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Modification and evaluation of a power weeder for Bangladesh condition

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Abstract

A study was conducted to modify and evaluate the Korean power weeder for 20cm line spacing with adjustable mechanism in Bangladesh condition. Five weeding technologies were used in the study namely Korean Multi-rows Power Weeder (KMPW), Modified Multi-rows Power Weeder (MMPW), Korean Single row Power Weeder (KSPW), BRRI Weeder (BW) and Hand weeding (HW). Korean multi-rows power weeder which is suitable for 30 cm line transplanted rice field was modified for 18, 20 and 22 cm line spacing using Auto-CAD engineering tools and fabricated in the BRRI research workshop. Modified power weeder was evaluated at BRRI research field, Gazipur and farmer's field at Kumarkhali, Kushtia in comparison with other weeding technology. During study walking speed, time of weeding, time spent for turning at headland, fuel consumption, number of weeds before and after weeding, number of weeds revived after 3 and 10 days of weeding operation, number of tiller damage, weeding quality and operator comments data were recorded. With the help of recorded data, weeding efficiency, field capacity and field efficiency of the weeder, weed biomass and cost of operation were calculated. It was observed that the average field capacity was 935, 1336, 540, 384 and 100 m^2/hr for MMPW, KMPW, KSPW, BW and HW, respectively. The weeding efficiency of the weeders were found 91.38, 86.62, 96.15, 77.55 and 88.37 percent at Gazipur and 90.55, 91.90, 89.07, 81.94 and 94.81 percent at Kushtia in 1st weeding whereas 81.73, 82.54, 68.52, 69.12 and 89.66 percent at Gazipur and 86.11, 85.35, 76.80, 69.12 and 91.97 percent at Kushtia in 2nd weeding for MMPW, KMPW, KSPW, BW and HW, respectively. Field efficiency was found 69.35, 69.91, 71.69 and 83.78 percent at Gazipur and 62.71, 52.86, 61.88 and 86.34 percent at Kushtia in 1st weeding whereas 71.37, 70.62, 68.38 and 84.98 percent at Gazipur and 72.36, 77.44, 67.09 and 87.17 percent at Kushtia in 2nd weeding for MMPW, KMPW, KSPW and BW respectively. Total operating cost on the basis of fixed and variable cost in terms of Tk/hr for MMPW, KMPW KSPW and BW was found 120.44, 147.41, 151.63 and 38.04 respectively. The cost of operating over traditional method for weeding was found 1711, 1896, 192 and 2009 Tk/ha for MMPW, KMPW, KSPW and BW respectively over the hand weeding. The modified weeder was found suitable to operate in the line transplanted field with adjustable facility of 18, 20 and 22 cm spacing.

Key words: Weeding technology, weeding efficiency, field capacity, field efficiency, operating cost

Introduction

Weed is one of the most important agricultural pests. Most of the weeds compete more for their nourishment through rapid development and manifestation by quick root and shoot development than crop. For the competitive abilities weeds form a serious negative effect in crop production and responsible for marked losses in crop yield (Mamun *et al.*, 1993). The probable yield loss due to unrestricted weed competition was 28.28% in broadcast aman rice (Karim *et al.*,1998). Poor weed control is one of the major factors for yield reduction of rice depending on the type of weed flora and their intensity (Amarjit *et al.*, 1994). Weed growth reduced the grain yield by 68-100% for direct seeded aus rice, 16-48% for transplant aman rice and 22.36 % for modern boro rice (Mamun, 1990). This loss is therefore, a serious threat for the food deficit countries like Bangladesh. So proper weed management is essential for rice production in Bangladesh. Now-a-days the chemical methods of weed control are gaining popularity all over the world

because of its miraculous results in weed control efficiency. Manual weeding requires huge labour force and accounts for about 25 percent of the total labour requirement (900-1200 man-hours/hectare) (Nag and Dutt, 1979). Moreover, the labour requirement for weeding depends on weed flora, weed intensity, time of weeding and soil moisture at the time of weeding and efficiency of worker. Often several weeding are necessary to keep the crop weed free. Reduction in yield due to weed alone is estimated to be 16-42 % depending on crop and location and involves one-third of the cost of cultivation (Rangasamy et al, 1993). Weeding and hoeing is generally done 15-20 days after sowing. The weed should be controlled and eliminated at their early stage. Depending upon the weed density, 20-30 percent loss in grain yield is quite usual which might increase up to 80 percent if adequate crop management practice is not observed.

