with mat seedling was increased by 2.13 times more than the case of 2 labor, from 0.186 h/ha to 0.583 h/ha. Time used in turning and reverse represent 8.7% (0.181 h/ha) from the total time that transplanter used in performing the planting operation.

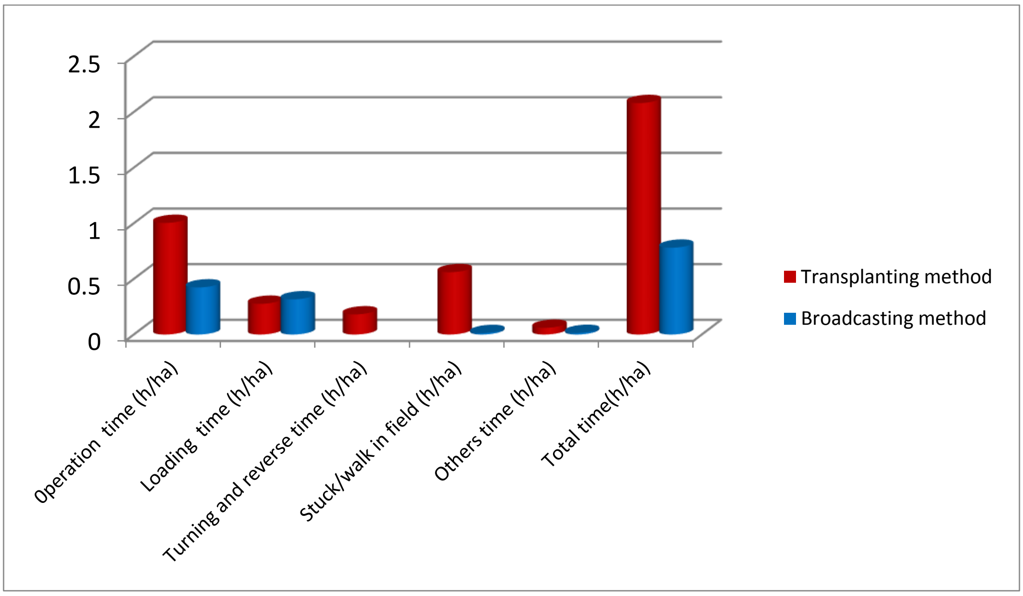

Figure 6: Time distribution comparison in planting operation between rice transplanter and broadcaster

Economic Cost Comparison in Planting Operation

Table 5 and Figure 5 present the economic comparison in planting operation between transplanted method and broadcasted method. The transplanting showed 1.71 times greater mean total economic cost of planting operation (1154.4 RM/ha versus 426 RM/ha). The cost of seeds and seedlings represented the most share contributors for the total cost of planting operation as compared to the other cost elements in both methods; 69.24% (799.3 RM/ha) for transplanting and 89.35% (381.6RM/ha) for broadcasting. The fuel cost was found to be the least contributor of the total cost of planting operation in both methods; 1.17% (13.5 RM/ha) for transplanting and 0.4% (1.7 RM/ha) for broadcasting. The fuel cost was affected by time spent in performing planting operation and engine power rating of the used field machineries. The share contributions for machinery and labor costs for the transplanting were 23.83% and 5.72% while for broadcasting were 0.61% and 8.96%.

Table 5: Economics comparison in planting operation between rice transplanting and broadcaster

Cost	Transplanting	Broadcasting
Seed/Seedling Cost (RM/ha)	799.3±24.34	381.6±10.83
Fuel Cost (RM/ha)	13.5±0.87	1.7±0.09
Machinery Cost (RM/ha)	275.1±8.82	2.6±0.12
Labor Cost (RM/ha)	66.6±2.03	38.2±0.86
Total Cost (RM/ha)	1154.4±35.16	426.4±19.43

