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The Appropriate Scale Mechanization Consortium for Sustainable Intensification Project (ASMC)

Report on

PERFORMANCE TESTING OF FIVE SEEDERS AND BROADCASTERS ON RICE PRODUCTION IN BATTAMBANG PROVINCE

09th March 2020

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I. Introduction

The Appropriate Scale Mechanization Consortium for Sustainable Intensification project (ASMC) is a 4-year project to address agricultural mechanization and its role towards extending sustainable intensification (SI) and conservation agriculture (CA) activities in different agroecosystems of Cambodia. The project goal is to improve the resilience of farming systems in the rain-fed lowland areas of Cambodia promoting appropriate-scale mechanization along with innovative rice cropping systems. ASMC designed and developed mechanization prototypes for a diversify of implements including:

1. Conventional and no-till seeder
2. Bucket scraper for laser land leveling
3. Broadcaster for seed and fertilizer
4. Roller-crimper.

This is an experimental study to perform testing of conventional seeder, no-till seeder, and broadcaster prototypes to compared with the performance of commercial mechanization including no-till seeder from Brazil and Eli seeder and also to compared to Cambodian traditional hand broadcasting. The experimental plan was created by CASC/DALRM/CIRAD and the data collection was conducted by RUA students under the supervision of CASC/DALRM/CIRAD and RUA. The experimental study was created in 4 plots which is equal to four farmer households or farmers' fields. But, this report presents the results of 2 plots because the plot of farmer's field number 2 was damaged by allowing cows to get into as a result of drought issue during the growing stage and the plot number 1 was not collected data regarding the performance of the machinery as CASC/DALRM/CIRAD team did the planting without the participant of students or research team from RUA. The experiment was conducted in Samrong village, Bannan district, Battambang province, Cambodia. All practical care on the paddy was followed the habit of individual farmer.

Pkar Romdul is a fragrant rice variety was selected for this experiment. It is a seasonal rice variety generally grow in June or July and harvesting in late October or early November. The planting was conducted in mid-July 2019 and harvested in mid-November 2019.

II. Objectives of the study

The specific objectives of the study are:

- To identify the field performance of the prototypes compared to other commercial machines and traditional hand broadcasting.
- To determine the growth and yield of rice as a result of using different tools.

III. Materials and Methods

3.1 Materials

Fig. 1 No-till seeder for four-wheel tractor, designed and developed by ASMC

Fig. 2 Conventional seeder pulled by power tiller, designed and developed by ASMC

Fig. 3 Broadcaster for four-wheel tractor

Fig. 4 No-till seeder Vence Tudo from Brazil

Fig. 5 Eli seeder

Fig. 6 Traditional hand broadcasting

Fig. 7 Pkar Rumduol paddy rice variety

3.2 Methods

The experimental study was designed for 7 treatments (Table 1).

Table 1: Treatments design for the experimental test.

No.	Explanation of each treatment	Acronym
1	Traditional hand broadcasting plus harrowing by power tiller	T0
2	Traditional hand broadcasting plus harrowing by power tiller	T0’
3	Sowing by no-till seeder for four-wheel tractor prototype	T1
4	Sowing by Vence Tudo no-till planter	T2
5	Sowing by Eli seeder	T3
6	Broadcasting by broadcast seeder for four-wheel tractor prototype	T4
7	Sowing by conventional seeder pulled by power tiller	T5

The experimental test was used split-plot design method as there are 2 locations of paddy field with completed randomized block (CRD) per location. In the same location, there are 7 experimental plots, represented to each treatment. The dimension of each experimental plot is in the range of 500 - 900m2.

The set target seed rate used is 180 kg/ha for traditional hand broadcasting and 80 kg/ha for machinery planting.

All agronomic care factors are depending on the habit of each farmer's practice, maintaining the same in all experimental plots.

The parameters of data collected for analysis and reporting as following:

A. Sowing or broadcasting stage

- Operational speed: the speed of walking or tractor driving to sow or broadcast, measuring using stop watch.

- Time consume: measure how much time spend to finish each experimental plot using stop watch.

- Field capacity is analyzed using the equation:

Field capacity = time consumed (h) /area (ha)

B. Growing stage

In the growing stage, selected randomly of 5 samples per experimental plot with dimension of $1m^2$ to collect data on growing from time to time for: plant density, plant height, plant diameter, and length of stem. All data was collected manually.

C. Harvesting and post-harvest stage

In the harvesting stage, production yield was calculated using the collected data in $1m^2$ of the 5 samples per plot. The paddy was harvested and transported to RUA campus to remove straw and to drive under sun shine to the target moisture content at 14%. In addition, other quality parameters were also analyzed using other 5 panicles collected randomly from nearby each sample for weight, length, number of seed, and percentage of good paddy seed per panicle. All data was collected manually.

IV. Results and discussion

4.1 The performance of machinery and tool

4.1.1 Field capacity

The experimental test was planned to conduct in 4 plots (equal to 4 paddy fields of 4 farmer households), but the data of performance of machinery and tool was collected when the staff and student from RUA joined the testing on 14th and 18th June 2019. The results showed that traditional hand broadcasting plus harrowing by power tiller (T0) is the highest time need, followed by conventional

seeder pulled by power tiller (T5) almost 8 and 6 hours per hectare, respectively (figure 8). The two planting methods are depending on the speed of human walk, although the seeder is pulled by power tiller. The walking and driving speed of power tiller for broadcasting or planting was about 6 km/hr (Figure 9). The T0 needs about 2 hours more time for harrowing. In the same figures 8 & 9, the no-till seeder made in Cambodia and Brazil are the same in field capacity (about 1.5 to 2 hr/ha) with driving speed in the range of 7 to 10 km/hr. For Eli seeder, the field capacity of the machine is between 1 and 3 hr/ha. The lowest time consume is T4 (broadcast seeder for four-wheel tractor) at just about 30 minutes to 1 hour per hectare. The driving speed was in the range of 7 to 10 km/hr as well, but the field capacity is higher than no-till seeder due to the more difficulty of turning of the no-till seeder.