Lower weeding cost is always preferable from the point of view of economic consideration. Proper weeding technology is also an important factor to the farmers in our country. Weeds of a land depends on availability of water supply, soil texture and structure, location of the field, weather and climatic condition of the field, depth of plough pan, and organic matter content of the soil. In Bangladesh, Aus, Aman and Boro rice covers about 8.83%, 48.46% and 42.71% of total cultivated area and it contributes to 5.21%, 33.40% and 61.40% of the total production respectively (BBS, 2008). But, this crop yield is much lower than of transplanted rice in other rice growing countries of the world. Severe weed infestation constitutes one of the reasons for such low yield (Mamun, 1981). The yield loss due to weed competition in Aman rice is 40% in Bangladesh (BRRI, 1991).

In Bangladesh, weeds are being controlled manually by hand pulling or by using simple tools like niranee, Japanese rice weeder, BRRI & BARI developed weeder, etc. Usually, two to three hand weeding are done for growing transplanted rice crop depending upon the nature of weeds and their intensity of infestation. However, these methods are laborious, less comfortable, time consuming and expensive also. Recently Korean made power weeder was collected under the "Research capacity development of BRRI-Project" which is suitable for mechanical transplanted field of 30 cm line spacing. Mechanical transplanter is not popular in the farmers' field. Most of the farmers of Bangladesh transplant rice considering BRRI recommended spacing. Under these circumstances, Korean power weeder needs to be modified for 20 cm line spacing with adjustable mechanism. Modified power weeder was evaluated in BRRI field in comparison with other weeding technologies. Considering above point, the experiment of development and evaluation of a power weeder for Bangladesh condition has been under taken.

Objectives

- To modify the Korean power weeder
- To develop a power weeder suitable for 18, 20 and 22 cm line spacing of transplantation
- To compare developed weeder with other weeding technology
- Cost-benefit analysis of the weeding technology

Materials and Method

Korean power weeder is suitable for 30 cm line spacing of rice field. It was modified for 18, 20 and 22 cm line spacings used in Bangladesh. AutoCAD tools were used to design the weeder. The weeder was fabricated as per design in the research workshop. During design, existing specification of the power weeder was studied. Specifications of the Korean and developed power weeder are given in Table 1. GI pipe, GI sheet, MS sheet, MS flat bar and MS shaft etc workshop materials were used to fabricate the weeder in the workshop. In addition, fuel, funnel, lubricant, rules, stop watch, and measuring tape were used during study. Fabricated weeder was evaluated during Boro/2013 season at BRRI experimental field and Kumarkhali, Kushtia. Five weeding technology was used in the study. Treatments were:

T_1=Modified Multi-row power weeder-3 rows (MMPW)
T_2= Korean Multi-row power weeder-3rows (KMPW)
T_3= Korean single row power weeder (KSPW)
T_4= BRRI weeder (BW)
T_5= Manual hand weeding (HW)

RCB design was applied with three replications. In case of T_1, T_4 and T_5 land was transplanted manually maintaining spacing 20×20 cm. For the remaining treatments, land was transplanted maintaining spacing 30×13 cm. Variety, fertilizer and crop management were same for all treatment accept spacing of transplanting. Every sub plot size was 180 m^2 and 186

m^2 in Gazipur and Kushtia respectively. First weeding was conducted at 16 and 20 days after transplanting (DAT) and the second weeding date was 32 and 36 DAT in Gazipur and Kushtia, respectively.

Description of the different weeding technologies

Korean Multi-rows power weeder (3- row)

A Korean power weeder was collected to be tested in Bangladesh condition. This is a mechanical power weeder which is suitable for weeding in both low and soft land conditions. It is operated by a small petrol engine. It can operate in the line transplanted rice field of 30 cm line spacing. It is normally developed for mechanical rice transplanted field. Because of three row operation in single pass, it covers 90 cm width of paddy field at a time. The weeding spike of the rotor was made of MS sheet and the rotor of the weeder was made of aluminum sheet. One man can operate this machine easily. The total weight of the weeder is 16.5 kg.