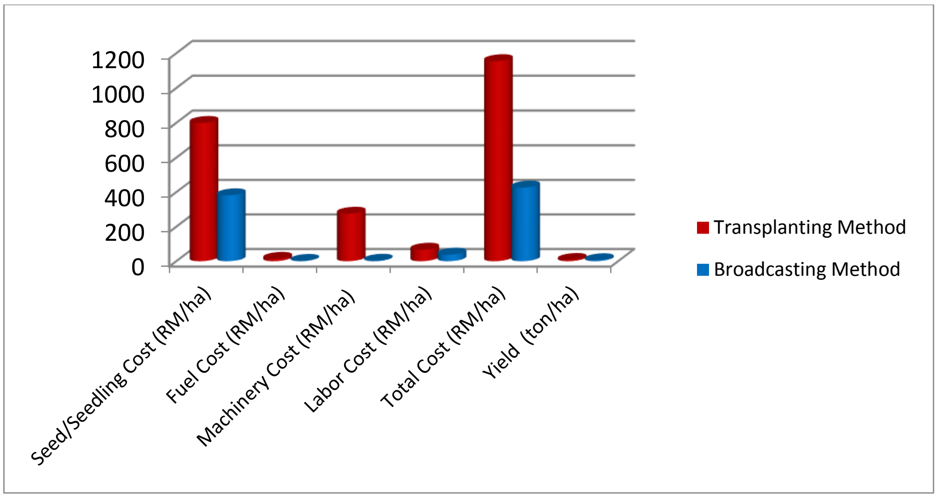

Figure 7: Economic cost distribution comparison in planting operation between transplanting and broadcasting methods

Mean seedling cost expenditure in transplanting was 1.09 times greater than broadcasting due to cost of nursery work from preparing seedbed and transporting the seedling to the farms under transplanting method. While in the farms under broadcasting the farmer only soaked the seed bags in water tank. (Figure 10)

(a) Preparing seedling mat *(b) Soaking the seeds*

Figure 10: Pre-planting operation with transplanting and broadcasting methods

Benefit-Cost Analysis of Rice Transplanting and Broadcasting Method

Table 6 presents the economic benefit/cost analysis for transplanted and broadcasted rice. The mean total production cost was 26.08% more with transplanting than broadcasting (6689.50 versus 5134.72 RM/ha). Similarly, Muhammad Younas (2016) and Nai-Kin and Romli, (2002) reported that direct seeding enabled farmers to save 20% and 29% of the total cost of a transplanted crop, respectively. The total productivity was 6.44% more with the transplanting than broadcasting (942.08 RM/ton versus 885.1 RM/ton).

Although higher production cost of transplanting, the mean gross income of it was 45% more than the broadcasting (8244.04 RM/ha versus 5690.49 RM/ha). As a result, the transplanting showed 1.8 times mean greater net income than the broadcasting (1554.54 RM/ha versus 555.76 RM/ha).

Benefit-cost ratios of transplanting and broadcasting were found to be 1.232 and 1.108 which mean that paddy production of both technologies in the study area is economically viable, but transplanting method were more economic viable than the broadcasting method. The deduction was 14% from the grain yield of transplanting method while it was 20% from the grain yield of broadcasting method this due to the grain yield produced by transplanting was lesser amount of immature grain, impurities and strange material than that one produced by broadcasting (the grain mill who bought the yield made this deduction).

Comparison of economic cost of production variables in both technologies revealed that broadcasting method enabled farmers to save 26.08% of the total cost, on the other hand the transplanted method showed 1.8 times mean greater net income than the broadcasted method (1554.54 RM/ha and 555.76 RM/ha). That made transplanting method better technological and economic advantages than the broadcasted method in rice planting in Malaysia.

Table 6: Benefit-cost analysis of rice transplanting and broadcasting methods

Details	Transplanting	Broadcasting
Yield (tons/ha)	7.10±0.44	5.80±0.71
Yield deduction 14% and 20% (tons/ha)	0.99±0.06	1.16±0.14
Paddy price (RM/ton)	1350	1230
Gross income (RM/ha)	8244.04±514.39	5690.49±699.47
Break even yield (ton/ha)	4.96	4.17
Rent (RM/ha)	2700.00	2700.00
Total cost of production (RM/ha)	6689.50±273.79	5134.72±194.69
Net income (RM/ha)	1554.54±565.29	555.76±635.24
Benefit-cost ratio	1.232	1.108
Total productivity (RM/ton)	942.08	885.11

CONCLUSIONS

Based on study findings, it is concluded that transplanting method is better as compared to broadcasting method of wet rice production based on the calculated net economic returns and Benefit Cost Ratio . Also, transplanting technology leads to higher yield as compared to broadcasting method and better weed controls.

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