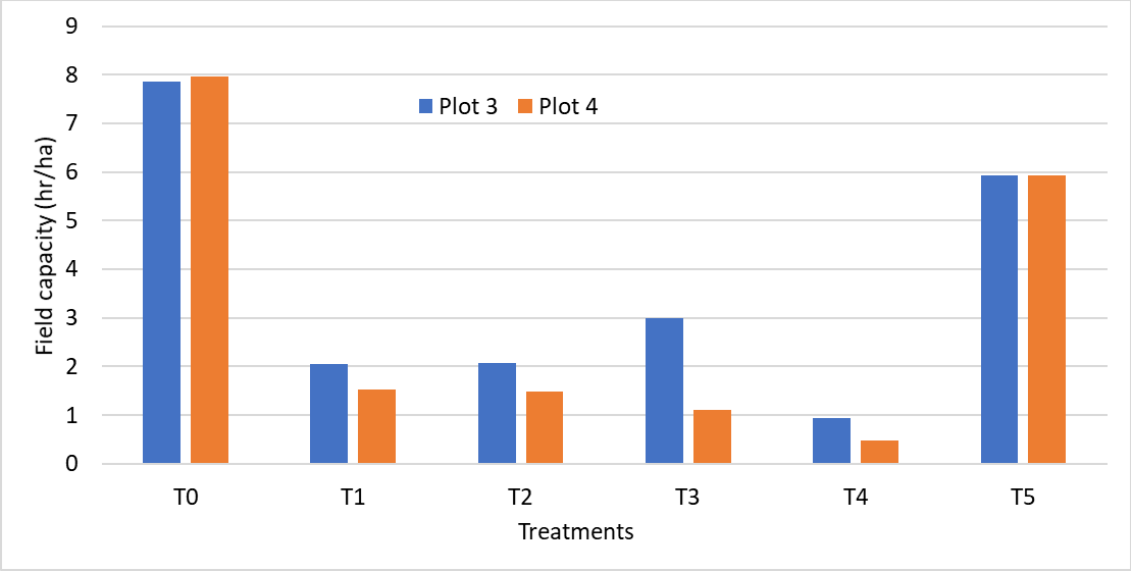

Fig8: Field capacity of the different planting machines and tools

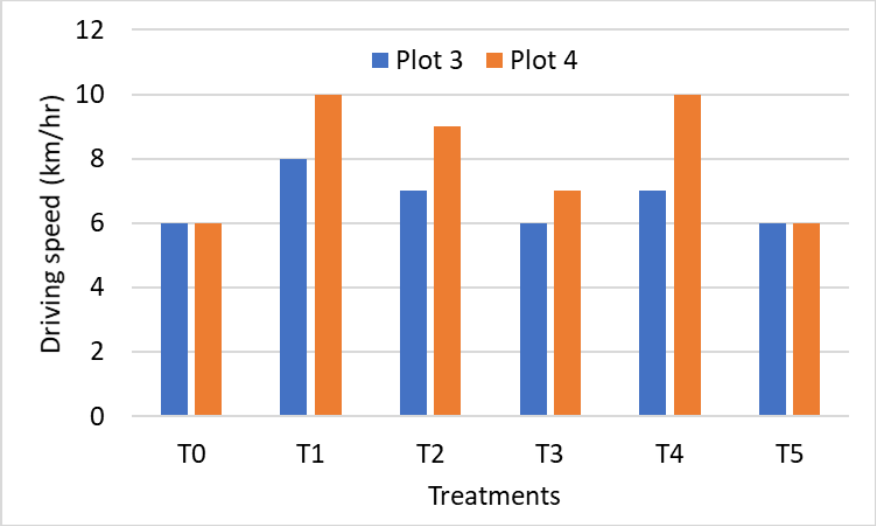

Fig9: Speed of driving

4.1.2 Fuel consumption

The fuel used for traditional hand broadcasting plus harrowing treatment is for power tiller (Kubota 12hp) to harrow to cover seed in the soil after broadcasted. The fuel used for no-till seeders and

broadcast seeders for four-wheel tractor (T1, T2, and T4) is for the four-wheel tractor, FORD 75hp. The fuel consumed by power tiller (Kubota 12hp) for T3 and plus an air blower engine for T5. The results in figure 10 illustrated that, the tractor pulled no-till seeder of ASMC prototype consumed the highest fuel up to about 12 liter per ha, while pulling the Brazilian no-till seeder was about 7 L/ha and was about 5.5 L/ha for broadcast seeder. For T3 and T5, the fuel consumption was the same accounted for 4 L/ha because the T3 (Eli seeder) needs to engines to operate.