Modified Multi-rows power weeder (3- row)

Korean power weeder was modified for Bangladesh condition. It is operated by a small petrol engine. It has three options for operation in the line transplanted rice field of 18, 20 and 22cm line to line spacing. Because of three row operation in single pass, it covers 54, 60 and 66 cm width of paddy field in a single pass. Single and triple spike plates were used for weeding. The weeding spike of the rotor was made of MS sheet and the rotor of the weeder was made of aluminum sheet. One man or woman can operate this machine easily. The total weight of the weeder is 22.9 kg.

Korean Single row power weeder

It is single row hand operated mechanical power weeder which is used for weeding in both low and dry land conditions. It is operated by a small petrol engine. It is suitable for operation for line to line distance 30 cm and covers 30 cm width of paddy field at a time. The weeding blade was made of MS/hard metal sheet. One man can operate this machine easily. The weight of the weeder is 7.2 kg. It is mainly used for grass and bush cutting.

BRRI weeder

BRRI weeder is a push type manually operated weeder. It should be used for line to line distance 20 cm for single row and covers 20 cm width of paddy field at a time. One man/woman can operate this weeder easily. The width of the rotor is 15 cm. It has 12 single spikes The weight of the weeder is 3.5 kg.

The following data were recorded and calculated during study

- Walking speed, m/sec.
- Time of weeding, min.
- Time spent for turning at headland, min
- Fuel consumption, l/hr
- Actual field capacity (m^2/hr)
- Theoretical field capacity (m^2/hr)
- Field efficiency of the weeder, %
- Number of weeds before weeding
- Number of weeds after 0, 3 and 10 days of weeding
- Number of tiller before weeding
- Number of tiller after weeding
- Weeding efficiency, %
- Weeding quality
- Weed biomass
- Cost of operation

Walking speed was recorded without any loss to measure the theoretical field capacity of the weeder. Total time of field operation was recorded to measure the actual field capacity of the weeder with turning loss, operator's personal loss, loss for machine adjustment and troubleshooting loss during field operation. Number of weeds and number of tiller was recorded from the pre-selected $1m^2$ area before and after field operation. Weeds were also collected from 1 m^2 area before weeding to measure the weed biomass. Collected weeds were dried 24 hr in the oven at 95^0C . The following formula was used to measure weeding capacity, weeding efficiency and number of damaged tiller/hill.

Field capacity

$$WC = \frac{A}{T} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

WC= Weeding capacity in ha/hr
A=Area of weeding in hector
T= Time of weeding in hr

Weeding efficiency

$$WE = \frac{w_1 - w_2}{w_1} \times 100 \ldots\ldots\ldots\ldots(2)$$

Where,

WE = Weeding efficiency in percentage
W_1= Number of weeds before operation
W_2= Number of weeds after operation

Damaged tiller rate

$$DTR = \frac{T_1 - T_2}{T_1} \times 100 \quad \text{..... (3)}$$

Where,

DTR = Damaged tiller in percentage
T_1= Number of tiller before weeding
T_2= Number of tiller after weeding

Table 1. Specification of different components of Korean multi rows and modified multi row power weeder

Items	KMPW	MMPW
Engine type and power	Petrol engine and 0.5 hp	Petrol engine and 0.5 hp
Start mode	Exclusive cartridge starting, recoil type	Exclusive cartridge starting, recoil type
Weight, kg	16.5	22.5
Dimension (L×W×H), cm	140×90×45	140×60×30
Number of rotor	3	3
Diameter of the rotor , cm	29	29
Width of the rotor, cm	18	10
Number of single spike plate in the middle rotor	6	12
Number of double spike plate in the middle rotor	6	0
Number of triple spike plate in the side rotor	0	12
Number of plate of five spike in the side rotor	12	0
Number of cover plate	6	6
Size of handle to carry, cm	40	40
Size of stand, cm	53	53