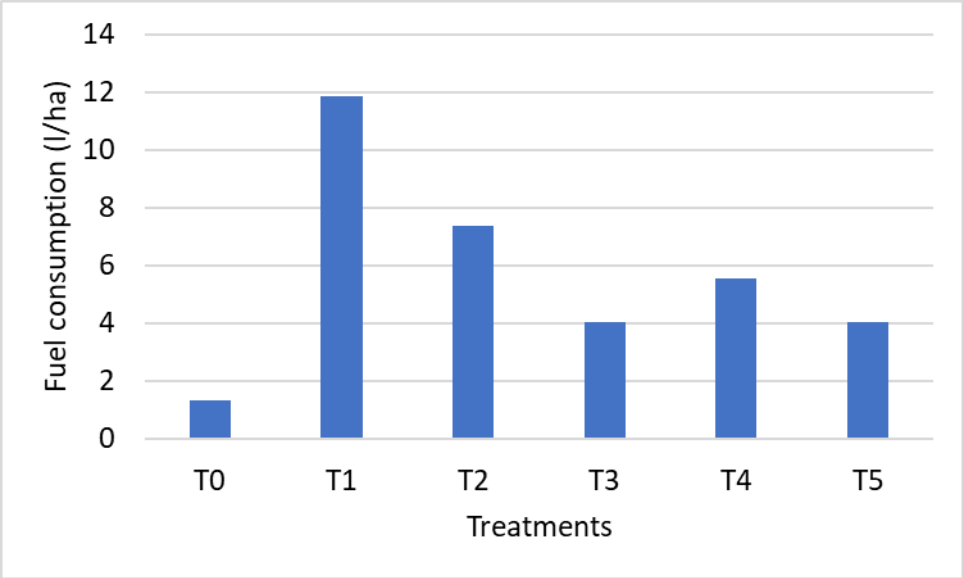

Fig10: Fuel consumption of each machine

4.1.3 Seed rate

Figure 10 below showed the seed drop that weighted before and after planting. Hand broadcasting and Eli seeder met the target seed rate, while other seeders did not. The seed drop of other seeders is in the range of 80 to 124 kg/ha.

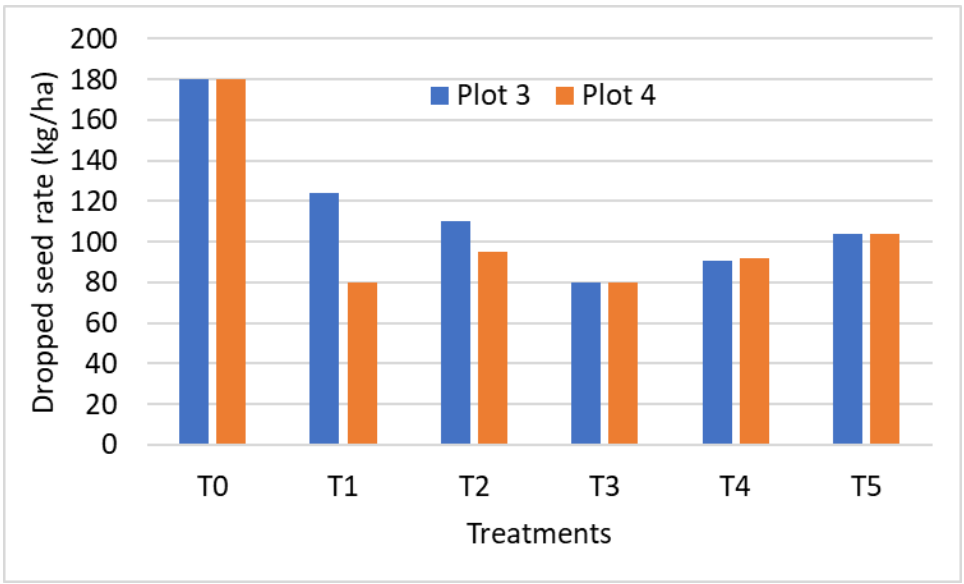

Fig10: Dropped seed

4.2 Growth of paddy rice

4.2.1 Plant density

Figure 11 a and b below show the number of plant grow in the period of 3 months after planting. In the 1st month growing, the number of plants were in the range of 150 to 230 plants/m2 (more than 1,500,000 plants/ha). The highest number of paddy plants grow was the experimental plot using hand broadcasting, followed by no-till seeder. The least number of plants was the experimental plot used broadcast seeder for four-wheel tractor in plot 3, but in plot 4 was no-till seeder of ASMC prototype. The number of plants increased when collected data in the 2nd month and 3rd month after planting. At about 90 days after planting, Brazilian no-till seeder and traditional hand broadcasting keep the highest position in number of plant, that increased up to about 420 plant per square meters or 4,200,000 plants per hectare. The least plant numbers was the broadcast seeder.

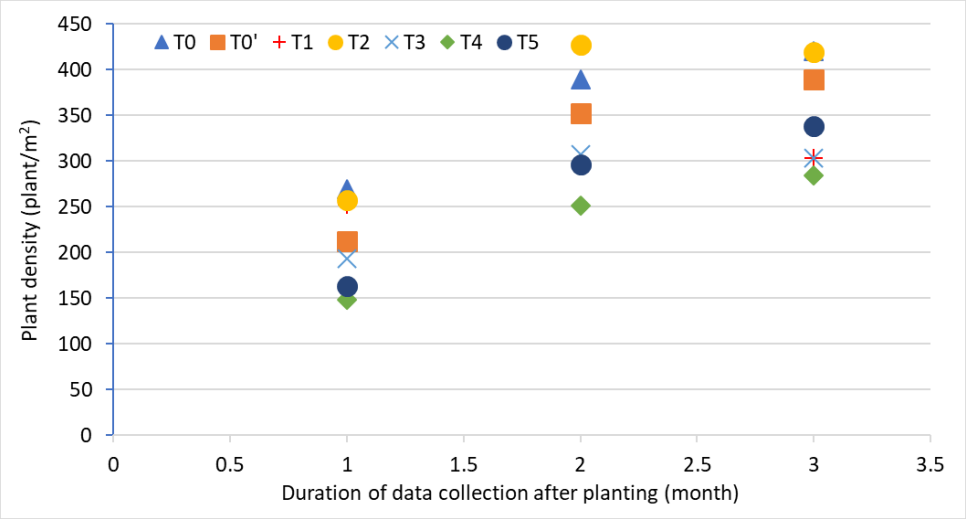

Fig11a: Plant density of paddy in plot 3

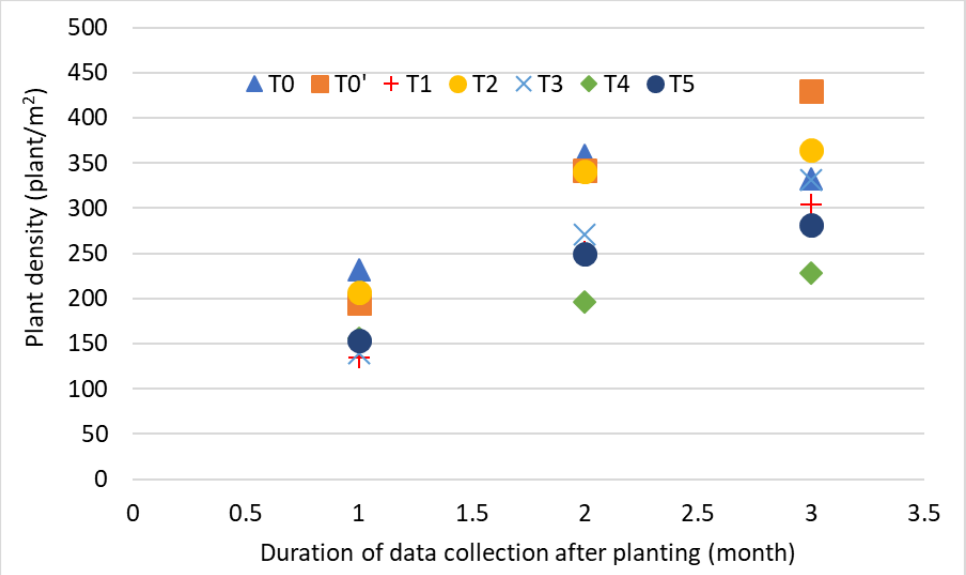

Fig11b: Plant density of paddy in plot 4

4.2.2 Plant height

Figure 12 a and b show the results of plant height of the paddy. The data was collected 3 times during the 2nd month, 3rd month, and 4th month after planting. In plot 3, the highest plant obtained for the paddy planted by no-till seeders (T1 & T2), increased gradually from about 70 cm in the 2nd months to about 160 cm in the fourth month. The lowest height was the paddy planted using conventional seeder pulled by power tiller (T5) between approximately 58 cm and 145 cm in the 2nd month and 4th month after planting. However, it is different compared to plot 4, where T5 was the tallest plant with T4 (broadcasted by broadcast seeder for four-wheel tractor) was the shortest one.