Spike arrangement and angle of action during operation is same for both cases except number of spike. In Korean power weeder, six spike plates comprising with five spikes were attached in each side rotors. In case of middle rotor, six spike plates comprising with single and double spikes were attached alternatively (Fig. 1). Whenever, in developed power weeder, six spike plates comprising with three spikes are attached in each side rotors. In case of

Design specification of the Korean and Modified Mult-rows Power Weeder

Spike and spike arrangement of the power weeder

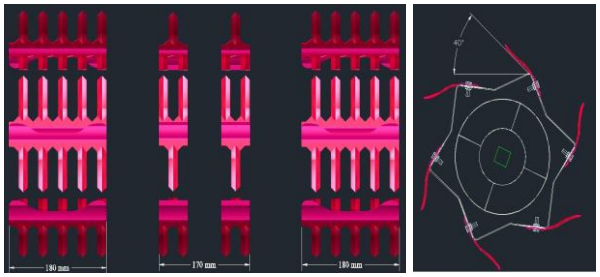

Fig 1. Spike arrangement of KMPW

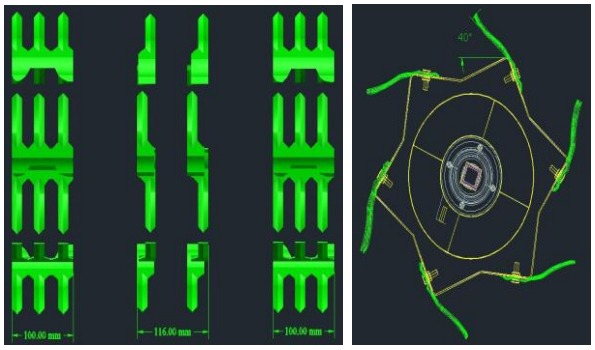

Fig 2. Spike arrangement of the MMPW

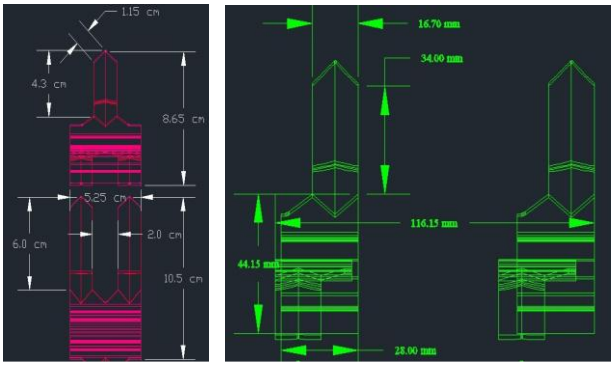

Fig 3. Spike plate dimension of the KMPW and MMPW

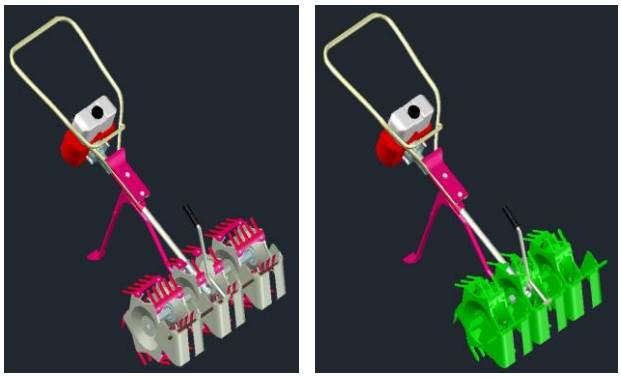

Fig 4.Korean and Modified power weeder

middle rotor, six spike plates comprising with single spike is attached (Fig. 2). Specifications of spikes are shown in Fig. 3. Complete isometric view of the Korean and modified power weeder is shown in Fig 4.

Results and discussion

Fabrication and description of the modified weeder

The modified power weeder was operated by a petrol engine. During design, the following criteria were considered-

- Ease of operation
- Ease of adjustment during field operation
- Adjustable with various line spacing

As par design, the modified power weeder was fabricated in the research workshop of BRRI.