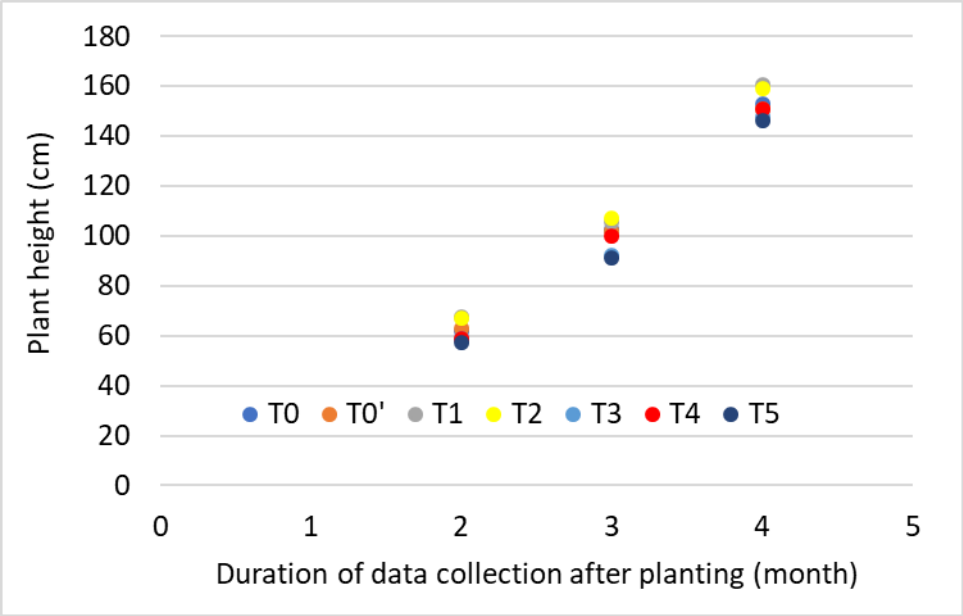

Fig12a: Plant height of paddy in plot 3

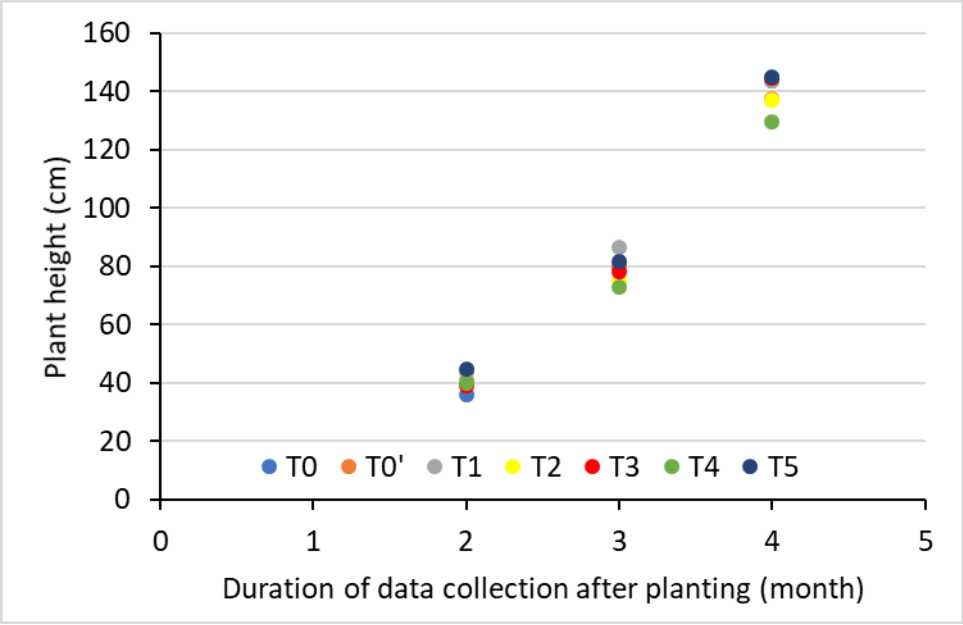

Fig12b: Plant height of paddy in plot 4

4.2.3 Plant diameter

About plant diameter, figure 13 a and b showed that the paddy in plot 3 is smaller than that of plot 4 in the diameter measured in the 3rd month after planting, although it is bigger at the beginning. To compared between the different planting tools, it is difficult to identify the level of differences. Further statistical analysis will be conducted in order to illustrate this. The plant diameter of the paddy was in the range of 110-120 mm in the 2nd month and enlarged to around 130mm in the 3rd month of growing for the paddy in plot 3. Whereas in plot 4, the plant diameter was in a bigger range from about 70 to 100 mm in the 2nd month and grew up to around 140 mm in the 3rd month. In plot 4, according the graphic in figure 13b, the growth of paddy planted by conventional seeder was the biggest and the paddy broadcasted by hand was the smallest at the first stage, but at the last stage they look getting the same size of plant.

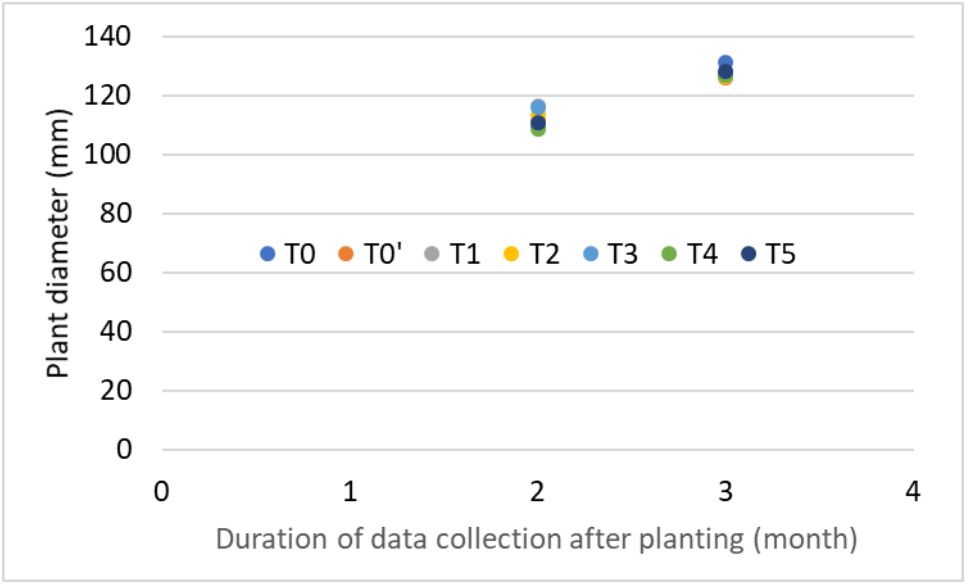

Fig13a: Plant height of paddy in plot 3

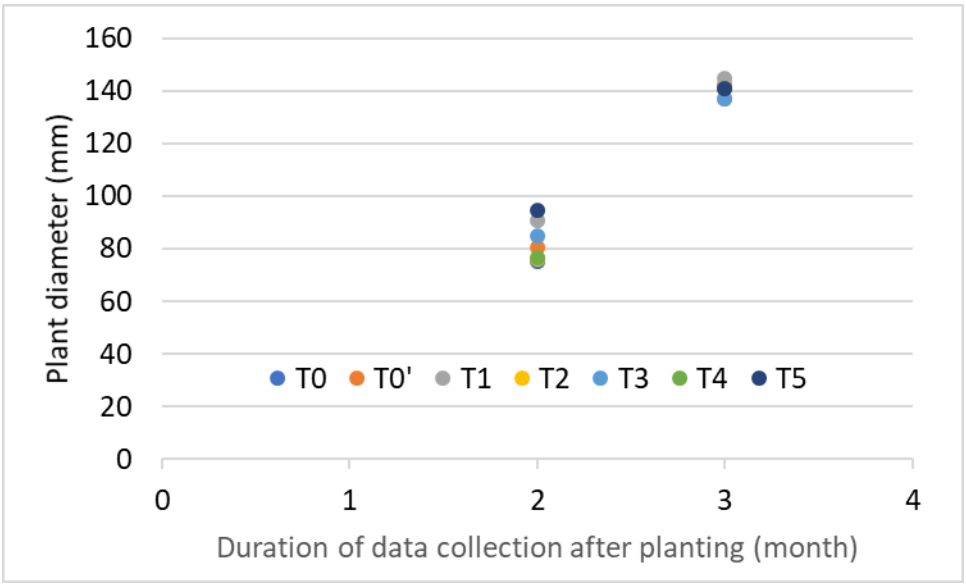

Fig13b: Plant height of paddy in plot 4

4.2.4 Length of leaf

Similar to the plant height, the paddy in plot 3 have longer leaf than that of the paddy in plot 4. This result might be from the influence of different crop care and fertilization between the 2 farmers. In plot 3, the length of leaf of the paddy increased from 35-45cm to 52-60cm and in plot 4 from 23-40cm to 40-52cm (Figure 14 a and b).