First weeding

Weeding efficiency

Weeding efficiency was calculated based on the weeds density before and after weeding for different weeding technology. Weeding efficiency was found for MMPW, KMPW, KSPW, BW and HW as 91.38,

86.62, 96.15, 77.55 and 88.37 percent in Gazipur whereas it was 90.55, 91.90, 89.07, 81.94 and 94.81 percent in Kushtia respectively (Table 1). Weeding efficiency was found more for MMPW compare to KMPW in both cases. Effective weeding area of MMPW is 33 cm out of 60cm (55%) whereas effective weeding area of KMPW is 48 cm out of 90 cm (53%). On the other hand spike to spike distance is more in Korean power weeder. As a result, the weeding efficiency of MMPW was more than KMPW. The percentage of weed remain was high for BW among the weeding technologies.

Tiller damage

Percent of tiller damage for KSPW was observed as 17.11 and 3.85 % which was higher than that of other technology followed by 11.84 and 1.55 % for KMPW in both Gazipur and Kushtia respectively. Tiller damage was observed for MMPW, KMPW, KSPW, BW and HW 9.33, 11.84, 17.11, 10.00 and 8.70 percent in Gazipur whereas it was 1.49, 1.55, 3.85, 0.76 and 0.72 percent in Kushtia respectively (Table 1).

Weeds revive

It was found that the percent of weed revive after 3days was high for KSPW, because KSPW could not uproot the weeds properly. In this case, the blade of KSPW only can cut the weed from the surface of the soil. Percent of weeds revive after 3 days for MMPW was observed 48.57% which was lowest than others (Table 1). On the other hand, percent of weed revive after 10 days was also high for KSPW and low for MMPW.

Table 1. Weeding performance of 1st weeding with different weeding technology at Gazipur and Kushtia

Parameters	Gazipur					Kushtia				
	MMPW	KMPW	KSPW	BW	HW	MMPW	KMPW	KSPW	BW	HW
No. of Weeds before weeding/m^2	406	299	312	245	215	254	247	247	227	212
No. of Weeds after weeding/m^2	35	40	12	55	25	24	20	27	41	11
Weeding efficiency (%)	91.38	86.62	96.15	77.55	88.37	90.55	91.90	89.07	81.94	94.81
% of weeds remain	8.62	13.38	3.85	22.45	11.63	9.45	8.10	10.93	18.06	5.19
No. of tiller before weeding/m^2	75	76	76	90	69	134	129	130	132	138
No. of tiller after weeding/m^2	68	67	63	81	63	132	127	125	131	137
% of tiller damage	9.33	11.84	17.11	10.00	8.70	1.49	1.55	3.85	0.76	0.72
No. of Weeds after 3 days of weeding/m^2	52	60	31	83	53	30	26	48	69	18
(%) of revive after 3 days	48.57	50.00	158.33	50.91	112.00	25.00	30.00	77.78	68.29	63.64
No. of Weeds after 10 days of weeding/m^2	104	126	54	136	87	31	27	50	72	21
(%) of revive after 10 days	197.14	215.00	350.00	147.27	248.00	29.17	35.00	85.19	75.61	90.91
Weeds biomass during weeding, gm/m^2	29.60	23.13	25.86	66.90	23.43	22.50	21.75	20.50	22.25	21.00

Note: Average data of three replications is presented in the Table.

MMPW

KMPW

KSPW

BW

Manual weeding

Fig. 5. Weeding activities during 1st weeding

Field efficiency

In Table 2, 69.35, 69.91, 71.69 and 83.78% field efficiency were found for MMPW, KMPW, KSPW and BW in Gazipur whereas it was 62.71, 52.86, 61.88 and 86.34% in Kushtia respectively. Field efficiency of MMPW and KMPW was observed nearly similar. Field efficiency of the technologies varied with the variation of total turning time loss. Turning loss was observed minimum in BW. For this reason, the field efficiency of BW was found highest followed by MMPW and KMPW. Field efficiency of KSPW was found more compared to multiple power weeders because of turning and placing time loss difference.

Walking speed

Walking speed during field operation of different weeding technology was measured considering total operating time excluding time of turning loss. Walking speed of MMPW, KMPW, KSPW and BW weeding was found 2232, 2354, 2462 and 2226 m/hr in Gazipur and 2579, 2709, 3064 and 2472 m/hr in Kushtia respectively (Table 2). The walking speed was found more in Kushtia than Gazipur for all technology because of soil condition. Walking speed of KMPW was more than MMPW, because weight of KMPW is less compared to MMPW.

Weeds biomass

Weed biomass was measured to observe the actual condition of the weeds in the paddy fields. Weed biomass was varied with the number, type and maturity of the weeds. Weed biomass was found 29.60, 23. 13, 25.86, 66.90 and 23.43 gm/m² in Gazipur and 22.50, 21.75, 20.50, 22.25 and 21.0 gm/m^2 for MMPW, KMPW, KSPW, BW and HW, respectively (Table 1).

Table 2. Field efficiency of the mechanical weeder during 1st weeding at Gazipur and Kushtia

Parameters	Gazipur					Kushtia				
	MMPW	KMPW	KSPW	BW	HW	MMPW	KMPW	KSPW	BW	HW
Length , m	50	50	50	25	25	30	20	22	22	22
Width of land, m	3.00	3.15	2.25	2.30	2.30	6.00	9.00	3.90	3.60	3.60
Area, m²	150	158	113	58	58	180	180	86	79	79
Number of pass	5	4	8	12	0	10	10	13	18	-
Total operating time, min	10	6	13	9	27	11	8	9	11	59
Turning losses, min	2.97	1.92	3.61	1.5	-	4.15	3.95	3.45	1.52	-
Turning losses/pass, min	0.59	0.55	0.48	0.13	0.00	0.42	0.40	0.27	0.08	-
Actual operating time, min	7	4	9	8	27	7	4	6	10	59
walking speed, m/hr	2232	2354	2462	2226	-	2579	2709	3064	2472	-
Theoretical capacity,m²/hr	1339	2119	739	445	128	1547	2438	919	494	80
Actual field capacity, m²/hr	929	1481	529	373	128	970	1289	569	427	80
Field Efficiency, %	69.35	69.91	71.69	83.78	-	62.71	52.86	61.88	86.34	-

Note: Average value of three replications is presented in the Table. Number of passes is fraction because of average value of two replications.

Second weeding

Weeding efficiency

Weeding efficiency depends on weed density, machine performance, operator skill, soil condition and maturity of weeds. It was calculated based on the weed density before and after weeding using different weeding techniques. Weeding efficiency was found for MMPW, KMPW, KSPW, BW and HW 81.73, 82.54, 68.52, 69.12 and 89.66 percent in Gazipur whereas it was 86.11, 85.35, 76.80, 69.12 and 91.97 percent in Kushtia respectively (Table 3). Average weeding efficiency was found similar of MMPW and KMPW. Weeding efficiency of the KSPW and BW was observed less than other technologies due to more matured weeds in the field. The percent of weed remain was high for BW and low for HW among the other weeding technology.

Tiller damage

Percentage of tiller damage for KSPW was observed 17.53 and 18.56 % which was higher than that of others in Gazipur and Kushtia respectively. Tiller damage was observed for MMPW, KMPW, KSPW, BW and HW 4.49, 5.56, 17.53, 5.88 and 5.36 percent in Gazipur whereas it was 3.37, 3.33, 18.56, 6.62 and 2.68 percent in Kushtia respectively (Table 3).

Walking speed

Walking speed during field operation of different weeding technology was also measured at 2nd weeding. Walking speed of MMPW, KMPW, KSPW and BW weeding was found 2005, 2459, 3065 and 2067 m/hr in Gazipur and 2261, 1722, 2325 and 2272 m/hr in Kushtia respectively (Table 4). Walking speed of KMPW was more than MMPW, because weight of KMPW is less compared to MMPW.

Field Capacity

Theoretical and actual field capacity was also measured of all weeding technology during 2nd weeding operation to calculate the field efficiency. Actual field capacity of MMPW, KMPW, KSPW, BW and HW was found 859, 1372, 529, 340 and 94 m²/hr in Gazipur whereas it was 982, 1200, 469, 395 and 99 m^2/hr in Kushtia respectively (Table 4). The field capacity of KMPW was more than MMPW in both cases, because KMPW covered more space (90 cm) in a single pass compared to MMPW (60 cm).