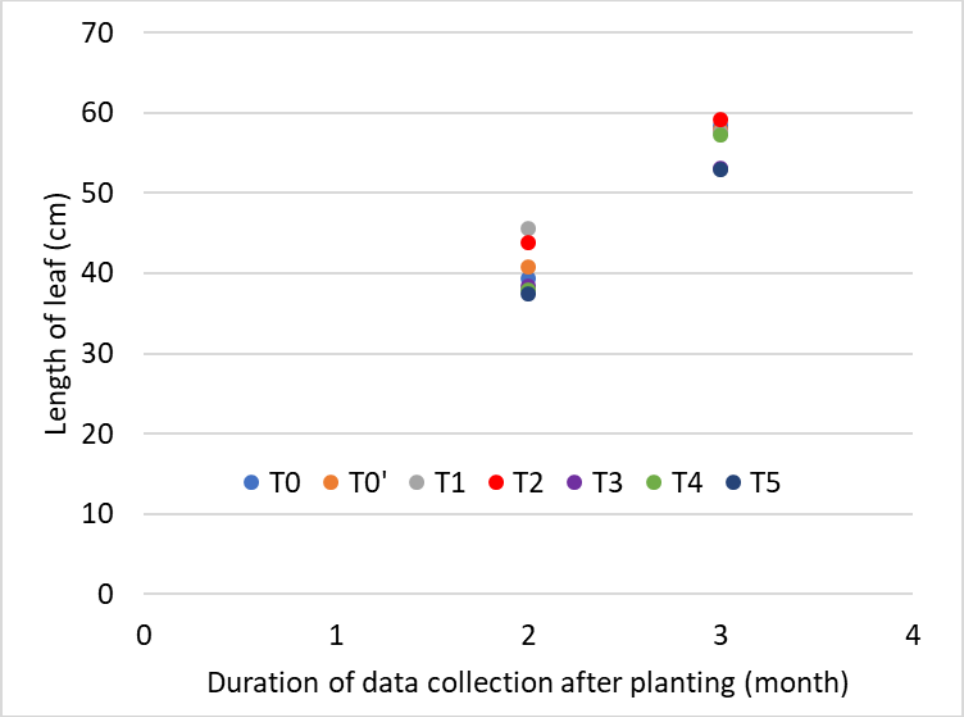

Fig14a: Length of paddy leaf in plot 3

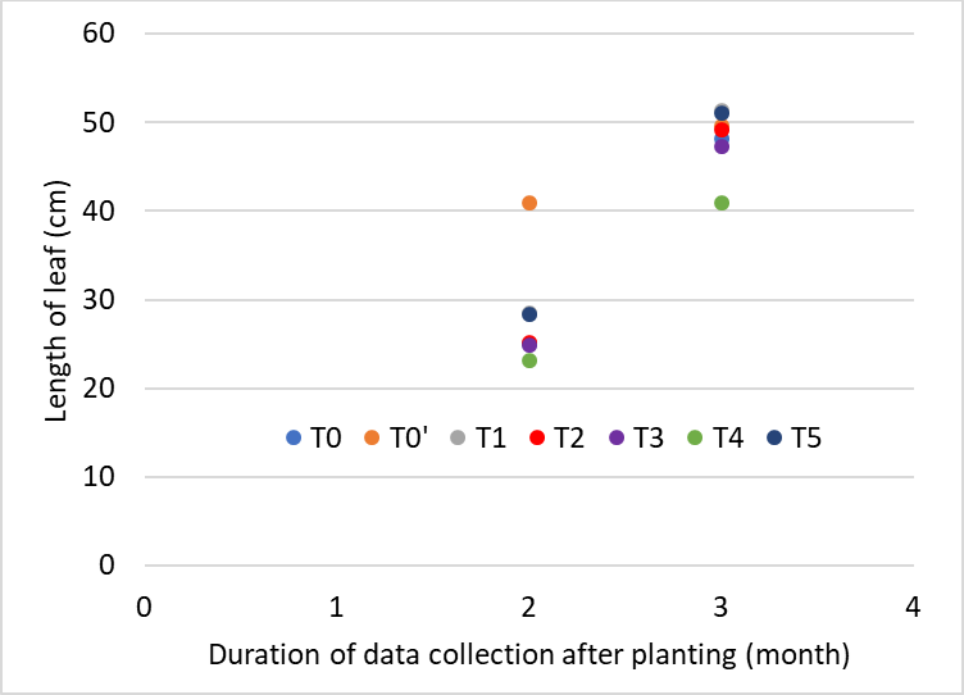

Fig14b: Length of paddy leaf in plot 4

4.3 Harvest and post-harvest stage

4.3.1 Overall production yield

Figure 15 below shows the overall production yield in average of paddy planted by different tools in ton/hectare at moisture content of 14%. Similar to other agronomic parameters shown above, the results are different between the plot 3 and plot 4, that this might be caused by the different crop care, fertilization, and soil fertility. In general, the plot 3 obtained higher yield, although there is an interesting to see that there is significant different for the yield of paddy planted by no-till seeder of ASMC prototype at approximately 4.1 ton/hectare (Fig. 15) which is also the highest yield in plot 4 compared among the different planting tools. However, in plot 3, the highest yield was the paddy planted by Brazilian no-till seeder (almost 5 t/ha), followed by traditional hand broadcasting (T0) accounted for about 4.8 t/ha. In plot 3, the lowest yield was the paddy planted by no-till seeder of ASMC prototype and in plot 4 was the paddy broadcasted by broadcast seeder for four-wheel tractor (t4) at about 2.4 t/ha.