Fig. 6. Weeding activities during 2nd weeding

Table 3. Weeding performance of 2nd weeding with different weeding technology at Gazipur and Kushtia

Parameters	Gazipur					Kushtia				
	MMPW	KMPW	KSPW	BW	HW	MMPW	KMPW	KSPW	BW	HW
Area, m²	150	158	113	58	58	180	180	86	79	79
No. of Weeds before weeding/m^2	104	126	54	136	87	108	130	125	136	137
No. of Weeds after weeding/m^2	19	22	17	42	9	15	19	29	42	11
Weeding efficiency (%)	81.73	82.54	68.52	69.12	89.66	86.11	85.38	76.80	69.12	91.97
% of weeds remain	18	17	31	31	10	14	15	23	31	8
No. of tiller before weeding/m^2	89	90	97	136	112	89	90	97	136	112
No. of tiller after weeding/m^2	85	85	80	128	106	86	87	79	127	109
% of tiller damage	4.49	5.56	17.53	5.88	5.36	3.37	3.33	18.56	6.62	2.68

Note: Average data of three replications is presented in the Table.

Field efficiency

Field efficiency of 2nd weeding operation at Gazipur was found 71.37, 70.62, 68.38 and 84.98% for MMPW, KMPW, KSPW and BW whereas it was 72.36, 77.44, 67.09 and 87.17% at Kushtia respectively (Table 4). Field efficiency of MMPW, KSPW and KMPW was observed nearly similar to each other. Field efficiency of the technologies varied with the variation of total turning time loss. Turning loss was observed minimum in case of BW. For this reason, the field efficiency of BW was found highest followed by MMPW and KMPW. Field efficiency of KSPW was found more compared to multiple power weeders because of turning and placing time loss difference.

Average field capacity

The average field capacity of 1st and 2nd weeding at Gazipur and Kushtia was found 935, 1336, 540, 384 and 100 m^2/hr for MMPW, KMPW, KSPW, BW and HW respectively (Table 5). The variation of average field capacity occurred due to effective width of weeder, length and width of field, operator skill, weed density, soil condition and standing water. The average fuel consumption of 1st and 2nd weeding operation at both Gazipur and Kushtia was observed 5483, 5572, 16552 ml/ha for KMPW, MMPW and KSPW, respectively (Table 5). The variation of fuel consumption was observed between 1st and 2nd weeding due to time of operation, turning time loss, mechanical error of machine and weed density. The highest fuel consumption was observed in KSPW compare to MMPW and KMPW. Highest fuel consumption was occurred due to less effective weeding area weeded by the KSPW. MMPW and KMPW weeded 60 cm and 90 cm respectively where as KSPW weeded only 30 cm width of the field in a single pass.

Table 4. Field efficiency of the mechanical weeder during 2nd weeding at Gazipur and Kushtia

Parameters	Gazipur					Kushtia				
	MMPW	KMPW	KSPW	BW	HW	MMPW	KMPW	KSPW	BW	HW
Length , m	50	50	50	25	25	30	20	22	22	22
Width of land, m	3	3.15	2.25	2.3	2.3	6	9	3.9	3.6	3.6
Area, m²	150	158	113	58	58	180	180	86	79	79
Number of pass	5	4	8	12	-	10	10	13	18	-
Total operating time, min	10.48	6.91	11.45	10.25	36.86	11	9	11	12	48
Turning losses, min	3	2.03	3.62	1.54	-	3.04	2.03	3.62	1.54	-
Turning losses/pass, min	0.60	0.51	0.45	0.13	-	0.30	0.20	0.28	0.09	-
Actual operating time, min	7.48	4.88	7.83	8.71	36.86	7.96	6.97	7.38	10.46	48
walking speed, m/hr	2005	2459	3065	2067	-	2261	1722	2325	2272	-
Theoretical capacity, m²/hr	1203	1943	866	400	-	1357	1549	699	453	-
Actual field capacity, m²/hr	859	1372	592	340	94	982	1200	469	395	99
Field Efficiency, %	71.37	70.62	68.38	84.98	-	72.36	77.44	67.09	87.17	-

Note: Average data of two replications is presented in the Table. Number of passes is fraction because of average value of three replications.