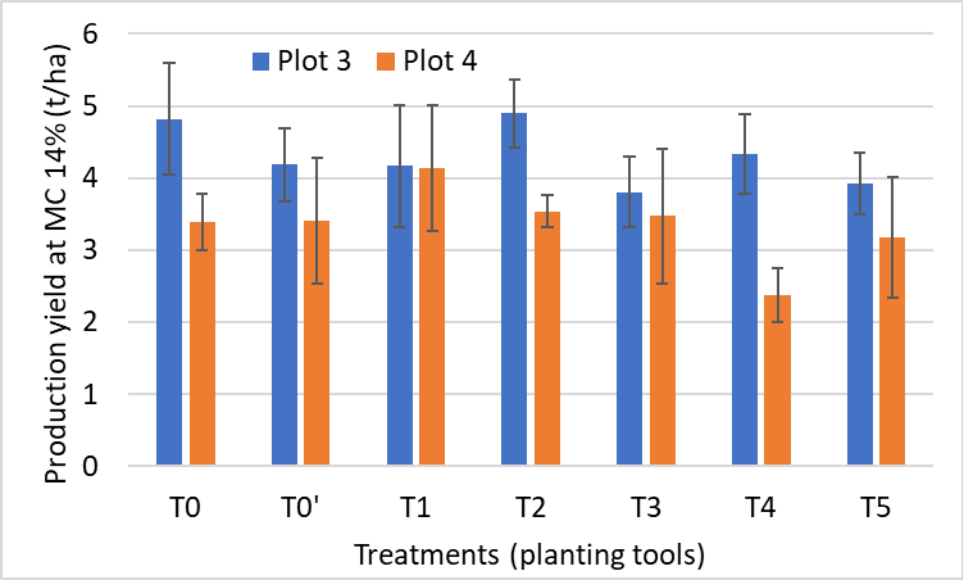

Fig15: Overall yield of paddy rice

4.3.2 Specific quality of paddy

As can be seen in the table 2 and table 3 below, the average length of panicle of paddy grown using the different tools in plot 3 and plot 4, the panicle length was in between 22.91cm and 25.82cm (Table 2) and between 21.11cm and 25.20cm (Table 3). In plot 3, the paddy planted by Brazilian no-till seeder (T2) was the highest panicle length (25.82cm), followed by Eli seeder (T3 = 24.14cm) and then conventional direct seeder (T5 = 23.70cm). The shortest one was the paddy sowed by broadcast seeder for four-wheel tractor (T4 = 22.91cm). Whereas, in plot 4 the paddy planted by no-till seeder of ASMC prototype (T1 = 25.20cm) is the tallest panicle length followed by Brazilian no-till seeder. The paddy grown by hand broadcasting received as the shortest panicle length.

Table 2: Specific quality of paddy by parameters: length of panicle, weight of panicle, total number of seed per panicle, total weight of seed per panicle, number of good seed and number of damaged seed in average in plot 3

Treatments	Parameters					
	Length of panicle (cm)	Weight of panicle (g)	Total number of seed in 5 panicles	Total weight of seed in 5 panicle (g)	Number of good seed in 5 panicles	Number of damaged seed in 5 panicles
T0	22.96 ± 2.29	2.78 ± 0.78	523 ± 103	15.72 ± 2.45	451 ± 106	91 ± 26
T0’	22.95 ± 3.09	2.19 ± 0.85	338 ± 110	12.80 ± 2.85	363 ± 103	25 ± 08
T1	22.99 ± 3.04	2.70 ± 0.98	504 ± 57	15.30 ± 1.09	459 ± 28	44 ± 38
T2	25.82 ± 2.30	2.10 ± 0.83	529 ± 82	16.70 ± 1.74	501 ± 83	28 ± 05
T3	24.14 ± 2.06	2.49 ± 0.76	451 ± 62	14.16 ± 2.03	421 ± 66	29 ± 09
T4	22.91 ± 2.23	2.57 ± 0.90	502 ± 86	15.14 ± 2.61	455 ± 96	47 ± 32
T5	23.70 ± 2.09	2.96 ± 0.78	541 ± 122	16.62 ± 3.04	505 ± 115	36 ± 15

Table 3: Specific quality of paddy by parameters: length of panicle, weight of panicle, total number of seed per panicle, total weight of seed per panicle, number of good seed and number of damaged seed in average in plot 4

Treatments	Parameters					
	Length of panicle (cm)	Weight of panicle (g)	Total number of seed in 5 panicles	Total weight of seed in 5 panicle (g)	Number of good seed in 5 panicles	Number of damaged seed in 5 panicles
T0	23.06 ± 2.85	2.08 ± 0.77	392 ± 83	12.42 ± 2.13	316 ± 62	76 ± 24
T0’	21.11 ± 2.80	2.20 ± 0.87	447 ± 147	12.76 ± 3.54	375 ± 151	72 ± 39
T1	25.20 ± 3.34	2.80 ± 1.47	543 ± 254	15.90 ± 6.98	474 ± 210	68 ± 50
T2	24.38 ± 2.56	2.42 ± 0.90	495 ± 113	13.70 ± 2.14	440 ± 91	55 ± 23
T3	23.72 ± 2.61	2.78 ± 0.86	546 ± 50	15.62 ± 2.51	470 ± 69	76 ± 34
T4	24.06 ± 2.36	2.48 ± 0.92	538 ± 106	13.86 ± 2.04	476 ± 84	62 ± 27
T5	23.56 ± 1.82	2.78 ± 0.58	573 ± 79	15.52 ± 0.93	493 ± 46	80 ± 53

For the average total weight of each panicle of the paddy grown using conventional seeder pulled by power tiller was the heaviest at 2.94 g and the lightest one was the paddy planted by Brazilian no-till seeder at 2.10 g (Table 2) for plot 3 and for plot 4 the heaviest one was the paddy grown by no-till seeder prototype at 2.80g with the lightest one was by hand broadcasting at 2.08g (Table 3). But in 5 panicles, the paddy grown by Brazilian no-till seeder (T2) was the best in term of total seed numbers, weight, and percentage of good seed in plot 3 and plot 4 was the no-till seeder of ASMC prototype. The worse one was the traditional hand broadcasting treatment (Table 2 & 3, Figure 16a & 16b).

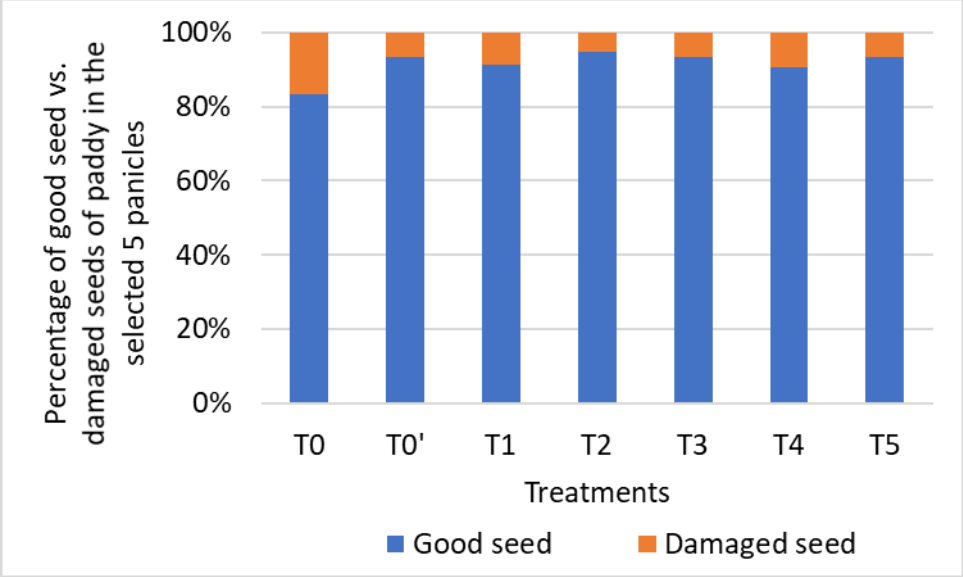

Fig16a: Comparison in percentage of average good and damaged seed of paddy in the selected 5 panicles of an experimental plot in plot 3

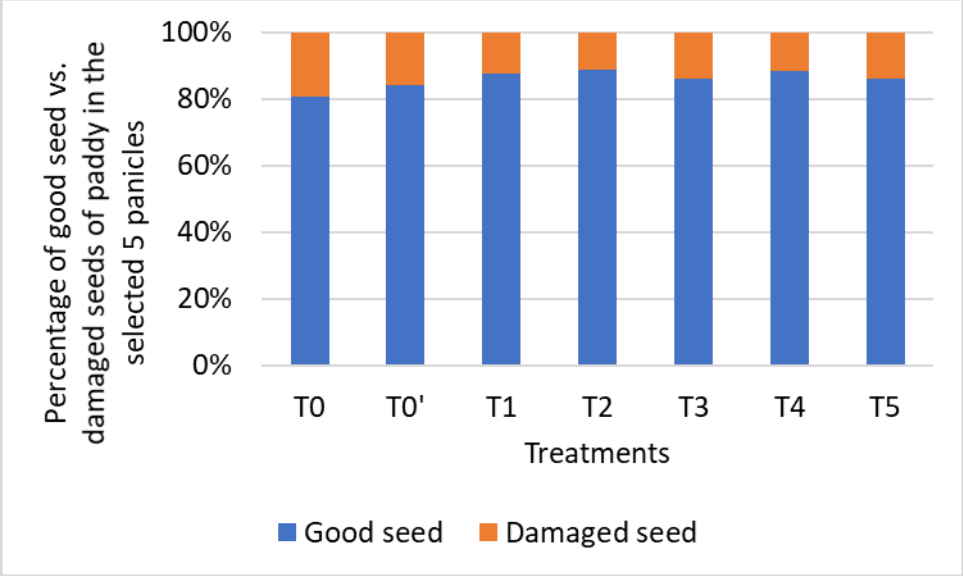

Fig16b: Comparison in percentage of average good and damaged seed of paddy in the selected 5 panicles of an experimental plot in plot 4

V. Conclusion

As can be seen in the results and discussion, the results of performance to operate the machine is different from time to time due to the operators (student and field staff of the project) have limited

experiences on using the machines and tools. In addition, the production yield and quality of paddy are also vary depending on the different crop care, fertilization, and soil fertility. However, we can conclude the results of this experimental study in overall as following:

1. Using machine and planting tools provided the higher field capacity, particularly with sit on driving tractor. The no-till seeder pulled by four-wheel tractor needs approximately 2 hours to complete the work in one hectare and broadcast seeder needs about 30 minutes to 1 hour, while conventional seeder pulled by power tiller with the driver walk behind needs about 6 hrs/ha and traditional hand broadcasting plus harrowing consumed almost 8 hrs/ha.
2. On fuel consumption, the traditional hand broadcasting plus harrowing used a little because just need for the power tiller to harrow to cover the seeds after broadcasting as this is the dry seed planting, just about 1.3 l/ha. Whereas, no-till seeder used a lot (about 7.5 l/ha for Brazilian no-till seeder and approximately 12 l/ha for ASMC no-till planter prototype). The ASMC no-till seeder prototype consumed more probably due to the comments of operators said that the seeder is heavier.
3. The traditional hand broadcasting spent less on fuel consumption, but more on seed as this farmer's habit used 180 kg/ha, while the seeders decreased to 80 kg/ha.
4. The overall production yield, the paddy planted by no-till seeder obtained the optimum production yield (at almost 5 t/ha) with better seed quality in term of length of panicle, weight of panicle, total number of seeds, weight of seeds, and percentage of good seeds vs. damaged seeds.

Acknowledgment

This poster is made possible by the support of the American People provided to the Feed the Future Innovation Lab for Sustainable Intensification through the United States Agency for International Development (USAID). The contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government. Program activities are funded by USAID under Cooperative Agreement No. AID-OAA-L-14-00006.

The direct seed drill pulled by power tiller design and prototyping began through funding by ACIAR. Modifications were done by the Department of Agricultural Engineering and the modified prototypes are being evaluated by the Appropriate Scale Mechanization Consortium (ASMC) team in Cambodia. The stickers on the planter just show that these modified prototype planters were purchased using USAID ASMC funds.

Also, thanks to Dr. Bob Martin, research fellow of Sydney University and Agri-smart Cambodia and BB2C for providing Eli seeder to join this experimental study.

Last but not least, appreciate to the farmers in Battambang province for their participation and contribution to this experimental study.