Table 5. Average field capacity and Fuel consumption of the weeding technology

Locations	Time of weeding	Capacity (m^2/hr)					Fuel consumption (ml/ha)				
		MMPW	KMPW	KSPW	BW	HW	MMPW	KMPW	KSPW	BW	HW
Gazipur	1st weeding	929	1481	529	373	128	5083	4907	19352	-	-
	2nd weeding	859	1372	592	340	94	5991	6112	17315	-	-
Kushtia	1st weeding	970	1289	569	427	80	6306	6694	17191	-	-
	2nd weeding	982	1200	469	395	99	4550	4575	12350	-	-
Average		935	1336	540	384	100	5483	5572	16552	-	-

Cost of operation

Table 6. Operating cost calculation of different weeding technology

a. Fixed cost calculation

Sl. No.	Items	MMPW	KMPW	KSPW	BW
1	Purchase price (p), Tk	65000	72000	48000	800
2	Salvage value (S), Tk (10% of p)	650	720	480	8
3	Working life (L), yr	10	10	10	5
4	[1]Average annual use (Au), hr/yr	480	480	480	480
5	Annual depreciation, D=(P-S)/L	6435	7128	4752	158.4
6	Interest on investment, I=(P+S)/2*I, where rate of interest is 12%	3939	4363.2	2908.8	48.48
7	Tax, insurance, T=3% of P	1950	2160	1440	24
8	Total fixed cost (D+I+T), Tk/yr	12324	13651.2	9100.8	230.88
9	*Total fixed cost, Tk/hr*	25.675	28.44	18.96	0.481

b. Variable cost

Sl no.	Items	MMPW	KMPW	KSPW	BW
1	[2]Labour cost per hour, L (Tk/hr)	37.5	37.5	37.5	37.5
	Fuel used, lit/hr	0.51	0.74	0.89	0
2	Fuel cost, Tk/hr	51	74	89	0
3	Lubricant cost , (Tk/hr) (lubricant cost is 3% of fuel const)	1.53	2.22	2.67	0
4	RPM/hr =3.5 % of purchase price /Average annual use, hr	4.74	5.25	3.50	0.06
5	Total Variable cost (Tk/hr)	94.77	118.97	132.67	37.56
6	*Total operating cost Tk/hr (Fixed cost+ Variable cost)*	120.44	147.41	151.63	38.04
8	*Weeding time, hr/ha*	10.7	7.49	18.52	26.04
9	*Operating Cost for tillage, Tk/ha*	1289	1104	2808	991
10	*Hand weeding cost, Tk/ha (Weeding time, 100 hr/ha)*		25000.00		
11	*Save over traditional methods of weeding*	1711	1896	192	2009

Note: Labor cost as opearator, 37.5 Tk/hr and as manual weeding, 31.25 Tk/ha. Hand weeding cost was collected by interviewing the farmers of the study area.

In the above Table 6, total operating cost on the basis of fixed and variable cost in terms of Tk/hr for DMPW, KMPW KSPW and BW was found 120.44, 147.41, 151.63 and 38.04 respectively. The operating cost on the basis of Tk/ha 1289, 1104, 2808, 991 and 25000 for MMPW, KMPW KSPW, BW and HW, respectively (Table 6). Farmers could save 1711, 1896, 192 and 2009 Tk/ha by using KMPW, MMPW, KSPW and BW respectively over the traditional method.

Conclusion

Korean multi-row power weeder was modified for Bangladesh conditions considering the line to line spacing 18, 20 and 22 cm because Korean power weeder is suitable only for mechanical transplanter rice field. Both Korean and modified power weeder was found suitable to control weeds in the line transplanted field. The average field capacity of 1st and 2nd weeding at Gazipur and Kushtia was found more for KMPW compared to others. All weeding technologies were found profitable over the traditional method though single row power weeder was least profitable. Farmers could save 1711, 1896, 192 and 2009 Tk/ha by using KMPW, MMPW, KSPW and BW respectively over the traditional method.

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